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Taranaki Regional Estuaries

Ecological Vulnerability Assessment

For Taranaki Regional Council

July 2019

REPORT INFORMATION & QUALITY CONTROL

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Executive Summary

Robertson Environmental Limited has been engaged by Taranaki Regional Council (TRC) to undertake the vulnerability assessment of twenty estuaries in the Taranaki Region in relation to the key coastal issues of eutrophication (excessive nutrients) and sedimentation (excessive muddiness), and to use the resulting information to inform long-term estuary monitoring recommendations.

The purpose of the assessment was to characterise each estuary's current ecological condition in relation to eutrophication and sedimentation, and compare the findings with relevant national standards (NZ Estuary Trophic Index, NZ ETI), to provide recommendations regarding future monitoring priorities at a regional scale. The fieldwork was undertaken in February 26th - 4th March 2019, and the results, overall vulnerability ratings, and monitoring recommendations are outlined below (see summary table on next page).

Estuary Vulnerability to Eutrophication and Sedimentation

As is characteristic of estuaries on the West Coast of NZ, all twenty of the Taranaki Region estuaries assessed were shallow, short residence time, tidal river estuaries (SSRTREs), each variable in size and partially separated from the sea by a range of physical features. The results showed that each estuary fits into one of four sub-types (based on physical attributes and freshwater inflows), each with different vulnerabilities to nutrients and fine sediment and therefore long-term monitoring requirements, as follows:

Estuary Type 1. Short length, low flow SSRTREs - <1 km long, beach located, low freshwater inflows (<1 m^3 s^{-1}), mouth sometimes restricted/closed. Taranaki Region estuaries that fit into this sub-group included Tapuae, Timaru, Te Henui, and Katikara Estuaries.

- **Physical characteristics:** Very short length, often beach located SSRTREs consist of relatively narrow channels situated between the upper edge of the beach and the tidal level. In some situations the channel meanders along the back of the beach for a small distance before entering the sea, whereas in others the discharge path is more direct. A few expand into small lagoons around the upper high water area. In very high tides and storm surges, saline water enters the stream inland of the beach for a small distance. At times the mouth is often restricted and can sometimes close for short periods, during which time the upper beach lagoon may expand and show eutrophication/sedimentation symptoms.
- **Overall vulnerability:** With the exception of Katikara Estuary, which was shown to be highly vulnerable to eutrophication impacts, Type 1 estuaries were the least vulnerable of the Taranaki Region estuaries to eutrophication and sedimentation. The main reason for this was their small size, comparatively low ecological diversity, and regular periods of high flushing (even though some examples experience periodic mouth closure/restriction). Consequently, although estimated nutrient and sediment loads to the estuaries were generally large, they are unlikely to be subjected to prolonged periods of eutrophication and muddiness. Synoptic surveys of this estuary type in Feb/March 2019 confirmed the absence of symptoms of eutrophication (i.e. opportunistic macroalgal and/or phytoplankton blooms) or sedimentation (extensive areas of soft muddy sediments), while Katikara Estuary had phytoplankton issues as indicated by highly elevated chlorophyll *a* concentrations throughout the subtidal channel habitat.

Estuary Type 2. Moderate length, low flow SSRTREs - 1-3 km long, low freshwater inflows (<2 m^3 s^{-1}), mouth sometimes restricted/closed. Taranaki Region estuaries that fit into this sub-group included Waiongana, Mimi, Manawapou, Onaero, Waingongoro, Kaupokonui, and Oakura Estuaries.

- **Physical characteristics:** Moderate length SSRTREs consist of relatively narrow channels situated between the tidal level and approximately 1-3 km inland. In some situations the channel meanders along the back of the beach for a distance before entering the sea, whereas in others the discharge path is more direct. A few expand into small lagoons around the upper high water area. The estuary mouth is generally open to the sea but in others it is often closed (e.g. Onaero Estuary).

Summary of NZ ETI-based susceptibility, current condition and overall vulnerability ratings, and monitoring recommendations, for twenty Taranaki Region estuaries, 2019. * See further details in 'Estuary Monitoring Recommendations' below.

Sub-Type[1]	Estuary	Coastal Stressor				Overall Vulnerability	Recommended Monitoring*	Monitoring Frequency
		Sedimentation		Eutrophication				
		Susceptibility	Current Condition (2019)	Susceptibility	Current Condition (2019)			
SSRTRE Type 1	Tapuae	Moderate	Moderate	Minimal	Minimal	Moderate	Synoptic monitoring only	10-yearly
	Timaru	Moderate	Moderate	Minimal	Minimal	Moderate		
	Te Henui	Moderate	Moderate	Minimal	Minimal	Moderate		
	Katikara	Moderate	Moderate	Moderate	High	Mod-High	Eutrophication-targeted monitoring	Annually
SSRTRE Type 2	Waiongana	Moderate	Moderate	Minimal	Minimal	Moderate	Synoptic monitoring only	10-yearly
	Mimi	Mod-High	Very High	Very High	Moderate	High	Broad- & fine-scale monitoring	3-year baseline, 5-yearly
	Manawapou	Moderate	Moderate	Minimal	Minimal	Moderate	Synoptic monitoring only	10-yearly
	Onaero	Moderate	Moderate	Minimal	Moderate	Moderate		
	Waingongoro	Moderate	Minimal	Minimal	Minimal	Minimal		
	Kaupokonui	Moderate	Moderate	Minimal	Minimal	Moderate		
	Oakura	Moderate	Moderate	Moderate	High	Mod-High	Eutrophication-targeted monitoring	Annually
SSRTRE Type 3	Tangahoe	Moderate	Moderate	Minimal	Minimal	Moderate	Synoptic monitoring only	10-yearly
	Urenui	Mod-High	Very High	Very High	Moderate	High	Broad- & fine-scale monitoring	3-year baseline, 5-yearly
	Mōhakatino	Mod-High	Very High	Moderate	Moderate	High		
SSRTRE Type 4	Waitotara	Mod-High	Very High	Minimal	Minimal	Mod-High		
	Waitara	Mod-High	Very High	Minimal	Moderate	Mod-High		
	Patea	Mod-High	Very High	Very High	Moderate	High		
	Whenuakura	Moderate	Moderate	Very High	Minimal	Mod-High	Eutrophication-targeted monitoring	Annually
	Tongaporutu	Mod-High	Very High	High	Moderate	High	Broad- & fine-scale monitoring	3-year baseline, 5-yearly
	Waiwhakaiho	Moderate	Moderate	Minimal	Minimal	Moderate	Synoptic monitoring only	10-yearly

- **Overall vulnerability:** Type 2 estuaries which had excessive nutrient/sediment loads and whose mouths were mostly closed (and therefore very poorly flushed) were identified as moderately to highly vulnerable. Those that had excessive nutrient/sediment loads but were mostly open to the sea were rated as moderately vulnerable. When nutrient/sediment loads were low and estuaries were open to the sea, estuaries had minimal vulnerability. Characteristic symptoms of eutrophication were opportunistic macroalgal blooms and/or elevated chlorophyll *a* symptomatic of phytoplankton blooms, with symptoms of sedimentation being extensive areas of soft fine muddy sediments. The expression of such symptoms was variable because of the flushing regime - being highly flushed during high flow events, and poorly flushed during summer low flows when their mouths become restricted and the upstream waters stratify. This meant that under high nutrient/sediment loads, the estuaries were likely to exhibit eutrophication and muddiness symptoms only during periods of mouth constriction and/or poor flushing.

Estuary Type 3. Long length, moderate flow SSRTREs - 3-12 km long, moderate freshwater inflows (4-6 m^3 s^{-1}), mouth always open. Taranaki Region estuaries that fit into this sub-group included Tangahoe, Urenui, and Mōhakatino Estuaries.

- **Physical characteristics**: Long SSRTREs, with moderate freshwater inflows and mouths always open, consist of a relatively narrow channel that extends inland for approximately 3-12 km. In some situations the channel meanders along the back of the beach for a distance before entering the sea, whereas in others the discharge path is more direct.
- **Overall vulnerability**: Type 3 estuaries all had moderate-high vulnerability (apart from Tangahoe Estuary), primarily reflecting their high sediment loads and soft mud habitat. The main reason for the moderate eutrophication rating was that, for estuaries where the nutrient load was excessive, the estuary was likely to oscillate between low and moderate-high levels of eutrophication; i.e. low levels of eutrophication and sedimentation in winter, and immediately during and following high flow events in the warmer months, and moderately eutrophic conditions with some sedimentation during summer base-flow conditions. This latter situation arises from the extensive estuary length and moderate freshwater inflow, which means that the residence time for water and nutrients is sufficient to allow for phytoplankton blooms under baseflow conditions (given that the time taken for a parcel of water to travel the length of the estuary under baseflow is ~1-3 days for these estuaries).

Estuary Type 4. Long length, high flow SSRTREs - 3-12 km long, high freshwater inflows (7-220 m^3 s^{-1}), mouth always open. Taranaki Region estuaries that fit into this sub-group included Waitotara, Waitara, Patea, Whenuakura, Tongaporutu, and Waiwhakaiho Estuaries.

- **Physical characteristics**: Long SSRTREs, with high freshwater inflows and mouths always open, consist of relatively narrow channels situated between the tidal level and approximately 3-12 km inland. In some smaller estuaries the channel meanders along the back of the beach for a distance before entering the sea, whereas in others the discharge path is more direct. Some of the smaller estuaries expand into lagoons around the upper high water area. In the larger examples (e.g. Tongaporutu, Waitara and Patea Estuaries), significant areas of intertidal flats are found in the mid-lower estuary.
- **Overall vulnerability**: Most of the Type 4 estuaries had high overall vulnerability. This rating reflects their high nutrient/sediment loads and, in most cases, significant intertidal habitat already affected by sedimentation (extensive areas of soft muddy sediments), despite the fact that flushing in these estuaries was found to be high, even during summer low flows (a consequence of the high freshwater inflows, extensive tidal intrusion, mouths always open and narrow channels). Although synoptic surveys of each estuary in March 2019 generally indicated the absence of symptoms of eutrophication (i.e. opportunistic macroalgal and/or phytoplankton blooms), eutrophic susceptibilities remain high for several of these long length/high flow systems. It is also noted that the vulnerability of the inshore coastal habitats from the river plumes of these large estuaries has not been assessed in this report, given it was outside the study brief.

We note that field survey results of conditions within Mimi, Urenui, Patea and Whenuakura estuaries ranged from minimal to moderate with respect to eutrophication status. However, these condition ratings did not reflect their very high susceptibility ratings (based on catchment nutrient loading and specified physical attributes), despite the survey being carried out towards the end of summer following a sustained period of warm weather and low river flows, i.e. during a high risk period for eutrophication to occur. The prevention of primary eutrophication symptoms in these very highly susceptible estuaries was likely attributable to other less well-understood factors (discussed further in the body of this report). Therefore further fine scale monitoring is recommended to better understand, characterise and manage these systems in relation to eutrophication (and sedimentation) impacts.

Finally, catchment land use and hydrological models have been factored into this assessment which are associated with varying degrees of accuracy. For this reason and others listed in Section 7, the work presented here should not be interpreted as a complete and comprehensive assessment of the issues facing Taranaki estuaries. Rather, this is a screening level assessment for the purpose of identifying estuaries which are vulnerable to, or are currently experiencing, issues related to sedimentation and/or eutrophication. Recommendations for future monitoring are made within this report which allow for more detailed assessments of the state and trend of estuarine health in the region.

Estuary Monitoring Recommendations

To maintain the value of the twenty surveyed Taranaki Region estuaries, and to ensure sufficient information is available to manage each in relation to the identified vulnerability to eutrophication and sedimentation, long-term monitoring is recommended for each estuary below.

For Tongaporutu, Mimi, Urenui, Mōhakatino, Waitotara, Waitara and Patea Estuaries, all with significant intertidal and subtidal habitat comprising poorly flushed/muddy substrata, moderate-high nutrient/sediment loads and high human use and cultural/ecological values, the following four components are recommended:

- **Broad scale habitat mapping** to document dominant estuary features (e.g. substratum, seagrass, saltmarsh, macroalgae) and monitor changes over time. It is typically repeated at 5-yearly intervals;
- **Fine scale monitoring** measures the condition of representative intertidal sediments (usually the dominant substrata type as well as deposition zones where sedimentation and eutrophication symptoms are more likely to be expressed) and subtidal channel habitat using a suite of physical, chemical and biological indicators. It is undertaken once annually for three consecutive years during the period Nov-March (usually at 2 intertidal and 3-4 subtidal sites), and thereafter at 5-yearly intervals;
- **Annual sedimentation rate (including grain size) monitoring** measures sedimentation trends within the estuary over time. Sediment plates should be deployed and monitored annually as per Hunt (2019);
- **High level data on dominant changes in catchment landuse** to track changes in high risk activities (e.g. land disturbance, point source discharges), and facilitate estimates of changes to naturally occurring catchment inputs of sediment, nutrients and other stressors (e.g. pathogens) likely from human influenced land disturbance.

For Katikara, Oakura and Whenuakura Estuaries, where overall eutrophication vulnerability is high, it is recommended that:

- **Annual monitoring of targeted eutrophication indicators** (intertidal and subtidal channel) be undertaken to provide data on long-term trophic state trends. To address potential for eutrophication, it is recommended that relevant water column and sediment-based indicators be monitored monthly during the period Nov-March each year at 1-2 sites representative of general conditions (e.g. mid-upper estuary) and at the same time, intertidal/shallow subtidal

- macroalgal cover be assessed throughout the intertidal/shallow subtidal estuary. This monitoring may cease if, after 1-2 years, eutrophication is not found to be a persistent issue in the estuaries. Because these estuaries are generally flushed regularly by high flow events, it is recommended that long-term monitoring for sedimentation be limited to low frequency (5-yearly), broad scale, screening level assessments only.

For Tapuae, Timaru, Te Henui, Waiongana, Manawapou, Onaero, Waingongoro, Kaupokonui, Tangahoe and Waiwhakaiho Estuaries, all of which had very low overall vulnerabilities to both sedimentation and eutrophication, we recommend:

- **Low frequency, screening level monitoring only**. To address the low potential for eutrophication/sedimentation issues (including both benthic and water column effects), it is recommended that low frequency (once every 10 years), screening level (synoptic) monitoring be undertaken to confirm that these low risk estuaries have not changed their vulnerability ratings.

The monitoring proposed, based on the NEMP framework, has been successfully applied to establish estuary monitoring priorities throughout NZ, and underpins the NZ ETI. Adopting a nationally consistent approach ensures the TRC benefit directly from work undertaken in other regions, as well as from established tools and existing national data, indicators and thresholds.

1 Introduction

1.1 Project Brief and Scope

Gathering information to inform the assessment of effects on the coastal environment is implicit in New Zealand's legislation for sustainable management. A key mechanism in this process is to undertake estuary vulnerability assessments, which are designed to consistently and transparently assess the vulnerability of estuaries in the region to major coastal issues (see Appendix A), to identify appropriate monitoring design, and guide management.

Recently, Taranaki Regional Council (TRC) contracted Robertson Environmental Limited to identify the habitat vulnerability and monitoring priorities associated with the key estuarine issues of eutrophication (excessive nutrients) and sedimentation (excessive muddiness) for estuarine ecological resources in the Taranaki Region using a similar approach to that recently used in the coastal vulnerability assessments in the Southland, Greater Wellington, Tasman, Manawatu-Wanganui and Nelson regions (Robertson and Stevens 2007a, 2007b, 2007c, 2008, 2012, 2016, 2017) and in the NZ Estuary Trophic Index (ETI) toolbox (Robertson et al. 2016a,b). The following report targets 20 estuaries in the Taranaki Region (Figure 1) and includes three main components which produce the following outputs:

- Estuarine Habitat Maps: An ArcMap GIS dataset depicting current broad-scale habitat and substrata types within each estuary, using aerial photographs and ground truthing techniques (e.g. Robertson 2019). Habitat and substrata maps for 20 estuaries are presented in the main document (also provided to TRC as electronic GIS files).
- Vulnerability Assessments: An assessment of the "vulnerability" and "existing condition" of the estuarine habitats to key estuarine issues of eutrophication and sedimentation using the recently developed NZ Estuary Trophic Index (ETI) toolbox (Robertson et al. 2016a,b).
- Monitoring Priorities: A recommended monitoring programme designed to track long-term changes in estuary condition and guide appropriate management in relation to these key issues in a stageable, cost effective and defensible manner.

1.2 Report Structure

The current report presents a brief overview of the scope and structure of the study (Section 1.1), methods used for the habitat mapping, vulnerability assessments and for identifying monitoring recommendations (Section 2), summary detail for each estuary, including their characteristics, values and uses, vulnerabilities to eutrophication and sedimentation, existing condition and recommended monitoring (Section 3), and an estuary-specific overview of the vulnerability assessment results (Section 4) and monitoring recommendations (Section 5).

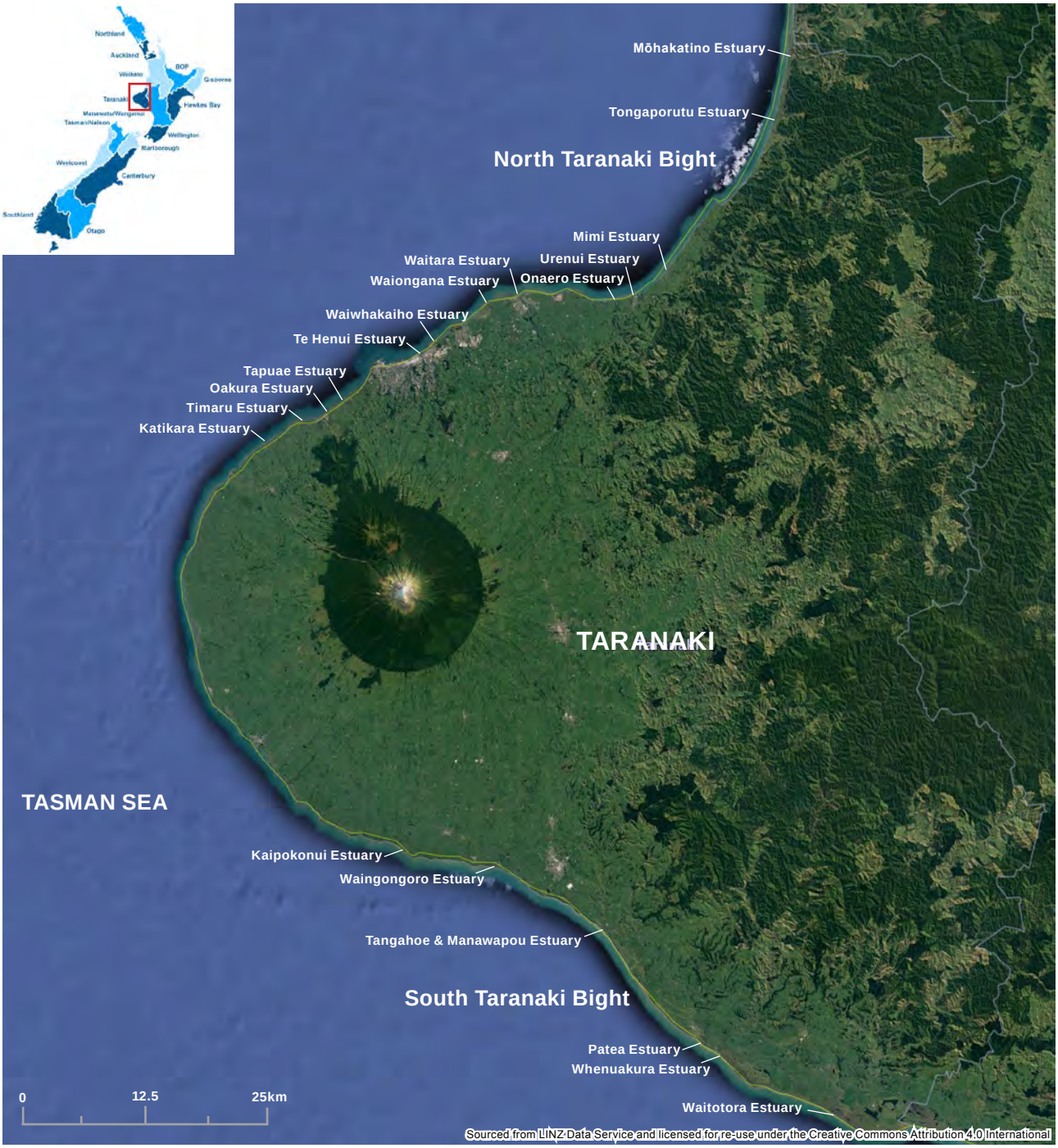


Figure 1. Taranaki Region, including locations of 20 estuaries assessed in the present study.

2 Assessment Methodology

2.1 Vulnerability Assessments and Monitoring Recommendations

The Taranaki Region Estuary Vulnerability Assessment (EVA) follows the NZ Estuary Trophic Index (ETI) approach (Robertson et al. 2016a,b) (see summary inset below), which is designed to be used by experts to represent how estuarine ecosystems are likely to react to the effects of excessive nutrients and fine sediment, and how to monitor and assess their existing level of eutrophication and sedimentation. A summary outline of the approach used for the Taranaki Region EVA is presented in Figure 2, with a detailed step-wise outline of the methods presented in Section 2.2. For each estuary, a final matrix used for recording the findings for each of the key steps is presented in Appendix C.

Summary of NZ Estuary Trophic Index (ETI) Tool

The NZ ETI is a stand-alone, hard-copy methodology that includes two sets of tools that provide screening guidance for assessing where an estuary sits in the eutrophication (and associated sedimentation) gradient, what is required to shift it to a different location in the gradient, and which indicators are required for monitoring. Each tool is presented in a separate report with supporting appendices. Although the ETI focuses on the issue of eutrophication, it includes relevant thresholds for determining the influence of fine sediments on estuary condition, in particular, sedimentation rate and area (spatial extent) of soft muds.

Screening Tool 1. Physical and Nutrient Susceptibility Tool

This method is designed to provide a relatively robust and cost effective approach to enable the prioritisation of estuaries for more rigorous monitoring and management. It applies a desktop susceptibility approach that is based on estuary physical characteristics, and nutrient input load/estuary response relationships for key NZ estuary types. The tool produces a single physical susceptibility score that can be used to classify either the physical susceptibility (i.e. very high, high, moderate, low susceptibility), and/or be combined with nutrient load data to produce a combined physical and nutrient load susceptibility rating. Nutrient areal load/trophic state bands for each estuary eutrophication type will be developed as a long-term goal, with data currently available for some estuary types, but not all as yet. This section also provides guidance on the use of a simple load/response model tool provided in the ETI toolbox, and recommendations for the use of more robust approaches for setting load limits. [*Note recent extensions to Tool 1 (Plew et al. under review) have also been employed to determine estuary eutrophic susceptibility in this report*].

Screening Tool 2. Trophic Condition Assessment Tool

This tool is a monitoring approach that characterises the ecological gradient of estuary trophic condition for relevant ecological response indicators (e.g. macroalgal biomass, dissolved oxygen), and provides a means of translating these ratings into an overall estuary trophic condition rating/score (the ETI). It provides guidance on which condition indicators to use for monitoring the various estuary types (and why they have been chosen), and on assessing the trophic state based on the indicator monitoring results and their comparison to numeric impairment bands (e.g. very high, high, moderate, low). The latter involves measurement of the expression of both primary (direct) eutrophication symptoms (e.g. macroalgae phytoplankton) and supporting indicators for secondary (indirect) symptoms of trophic state.

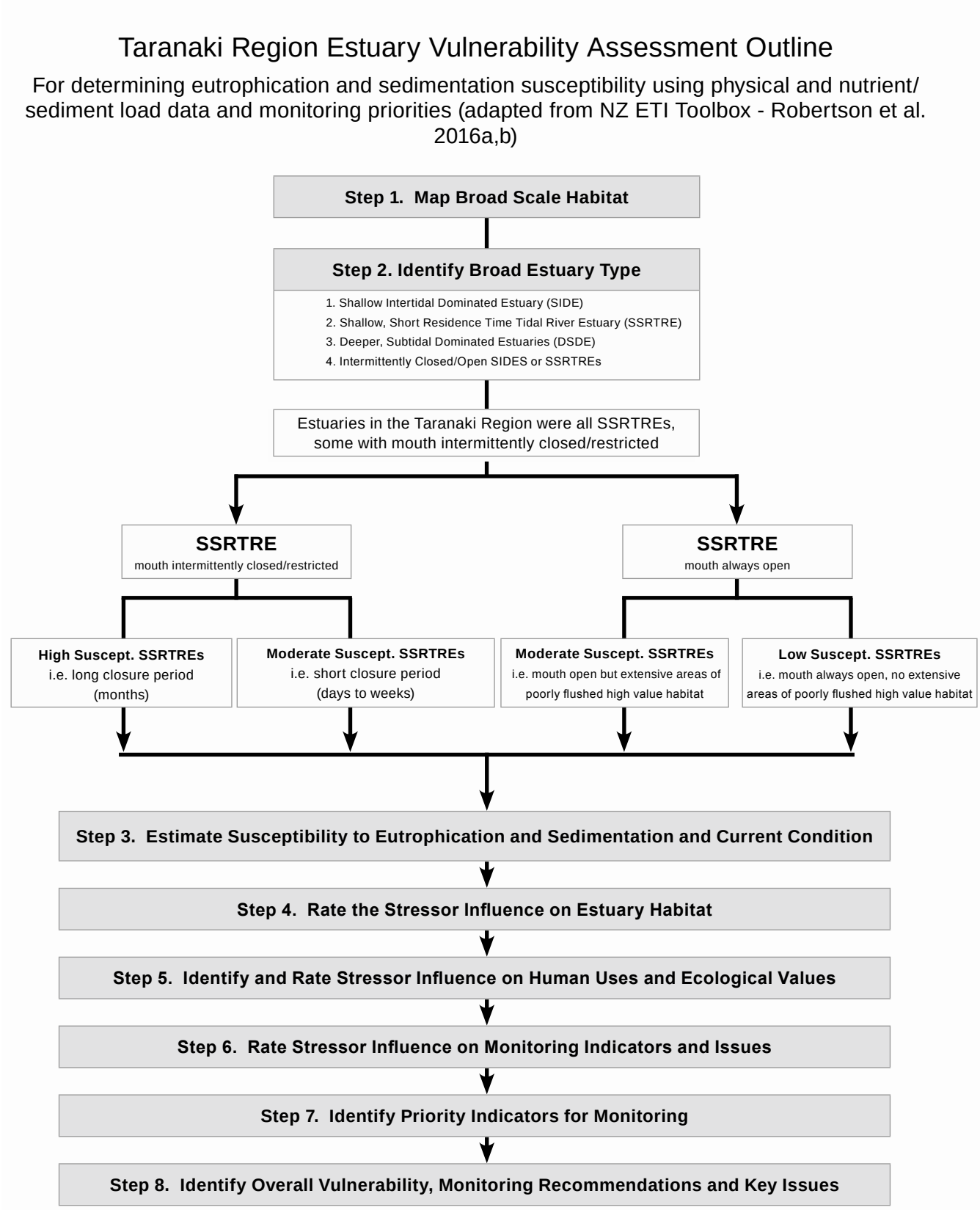


Figure 2. Flow diagram outlining the procedure used to assess the eutrophic and sedimentation susceptibility of estuaries and provide monitoring recommendations in the present report. Note: estuary-specific vulnerability matrices (including NZ ETI Tool 1 & Tool 2 outputs) are presented in Appendix C.

2.2 Summary of the steps used in the Taranaki Region Estuary Vulnerability Assessment

Step 1: Generate Broad Scale Estuary Habitat Maps

In order to identify habitats in Taranaki Region estuaries, broad scale mapping based on the National Estuarine Monitoring Protocol - NEMP (Robertson et al. 2002) was used to record the primary habitat features at a structural class level e.g. vegetation: saltmarsh, seagrass, macroalgae, and substrata: mud, sand, cobble, rock. Features were ground-truthed on 1:2,000, 0.3 m pixel^{-1}, colour aerials flown in summer 2016-18 and provided by LINZ (http://data.linz.govt.nz/layer/99140) and digitised into ArcMap 10.5 to produce GIS maps of dominant intertidal substrata, saltmarsh, and seagrass (*Zostera* spp. or *Ruppia* spp.).

Estuaries were mapped from a 120^{o} angle from the low tide channel entering the sea to the upper extent of saline intrusion (directly measured or where inaccessible estimated based on the presence of salt intolerant plants).

Appendix D lists the class definitions used to classify estuarine substrata and vegetation. Substrata were mapped separately, with the total area of soft mud used as a primary indicator of fine sedimentation impacts, and seagrass and macroalgae were assessed using measures of biomass and percentage cover, as described in the ETI (Robertson et al. 2016a,b) and elsewhere (e.g. Robertson 2019). Broad scale habitat features were digitised into ArcMap 10.5 shapefiles, and combined with field notes and georeferenced photographs to produce habitat maps showing the dominant cover of: substrata (e.g. mud, sand, cobble, rock), macroalgae (e.g. *Ulva* spp., *Gracilaria* spp.), seagrass, and saltmarsh vegetation. These broad scale results are summarised in Section 3, with the supporting GIS files (supplied as a separate electronic file) providing a more detailed data set designed for easy interrogation to address specific monitoring and management questions.

Step 2: Identify Estuary Type

Susceptibility to eutrophication and sedimentation in estuaries is influenced by specific physical modifying characteristics including dilution, flushing, residence time, depth and intertidal extent.

The ETI adopted a simple four category typology (described further in Table 1) specifically suited to the assessment of estuarine eutrophication susceptibility in NZ (an adaptation of the more detailed New Zealand Coastal Hydrosystems Typology, Hume 2016), as follows:

1. Shallow intertidal dominated estuaries (SIDEs);
2. Shallow, short residence time tidal river and tidal river with adjoining lagoon estuaries (SSRTREs);
3. Deeper subtidal dominated, longer residence time estuaries (DSDEs);
4. The ETI classed SIDEs and SSRTREs whose mouths intermittently close for short or long periods as ICOLLs (intermittently closed/open lakes and lagoons estuaries), but ICOLLs are more accurately sub types of SIDEs and SSRTREs.

The results of the broad scale assessment indicated that all the Taranaki Region estuaries assessed were SSRTREs, some of which have intermittently open/closed mouths, and that they could be grouped in the following four sub-types (further details in Appendix B):

- **Type 1**: Short length, low flow SSRTREs: <1 km long, beach located, low freshwater inflows (<1 m^3 s^{-1}), mouth sometimes restricted/closed;
- **Type 2**: Moderate length, low flow SSRTREs: 1-3 km long, low freshwater inflows (<2 m^3 s^{-1}), mouth sometimes restricted/closed;
- **Type 3**: Long length, moderate flow SSRTREs: 3-12 km long, moderate freshwater inflows (4-6 m^3 s^{-1}), mouth always open;
- **Type 4**: Long length, high flow SSRTREs: 3-12 km long, high freshwater inflows (7-220 m^3 s^{-1}), mouth always open.

Because freshwater inflow is considered a stronger determinant of an estuary's vulnerability to catchment sediment and nutrient loads than its length (e.g. Plew et al. 2018), the sub-typing of estuaries was weighted towards freshwater inflow.

Step 3: Assess Key Stressor Influence Based on Magnitude, Existing Condition and Susceptibility

Eutrophication of shallow SSRTREs in NZ is a process driven by the enrichment of water by nutrients, especially compounds of nitrogen (N) and, to a lesser extent, phosphorus (P), whereas sedimentation is a process driven by the enrichment of water by sediments, especially fine sediments (i.e. muds). Because fine sediments often contain elevated nutrients, the two issues of eutrophication and sedimentation are generally interlinked. Catchment inputs are the primary source of nutrients and fine sediments and, if individually present in excess, they result in ecological degradation, which is exacerbated when they occur together (e.g. muddy, nutrient-rich sediments leads to lower pore water exchange, increased sediment bound nutrients, increased organic matter, reduced sediment oxygenation, elevated toxic sulphide levels; e.g. Robertson 2018). In this section, the likely influence of the key stressors of nutrients and fine sediment on the ecological condition of Taranaki Region estuaries is assessed as follows (and includes the use of detailed estuary data presented in Appendices B and C):

<table>
<tr><td>Susceptibility to Eutrophication</td><td>Based on a modification of the ETI, nutrient load thresholds for SSRTREs are recommended as follows:
1. High susceptibility SSRTREs i.e. with long periods of mouth closure or restriction (months). Eutrophic conditions unlikely at estimated areal TN load <35 mg m^{-2} d^{-1}
2. Moderate susceptibility SSRTRE i.e short periods of mouth closure or restriction (days to weeks), or with extensive poorly flushed high value habitat i.e. estuaries with long water column residence time. Eutrophic conditions unlikely at estimated areal TN load <100-250 mg m^{-2} d^{-1}
3. Low susceptibility SSRTRE i.e mouth always open or mouth generally open with short periods of mouth closure or restriction (days to weeks) and no significant areas of poorly flushed high value habitat i.e. a well flushed water column. Eutrophic conditions unlikely at estimated areal TN load <2000 mg m^{-2} d^{-1}
Areal N load = TN estuary load (mg N d^{-1})/estuary area (m^2). For the Taranaki Region estuaries, TN load estimates were derived using the NIWA CLUES model (Version 10.5, released June 2017) default setting using REC2 and LCBB3 (2008/2009) land cover).</td></tr>
<tr><td>Current Eutrophication Condition</td><td>The current trophic state of the Taranaki Region estuaries was assessed using the ETI Tool 2 approach, including recent extensions (Plew et al. under review). This approach requires data or expert opinion for at least one primary indicator and one supporting indicator. For the Taranaki Region estuaries, measured chlorophyll a and macroalgal cover data or expert opinion was used for the primary indicator and redox potential for the supporting indicator to develop an ETI trophic state score (note that other indicator data is also presented where available in order to provide additional support).</td></tr>
<tr><td>Susceptibility to Sedimentation (Muddiness)</td><td>The susceptibility of estuaries to the accumulation of fine sediments is related both to the suspended sediment input load and the physical (sediment trapping) characteristics of each estuary. Currently, there is insufficient information to identify robust sedimentation susceptibility thresholds for NZ estuaries, but for screening level purposes it is appropriate to use the Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio as a means of identifying catchments with excessive sediment loads. For the Taranaki Region estuaries, the chosen CSSL/NSSL ratio thresholds were as follows: low 1-1.1, moderate 1.1-2, high 2-5, very high >5. Catchment sediment load estimates were derived from the NIWA's CLUES model (Version 10.5, released June 2017)[1]. The load threshold ratings were then combined (using the matrix below) with ratings for the likelihood of sediment trapping based on the assumption that high susceptibility SSRTRE estuaries are physically susceptible to fine sediment accumulation.
[1]CSSL estimated using CLUES (default setting of REC2 and LCBB3 (2008/2009) land cover), NSSL estimated by setting CLUES land cover to native forest, with a further 50% reduction applied to account for high expected sediment retention in wetlands in the catchment under natural state (Kreiling et al., 2013, McKergow et al. 2007, Tanner et al. 2010, Kadlec & Wallace 2009; Mitsch & Grosslink 2007, and International BMP Database 2007 as presented in Semadeni-Davies 2009).
<table>
<tr><th rowspan="2">Estuary Category</th><th colspan="4">Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL)</th></tr>
<tr><th>CSSL = 1 to 1.1 x NSSL</th><th>CSSL = 1.1 to 2 x NSSL</th><th>CSSL = 2 to 5 x NSSL</th><th>CSSL > 5 x NSSL</th></tr>
<tr><td>SSRTREs with extensive areas of poorly flushed habitat</td><td>Minimal Susceptibility</td><td>Moderate Susceptibility</td><td>High Susceptibility</td><td>Very High Susceptibility</td></tr>
<tr><td>SSRTREs with no extensive areas of poorly flushed habitat</td><td>Minimal Susceptibility</td><td>Minimal Susceptibility</td><td>Minimal Susceptibility</td><td>Moderate Susceptibility</td></tr>
</table></td></tr>
<tr><td>Current Sedimentation Condition</td><td>The current ETI thresholds for % estuary area dominated by soft mud substrata (i.e. sediment mud content >25%) were used to assess the current sedimentation (or muddiness) of the Taranaki Region estuaries as follows: low 1%, moderate 1-5%, high 5-15%, very high >15%.</td></tr>
<tr><td>Determine Overall Vulnerability</td><td>This step combines the susceptibility and current condition ratings to get an overall vulnerability rating. If the estuary was assessed for condition during reasonable worst case times, then the existing condition rating is used as the final rating. However, if there is considerable uncertainty around the condition rating, then the more conservative susceptibility rating (or combination) is used.</td></tr>
</table>

Step 4: Rate the Stressor Influence on Habitat

The influence of key stressors on the ecological condition of each listed estuarine habitat type is rated based on the results of Steps 1-3.

Step 5: Identify and Rate Stressor Influence on Human Uses and Ecological Values

Human uses and ecological values were identified and their presence assessed using four broad rating categories (Very Low, Low, Moderate, High) based on a UNESCO (2000) methodology. Expert judgement is used to provide an overall rating for stressor influence on each use as follows:

1. Human Uses and Values. The information used to rate human uses and values of coastal habitat is based on local knowledge and available information (Schedule 5B of the Proposed Coastal Plan for Taranaki - Schedule 5B of the Proposed Coastal Plan for Taranaki "Sites of significance to Māori and associated values"). We note that amenity values can be informed from the results of a recent recreational water use survey carried out by TRC. The results generally indicate that the most popular water based activity in Taranaki estuaries is swimming, and the three next most popular activities in varying order were fishing, whitebaiting and kayaking (TRC 2019, pers. comm).

   The estimated number of people involved are used to guide the rating:

   - Very Low: <10 per year;
   - Low: 10 to 50 per year (<30 per day in summer);
   - Moderate: >30 per day (may be only in summer) but <200 per day;
   - High: >200 per day (any time during year).

2. Ecological Values (Richness). Ecological value defines an ecosystem's natural riches (generally interpreted as habitat diversity and biodiversity). It can be supposed that the richer and more 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. The information used to rate the ecological value will be drawn from local knowledge, available reports and information (Taranaki Regional Council 2015 - https://www.trc.govt.nz/assets/Documents/Environment/Coast/reg-landscape-study-of-naki-coastal-enviro.pdf), and expert opinion.

Step 6: Rate the Stressor Influence on Monitoring Indicators and Issues

Monitoring indicators that can be used to assess the influence of stressors are identified. For each, a rating is applied based on the extent that each monitoring indicator is likely to be affected by the stressor influence that was estimated in Step 3. Because each monitoring indicator is assigned into an appropriate issue category, then it is straightforward to assess which issues are likely to arise and what should be monitored. In this section, the overall stressor influence rating for each indicator is also determined using an appropriate weighting for each stressor.

Step 7: Identify Priority Indicators for Monitoring

Combine the results of Steps 4 and 6 to determine the priority indicators for monitoring.

Step 8. Identify Overall Vulnerability, Key Issues, Monitoring Recommendations

Finally, determine overall vulnerability by combining total stressor influence, total human use rating and total ecological values rating, identify key issues for monitoring, and make monitoring recommendations based on priority monitoring indicators.

Table 1. Main estuary categories used in susceptibility analysis

1. Shallow, Intertidal Dominated Estuaries (SIDEs)	
For NZ's dominant estuary types (i.e. shallow, short residence time (<3 days), and predominantly intertidal, tidal lagoon estuaries and parts of other estuary types where extensive tidal flats exist e.g. Firth of Thames, Kaipara Harbour, Freshwater Estuary - Stewart Island), flushing is too strong for significant retention of dissolved nutrients. Nevertheless, retention can still be sufficient to allow for retention of fine sediment and nutrients (particularly if these are excessive), deleterious for healthy growths of seagrass and saltmarsh, and nuisance growths of macroalgae in at-risk habitat. In these latter estuary types, assessment of the susceptibility to eutrophication must focus on the quantification of at-risk habitat (generally upper estuary tidal flats), based on the assumption that the risk of eutrophication symptoms increases as the habitat that is vulnerable to eutrophication symptoms expands. Nitrogen has been identified as the element most limiting to algal production in most estuaries in the temperate zone and is therefore the preferred target for eutrophication management in these estuaries (Howarth and Marino 2006). ***Susceptibility to Nutrient Loads: Moderate to High; Major Primary Producers: Macroalgae.***	 Freshwater Estuary (Stewart Island): high susceptibility pristine estuary
2. Shallow, Short Residence Time Tidal River, and Tidal River with Adjoining Lagoon, Estuaries (SSRTREs)	
NZ also has a number of shallow, short residence time (<3 days) tidal river estuaries (including those that exit via a very well-flushed small lagoon) that have such a large flushing potential (freshwater inflow/estuary volume ratio >0.16) that the majority of fine sediment and nutrients are exported to the sea. Tidal Rivers with mouth restrictions or closure periods of days rather than months and high freshwater inflows (e.g. Lake Onoke) can also fit in this category. In general, these estuary types have extremely low susceptibilities and can often tolerate nutrient loads an order of magnitude greater than shallow, intertidal dominated estuaries. These shallow estuary types are generally N limited. ***Susceptibility to Nutrient Loads: Low to Very Low; Major Primary Producers: Macroalgae, but low production, especially if freshwater inflow high.***	 Waimatuku Estuary (Southland)
3. Deeper, Subtidal Dominated, Estuaries (DSDEs)	
Mainly subtidal, moderately deep (>3 m to 15 m mean depth) coastal embayments (e.g. Firth of Thames) and tidal lagoon estuaries (e.g. Otago Harbour) with moderate residence times >7 to 60 days, can exhibit both sustained phytoplankton blooms, and nuisance growths of opportunistic macroalgae (especially *Ulva* spp. and *Gracilaria* spp.) if nutrient loads are excessive. The latter are usually evident particularly on muddy intertidal flats near river mouths and in the water column where water clarity allows. Deeper, long residence time embayments and fiords are primarily phytoplankton dominated if nutrient loads are excessive. Outer reaches of such systems which sustain vertical density stratification can be susceptible to oxygen depletion and low pH effects (Sunda and Cai 2012, Zeldis et al. 2015). In both cases, it is expected that the US ASSETS approach will adequately predict their trophic state susceptibility. These deeper estuary types are generally N limited. ***Susceptibility to Nutrient Loads: Moderate to Low; Major Primary Producers: Macroalgae (moderately deep) and phytoplankton (deeper sections).***	 Pelorus Sound (Marlborough)
4. Intermittently Closed/Open Estuaries (SIDEs and SSRTREs)	
Shallow tidal lagoon and tidal river type estuaries (<3 m deep) that experience periodical mouth closure or constriction have the highest susceptibility to nutrient retention and eutrophication, with the most susceptible being those with closure periods of months (e.g. Waituna Lagoon, Southland) rather than days (e.g. Lake Onoke, Wellington). In general, the tidal rivers have shorter periods of mouth closure (unless they are very small) than the more buffered tidal lagoons. The high susceptibility arises from reduced dilution (absence of tidal exchange at times) and increased retention (through both enhanced plant uptake and sediment deposition). Excessive phytoplankton and macroalgal growths and reduced macrophyte growth are characteristic symptoms of eutrophication in mouth restricted or closed estuaries. In such situations, which vary between marine and close to freshwater salinities, a co-limiting situation between N and P is expected, and as a consequence nutrient load/estuary response relationships should consider both N and P. ***Susceptibility to Nutrient Loads: Very High; Major Primary Producers: Both Macroalgae and Phytoplankton.***	 Waituna Lagoon (Southland): high susceptibility intermittently open/closed estuary

3 Results and Discussion

Mōhakatino Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Mod-High	Very High
	Eutrophication	Moderate	Moderate

The Mōhakatino Estuary is a long length, shallow tidal river estuary whose mouth is predominantly open. It has a moderate freshwater inflow and is located ~3 km south of Mokau. Intertidal sediments are characterised by soft muds (4.6 ha, 34% unvegetated intertidal area) and sands and include some relatively sparse saltmarsh dominated by rushland (*Apodasmia similis* - Jointed wirerush, *Juncus krausii* - Searush, *Plagianthus divaricatus* - Saltmarsh ribbonwood) and to a lesser extent sedgeland (*Scheonoplectus pungens* - Three-square) and herbfield (*Sarcocornia quinqueflora* - Glasswort) vegetation limited to the mid-upper reaches. The estuary catchment is dominated by mixed native forest, and includes exotic forest and sheep and beef farming (see summary information overleaf).

Human use, ecological and cultural values: Recognised as a "Key Native Ecosystem" (KNE) with good access, the estuary is valued for its spiritual and aesthetic appeal, bathing, biodiversity, food harvesting and mahinga kai. The estuary is significant to Ngāti Tama as it is here where the Tokomaru waka landed. The river was abundant with tuna, īnanga, and mātaitai especially kutae (mussel) which was gathered at the mouth and the surrounding coastal reefs. Ecologically, habitat diversity is moderate-high with some of its intertidal vegetation, saltmarsh (in this case rushland, and some sedgeland and herbfield) intact, and contains breeding areas for native fish and supports whitebait, flounder and shellfish. However, there is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed for grazing and roading infrastructure.

Eutrophication status: The estuary is moderately (NZ ETI Tool 1, Band B) susceptible to macroalgal-based eutrophication at times based on (1) its relatively high proportion (>40%) of intertidal habitat, and (2) its relatively high nutrient load (the current estimated N areal loading of 457.5 mg TN m^{-2} d^{-1} exceeds the tentative guideline for moderate susceptibility SSRTREs of ~250 mg TN m^{-2} d^{-1}).

The 2019 field survey confirmed the absence of nuisance opportunistic macroalgae from all parts of the estuary, resulting in an NZ ETI (Tool 2) condition rating of moderate. Their absence was most likely related to turbidity-induced light limitation (during hightide) and/or flushing (tidal/during flood periods). In addition, the main subtidal channel waters (surface and bottom) had an absence of nuisance phytoplankton blooms (very low [chl *a*]), again reflecting light limitation and/or flushing in that part of the system. However, on occasions during low flows when the estuary is stratified and turbidity is low, nuisance algal/macrophyte growth may occur.

It is important to note that because mud-impacted systems are generally more susceptible to eutrophication impacts, nuisance growths could quickly expand and estuary conditions deteriorate in the short-medium term, particularly if the mouth becomes constricted.

Sedimentation (muddiness) status: The estuary is rated as mod-highly vulnerable to muddiness issues based on the fact that, although the estimated current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL) and excess sediments are likely to be flushed to the sea during high flows, the catchment is naturally erosion prone (Suspended Sediment Yield map of sediment delivery to rivers and stream [https://www.niwa.co.nz/freshwater/management-tools/sediment-tools/suspended-sediment-yield-estimator]) and the synoptic survey which showed that the estuary is dominated by muddy sediments in the less well flushed mid-upper (intertidal and subtidal) reaches. Ecologically, the overall high mud extent fits the NZ ETI Band D (very high muddiness) condition rating.

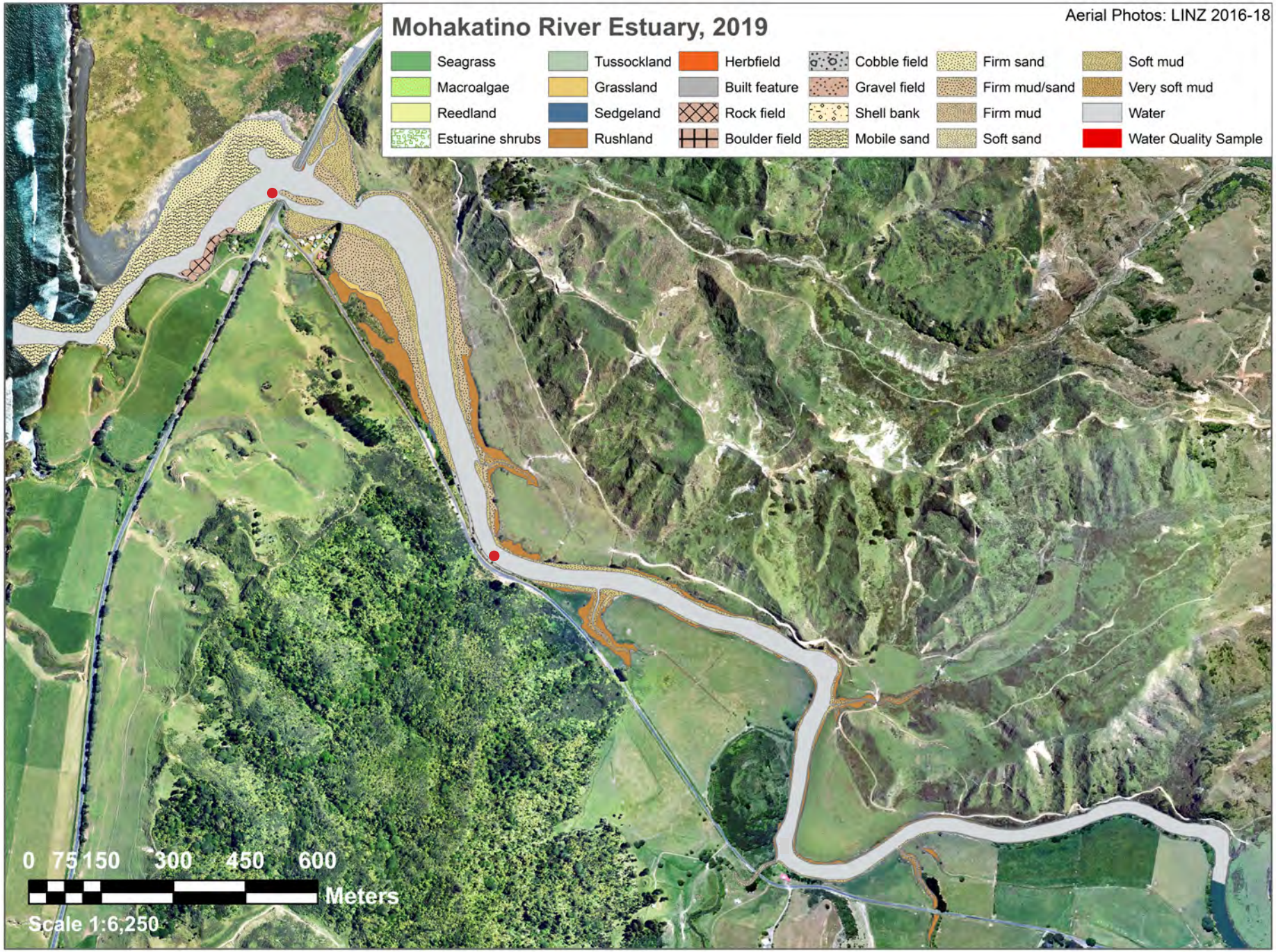


Figure 3. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sampling locations, Mōhakatino Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Mōhakatino River Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 3, 32.1 ha
	Intertidal/Subtidal	52% intertidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	2-3 m, 4 km (salt wedge extent)
	Freshwater Inflow	Mean annual 5.0 m^3 s^{-1}*
	Saltmarsh, Seagrass	3.3 ha saltmarsh, no seagrass
	Soft Mud	4.6 ha (34% unvegetated intertidal area)
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Low-Mod**
Catchment	Catchment size	120.6 km^2
	Max Dairy Cows Permitted	0
	Suspended Sediment Loading	172.6 kt yr^{-1}
	Total Nitrogen Loading	53.6 t yr^{-1} (457.5 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	20.3 t yr^{-1}
	Dominant Landuse	80% native forest, 0.4% exotic forest, 0% dairy, 19% sheep/beef.
	Dominant Toprock Geology	Alluvial 7%, mudstone 6%, massive sandstone 87%.

*Estimated mean flow at river mouth from NIWA's NZ River Maps software tool.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 2 representative subtidal channel sites (see locations in Figure 3). Sampled values in Appendix B.

Monitoring and Investigations

For "moderate-length (mouth sometimes closed or restricted) SSRTREs" with very significant intertidal and subtidal habitat characterised by extensive poorly flush/muddy substrata, moderate-high nutrient/sediment loads and high human use and cultural/ecological values, it is recommended that both broad scale habitat mapping and fine scale monitoring be undertaken on a long-term basis to assess trends in estuary ecological condition using the National Estuary Monitoring Protocol (Robertson et al. 2002), plus subsequent improvements (Robertson 2018; Plew et al. *under review*). Outputs should be compared against relevant national standards (i.e. NZ ETI; Robertson et al. 2016a,b) to gauge overall estuary condition. In addition, sedimentation plates, which, over the long-term, will help provide an indicative measure of the rate of sedimentation in the estuary, should be deployed and monitored annually as per Hunt (2019).

Broad scale habitat mapping documents the key habitats within the estuary, and changes to these habitats over time. It is typically repeated at 5-yearly intervals. Fine scale monitoring measures the condition of the high susceptibility intertidal and subtidal habitat through physical, chemical and biological indicators. It is undertaken once annually for three consecutive years during the period Nov-March (usually at 2 intertidal and 3-4 subtidal sites), and thereafter at 5-yearly intervals. Both components have not yet been measured in this estuary.

Tongaporutu Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Mod-High	Very High
	Eutrophication	High	Moderate

The Tongaporutu Estuary, one of the few places where indigenous coastal forest adjoins the coastal marine area, is a long length, predominantly shallow, often poorly-flushed tidal river estuary whose mouth is predominantly open. It has a high freshwater inflow and is located close to the settlement of Tongaporutu, 15 km south of Mokau. Sediments are dominated by coarse/muddy sands in the expansive intertidal flats in lower estuary, but soft muds (7.8 ha, 23% non-vegetated intertidal flats) dominate the mid-upper estuary channel margins. Mid-estuary saltmarsh comprises *Apodasmia similis* (Jointed wirerush), *Juncus krausii* (Searush) and *Plagianthus divaricatus* (Saltmarsh ribbonwood). The estuary mouth is mostly open to the sea but may become restricted during periods of lowflow, limiting tidal mixing, and consequently the estuary waters can become brackish. The estuary catchment is mixed native forest (highly dominant, 82%), exotic forest, sheep and beef farming (see summary information overleaf).

Human use, ecological and cultural values: Recognised as a "Key Native Ecosystem" (KNE) with good access, the Tongaporutu Estuary is valued for its spiritual/aesthetic appeal, bathing, biodiversity, food harvesting and mahinga kai. It is also significant for Ngāti Tama with a number of pā sites along its river banks. This estuary channel was abundant with fish and mātaitai was gathered form the mouth and the surrounding reefs. Ecologically, habitat diversity is moderate-high with some of its intertidal vegetation, saltmarsh (in this case rushland and to a much lesser extent herbfield) intact. The estuary also contains important breeding areas for native fish as well as abundant shellfish with high species diversity. However, there is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed for grazing and a small area of urban use.

Eutrophication status: The estuary is highly (NZ ETI Tool 1, Band C) susceptible to macroalgal-based eutrophication at times based on (1) its relatively high proportion (>40%) of intertidal habitat, and (2) its moderate nutrient load (the current estimated N areal loading of 630 mg TN m^{-2} d^{-1} does not exceed the tentative guideline for low susceptibility SSRTREs of ~2,000 mg TN m^{-2} d^{-1}).

Despite the high rating, the 2019 field survey showed minimal signs of nuisance opportunistic macroalgal growth, resulting in an NZ ETI (Tool 2) condition rating of moderate. Their low incidence was most likely related to turbidity-induced light limitation (during hightide) and flushing during flood periods. Synoptic (one-off) sampling of the main subtidal channel waters (surface and bottom), indicated an absence of nuisance phytoplankton blooms (very low [chl *a*]), again reflecting light limitation and/or flushing in that part of the system. However, on occasions during low flows when the estuary is stratified and turbidity is low, nuisance algal/macrophyte growth may occur.

In addition, such a mud-impacted estuary (in this case in its mid-upper reaches) generally is more susceptible to eutrophication impacts, so the present survey results must be viewed in that context, and the potential for rapid ecological decline accounted for in any long-term monitoring programme.

Sedimentation (muddiness) status: The estuary is rated as highly vulnerable to muddiness issues based on the fact that, although the estimated current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL) and excess sediments are likely to be flushed to the sea during high flows, the catchment is naturally erosion prone (Suspended Sediment Yield map of sediment delivery to rivers and stream [NIWA]) and the synoptic survey showed that the estuary is dominated by muddy sediments in the less well flushed mid-upper (intertidal and subtidal) reaches. Ecologically, the overall high extent fits the NZ ETI Band D (very high) condition rating.

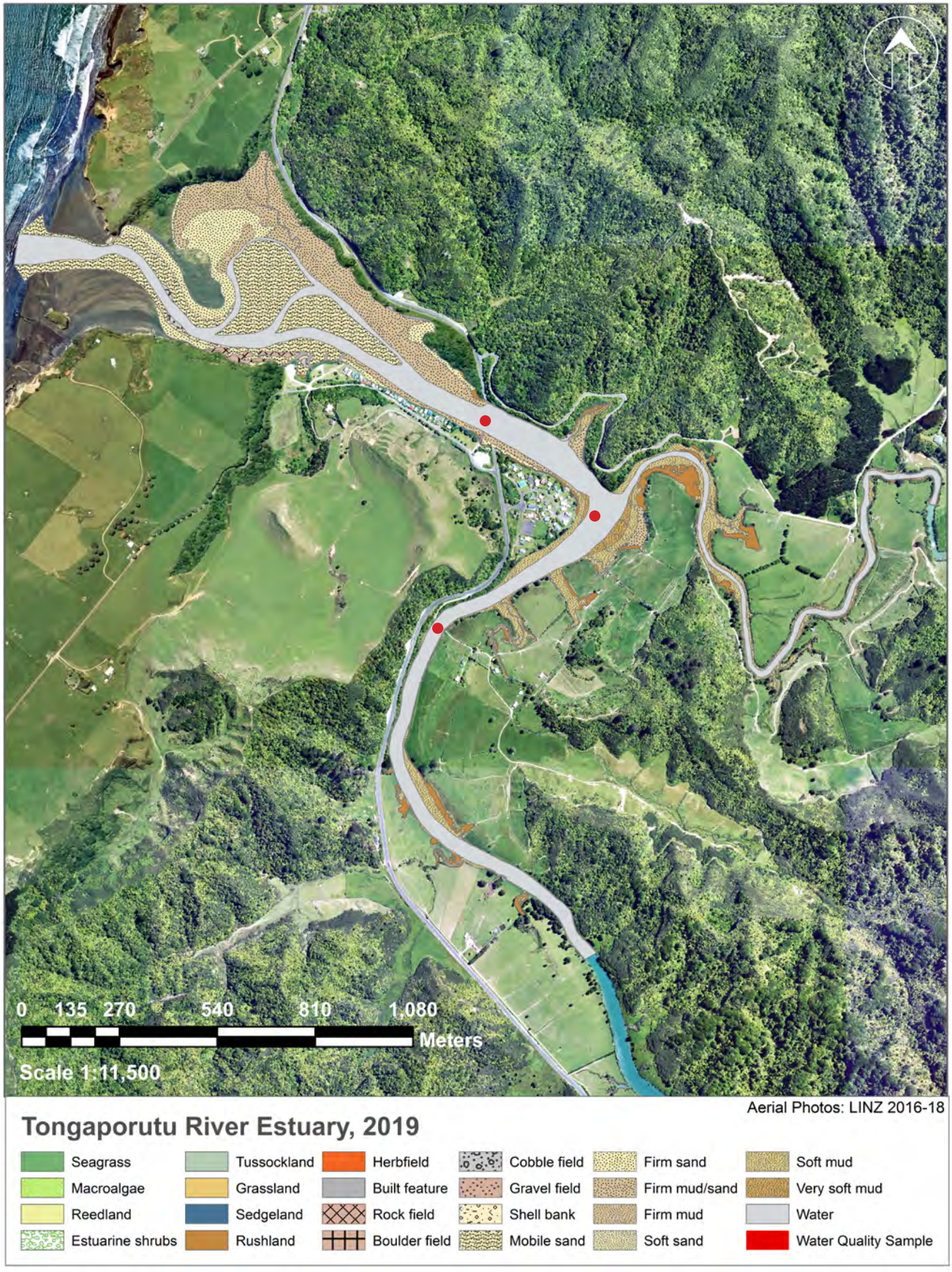


Figure 4. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Tongaporutu Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Tongaporutu Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 4, 58.2 ha
	Intertidal/Subtidal	63% intertidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	1-2 m, 6 km (salt wedge extent)
	Freshwater Inflow	Mean annual 9.3 m^3 s^{-1}*
	Saltmarsh, Seagrass	2.8 ha saltmarsh, no seagrass
	Soft Mud	7.8 ha (23% unvegetated intertidal area)
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Low**
Catchment	Catchment size	270.4 km^2
	Max Dairy Cows Permitted	665
	Suspended Sediment Loading	362.4 kt yr^{-1}
	Total Nitrogen Loading	133.9 t yr^{-1} (630 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	48.1 t yr^{-1}
	Dominant Landuse	82% native forest, 2% exotic forest, 0% dairy, 16% sheep/beef.
	Dominant Toprock Geology	Alluvial 3%, massive mudstone 12%, peat 2%, massive sandstone 85%.

*Estimated mean flow at river mouth from NIWA's NZ River Maps software tool.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 3 representative subtidal channel sites (see locations in Figure 4). Sampled values in Appendix B.

Monitoring and Investigations

For "long-length (mouth sometimes closed or restricted) SSRTREs" with significant intertidal and subtidal habitat comprising poorly flushed/muddy substrata, moderate-high nutrient/sediment loads and high human use and cultural/ecological values, it is recommended that both broad scale habitat mapping and fine scale monitoring be undertaken on a long-term basis to assess trends in estuary ecological condition using the National Estuary Monitoring Protocol (Robertson et al. 2002), plus subsequent improvements (Robertson 2018). Outputs should be compared against relevant national standards (i.e. NZ ETI; Robertson et al. 2016a,b). In addition, sedimentation plates, which, over the long-term, will help provide an indicative measure of the rate of sedimentation in the estuary, should be deployed and monitored annually as per Hunt (2019).

Broad scale habitat mapping documents the key habitats within the estuary, and changes to these habitats over time. It is typically repeated at 5-yearly intervals. Fine scale monitoring measures the condition of the high susceptibility intertidal and subtidal habitat through physical, chemical and biological indicators. It is undertaken once annually for three consecutive years during the period Nov-March (usually at 2 intertidal and 3-4 subtidal sites), and thereafter at 5-yearly intervals. Both components have not yet been measured in this estuary.

Mimi Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Mod-High	Very High
	Eutrophication	Very High	Moderate

The Mimi Estuary is a relatively small, long, shallow, moderately-highly flushed tidal river estuary (SSRTRE) that has a moderate-high freshwater inflow, extends approximately 3 km inland, and is located approximately 25 km northeast of Urenui. The estuary mouth is mostly open to the sea, but at times it migrates and can be semi-restricted, which means the estuary is often brackish.

Sediments are dominated by muds and sands in the middle to upper estuary and sands in the lower reaches. The middle estuary includes several small pockets of saltmarsh including *Juncus krausii* (Searush) and *Apodasmia similis* (Jointed wirerush) and to a much lesser extent reedland (*Typha orientalis,* Raupo) and herbfield (*Triglochin striata*, Arrow-grass) vegetation.

The estuary catchment is mixed native forest, exotic forest (including consented forestry), dairy and sheep and beef farming (see summary information below).

Human use, ecological and cultural values: The estuary is recognised as an important nursery area for marine and freshwater fish (including diverse and regionally distinctive native species) and birds (e.g. the 'Threatened (Nationally Vulnerable)' Northern New Zealand dotterel (*Charadrius obscurus aquilonius*), Caspian tern (*Hydroprogne caspia*) and red-billed gull (*Larus novaehollandiae scopulinus*). With a high degree of natural character, it is considered a "Key Native Ecosystem" (KNE), and habitat diversity is moderate with some of its intertidal saltmarsh intact, although there is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed primarily for grazing. The full name of this estuary is Mimitangiatua, and it is significant to Ngati Mutunga for many reasons. Historically, the river has been used for food gathering and there are a number of pā and kāinga located along its banks. Human activity is minimal associated with low key recreation use, and the visiting experience maintains a sense of remoteness and high scenic associations.

Eutrophication status: The estuary is 'very highly' (NZ ETI Tool 1, Band D) susceptible to macroalgal-based eutrophication at times based on:

1. its relatively high proportion of intertidal habitat (>40%); and,
2. its high nutrient load (the current estimated N areal loading of 2,429 mg TN m^{-2} d^{-1} exceeds the tentative guideline for moderate susceptibility SSRTREs of ~250 mg TN m^{-2} d^{-1}).

In terms of current conditions, the field survey (2019) showed an absence of nuisance opportunistic macroalgae, fitting the 'moderate' (NZ ETI Tool 2, Band B) condition category. Their low incidence was most likely related to turbidity-induced light limitation (during hightide) and flushing during flood periods.

Synoptic (one-off) sampling of the main subtidal channel waters (surface and bottom) showed no signs of nuisance phytoplankton blooms (very low [chl *a*]), with light limitation and/or flushing in that part of the system the most plausible explanation. However, on occasions during low flows when the estuary is stratified and turbidity is low, nuisance algal/macrophyte growth may occur.

Sedimentation (muddiness) status: The estuary is rated as moderate-highly vulnerable to muddiness issues based on the facts that, while the estimated current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL), and excess sediments are likely to be flushed to the sea during high flows, the catchment is naturally erosion prone (Suspended Sediment Yield map of sediment delivery to rivers and stream [NIWA]) and the synoptic survey showed that the estuary is impacted by muddy sediments (26% intertidal area) in the less well flushed mid-upper (intertidal and subtidal) reaches. Ecologically, the overall relatively high mud extent fits the NZ ETI Band D (very high) condition rating.

Figure 5. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sampling locations, Mimi River Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Mimi Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 2, 10.3 ha
	Intertidal/Subtidal	49% intertidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	0.5-1.0 m, ~2 km (salt wedge extent)
	Freshwater Inflow	Mean annual 3.6 m^3 s^{-1}*
	Saltmarsh, Seagrass	0.9 ha saltmarsh, No intertidal seagrass
	Soft Mud	1.2 ha (26% intertidal area)
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Low-Moderate**
Catchment	Catchment size	133.4 km^2
	Max Dairy Cows Permitted	1735
	Suspended Sediment Loading	186.1 kt yr^{-1}
	Total Nitrogen Loading	91.3 t yr^{-1} (2,429 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	42.7 t yr^{-1}
	Dominant Landuse	Native forest 56%, Exotic forest 4%, Dairy 7%, Sheep/beef 32%.
	Dominant Toprock Geology	Alluvial 9%, Massive mudstone 20%, Ash (older than Taupo ash) 22%, Massive sandstone 50%.

*Estimated mean flow at river mouth from NIWA's NZ River Maps software tool.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 3 representative subtidal channel sites (see locations in Figure 5). Sampled values in Appendix B.

Monitoring and Investigations

For "moderate-length (mouth sometimes closed or restricted) SSRTREs" with significant intertidal and subtidal habitat comprising relatively extensive poorly flushed/muddy substrata, moderate-high nutrient/sediment loads and high human use and very high cultural/ecological values, it is recommended that both broad scale habitat mapping and fine scale (intertidal and subtidal) monitoring be undertaken on a long-term basis to assess trends in estuary ecological condition using the National Estuary Monitoring Protocol (Robertson et al. 2002), plus subsequent improvements (Robertson 2018; Robertson and Robertson 2018). Outputs should be compared against relevant national standards (i.e. NZ ETI; Robertson et al. 2016a,b). In addition, sedimentation plates, which, over the long-term, will help provide an indicative measure of the rate of sedimentation in the estuary, should be deployed and monitored annually as per Hunt (2019).

Broad scale habitat mapping documents the key habitats within the estuary, and changes to these habitats over time. It is typically repeated at 5-yearly intervals. Fine scale monitoring measures the condition of the high susceptibility intertidal and subtidal habitat through physical, chemical and biological indicators. It is undertaken once annually for three consecutive years during the period Nov-March (usually at 2 intertidal and 3-4 subtidal sites), and thereafter at 5-yearly intervals. Both components have not yet been measured in this estuary.

Urenui Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Mod-High	Very High
	Eutrophication	Very High	Moderate

The Urenui Estuary is a moderate length, shallow, often poorly-flushed tidal river estuary. It has a moderate freshwater inflow and is located at Urenui township. Intertidally, sediments are characterised by soft muds (5.7 ha, 39.2% non-vegetated intertidal flats) and sands and include a significant area of high tide saltmarsh dominated by *Juncus krausii* (Searush) and *Apodasmia similis* (Jointed wirerush) and to a lesser extent herbfield (*Triglochin striata*, Arrow-grass) vegetation. The middle estuary also comprises a small band of variably sized mangrove (*Avicennia marina var. resinfera*) shrubs, the distribution of which appears to be expanding towards the main channel. The estuary mouth is mostly open to the sea but may become restricted during periods of low-flow, limiting tidal mixing, and consequently the estuary waters can become brackish. The estuary catchment is mixed native forest, exotic forest (including consented forestry), dairy and sheep and beef farming (see summary information overleaf).

Human use, ecological and cultural values: Recognised as a "Key Native Ecosystem" (KNE) with good access, the Urenui Estuary is valued for its aesthetic appeal, bathing, biodiversity, and food harvesting. Ecologically, habitat diversity is moderate-high with some of its intertidal vegetation, saltmarsh (in this case rushland, mangrove and herbfield) intact. However, there is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed for grazing and urban use. The estuary is recognised as an important nursery area for marine and freshwater fish and birds. Culturally, this estuary is significant to Ngati Mutunga, with a large number of pā located along its banks. The mouth of the river provided a plentiful supply of pipi, pūpū, pātiki kahawai and other fish.

Eutrophication status: The estuary is very highly (NZ ETI Tool 1, Band D) susceptible to macroalgal-based eutrophication at times based on (1) its relatively high proportion (>40%) of intertidal habitat, and (2) its very high nutrient load (the current estimated N areal loading of 1102.4 mg TN m^{-2} d^{-1} exceeds the tentative guideline for moderate susceptibility SSRTREs of ~250 mg TN m^{-2} d^{-1}). Despite the very high rating, the 2019 field survey showed very limited nuisance opportunistic macroalgal growth, resulting in an NZ ETI (Tool 2, Band B) condition rating of moderate. Nuisance macroalgae were present as only a single low density (20-30% cover, biomass ~100 g wet weight m^{-2}) patch of *Ulva intestinalis* in shallow margin areas of the middle estuary (i.e. the only Taranaki Region estuary assessed with any macroalgae at all). Their low incidence was most likely related to turbidity-induced light limitation (during hightide) and flushing during flood periods. Synoptic (one-off) sampling of the main subtidal channel waters (surface and bottom) indicated an absence of nuisance phytoplankton blooms (very low [chl *a*]), again reflecting light limitation and/or flushing in that part of the system. However, on occasions during low flows when the estuary is stratified and turbidity is low, nuisance algal/macrophyte growth may occur.

It is important to note that because mud-dominated systems are generally more susceptible to eutrophication impacts, nuisance growths could quickly expand and estuary conditions deteriorate in the short-medium term, particularly if the mouth becomes constricted.

Sedimentation (muddiness) status: The estuary is rated as highly vulnerable to muddiness issues based on the fact that, although the estimated current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL) and excess sediments are likely to be flushed to the sea during high flows, the catchment is naturally erosion prone (Suspended Sediment Yield map of sediment delivery to rivers and stream [NIWA]) and the synoptic survey showed that the estuary is dominated by muddy sediments in the less well flushed mid-upper (intertidal and subtidal) reaches. Ecologically, the overall high mud extent fits the NZ ETI Band D (very high) condition rating.

Figure 6. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Urenui Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Urenui Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 3, 21.2 ha
	Intertidal/Subtidal	31% subtidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	0.5-1.0 m, ~3 km (salt wedge extent)
	Freshwater Inflow	Mean annual 4.4 m^3 s^{-1}*
	Saltmarsh, Seagrass	1.9 ha saltmarsh, No intertidal seagrass
	Soft Mud	5.7 ha (39.2% intertidal area)
	Macroalgae	0.08 ha (20-30% cover, ~100 g ww m^{-2})
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Low-Moderate**
Catchment	Catchment size	132.8 km^2
	Max Dairy Cows Permitted	745
	Suspended Sediment Loading	149.4 kt yr^{-1}
	Total Nitrogen Loading	85.3 t yr^{-1} (1102.4 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	66.3 t yr^{-1}
	Dominant Landuse	Native forest 66%, Exotic forest 3%, Dairy 9%, Sheep/beef 22%.
	Dominant Toprock Geology	Massive mudstone 54%, ash (older than Taupo ash) 17%, massive sandstone 24%.

*Estimated mean flow at river mouth from NIWA's NZ River Maps software tool.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 3 representative subtidal channel sites (see locations in Figure 6). Sampled values in Appendix B.

Monitoring and Investigations

For "moderate-length (mouth sometimes closed or restricted) SSRTREs" with very significant intertidal and subtidal habitat characterised by extensive poorly flush/muddy substrata, moderate-high nutrient/sediment loads and high human use and cultural/ecological values, it is recommended that both broad scale habitat mapping and fine scale monitoring be undertaken on a long-term basis to assess trends in estuary ecological condition using the National Estuary Monitoring Protocol (Robertson et al. 2002), plus subsequent improvements (Robertson 2018). Outputs should be compared against relevant national standards (i.e. NZ ETI; Robertson et al. 2016a,b). In addition, sedimentation plates, which, over the long-term, will help provide an indicative measure of the rate of sedimentation in the estuary, should be deployed and monitored annually as per Hunt (2019).

Broad scale habitat mapping documents the key habitats within the estuary, and changes to these habitats over time. It is typically repeated at 5-yearly intervals. Fine scale monitoring measures the condition of the high susceptibility intertidal and subtidal habitat through physical, chemical and biological indicators. It is undertaken once annually for three consecutive years during the period Nov-March (usually at 2 intertidal and 3-4 subtidal sites), and thereafter at 5-yearly intervals. Both components have not yet been measured in this estuary.

Onaero Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Moderate	Moderate
	Eutrophication	Minimal	Moderate

The Onaero Estuary is a moderate length, shallow, tidal river estuary. It has a low freshwater inflow and is located 2 km west of the Urenui township. The main subtidal channel (10-20 m wide) comprises 63% of the estuary, with intertidal sediments largely dominated by sands and there is a narrow strip of saltmarsh (*Cyperus ustulatus* - Giant umbrella sedge) vegetation within the middle reaches. The estuary mouth fluctuates between an open and closed state (time frame unknown), and when restricted/closed, tidal mixing is limited and estuary waters become brackish. The estuary catchment is mixed native forest, exotic forest (including consented forestry), dairy and sheep and beef farming (see summary information overleaf).

Human use, ecological and cultural values: The estuary is valued for its spiritual/aesthetic appeal, bathing, biodiversity, and food harvesting. It is significant to Ngati Mutunga, with a number of pā located in close proximity. The mouth of the river provided a plentiful supply of pipi, pūpū, pātiki kahawai and other fish. Ecologically, habitat diversity is low-moderate with a very limited area of intertidal saltmarsh vegetation (in this case a strip of rushland) intact. There is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed primarily for grazing.

Eutrophication status: Despite its very high nutrient load (the current estimated catchment N areal loading of 7,302.4 mg TN m^{-2} d^{-1} exceeds the guideline for low susceptibility tidal river estuaries of ~2000 mg TN m^{-2} d^{-1}, Robertson et al. 2016), the estuary has minimal susceptibility to eutrophication (NZ ETI Tool 1, Band A). This is primarily because of its highly flushed nature, given that it is predominantly strongly channelised with very few poorly flushed areas, and has adequate freshwater inflow.

The (one-off) synoptic survey in 2019, confirmed the absence of opportunistic macroalgal and phytoplankton blooms throughout the intertidal and subtidal estuary, but with low-moderate chlorophyll *a* and dissolved oxygen concentrations in subtidal channel waters, an NZ ETI (Tool 2) condition rating of 'moderate' (Band B) for eutrophication impacts was allocated.

We note that, while periodic (short-term) changes in eutrophic susceptibility are expected (particularly if the mouth becomes constricted), given the low degree of eutrophic symptoms on the day of sampling when flushing was low (i.e. baseflow conditions), the low susceptibility rating is considered appropriate.

Sedimentation (muddiness) status: Despite emptying a catchment naturally prone to erosion (Suspended Sediment Yield map of sediment delivery to rivers and stream [NIWA]), the estuary has moderate vulnerability to muddiness issues based on the facts that the current suspended sediment load (CSSL) is 2-5 times the estimated natural state SS load (NSSL), but with some subtidal muds, and the mouth may be occasionally restricted. Currently, the overall moderate mud extent fits the NZ ETI Band B (moderate muddiness) condition rating.

Figure 7. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Onaero Estuary, 2019. Water quality sampling involved assessment of conditions in bottom (0.5 m from bottom) waters only at each site.

Onaero Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 2, 2.6 ha
	Intertidal/Subtidal	63% subtidal
	Mouth Status (on day of survey)	Closed
	Mean Depth, Length	0.5-1 m, 1 km (salt wedge extent)
	Freshwater Inflow	Mean annual 2.4 m^3 s^{-1}*
	Saltmarsh, Seagrass	0.4 ha saltmarsh, no seagrass
	Soft Mud	No intertidal soft mud
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Low**
	[Dissolved oxygen] (subtidal channel)	Mod-High**
Catchment	Catchment size	89.8 km^2
	Max Dairy Cows Permitted	1085
	Suspended Sediment Loading	75.1 kt yr^{-1}
	Total Nitrogen Loading	69.3 t yr^{-1} (7,302.4 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	36 t yr^{-1}
	Dominant Landuse	43% native forest, 3% exotic forest, 31% dairy, 24% sheep/beef.
	Dominant Toprock Geology	Alluvial 5%, ash (older than Taupo ash) 45%, massive mudstone 38%, massive sandstone 12%.

*Estimated mean flow at river mouth from NIWA's NZ River Maps software tool.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 2 representative subtidal channel sites (see locations in Figure 7). Sampled values in Appendix B.

Monitoring and Investigations

The low rating for both eutrophication and sedimentation in this estuary signifies a requirement for low frequency, screening level monitoring only.

To address the low potential for eutrophication/sedimentation issues (including both benthic and water column effects), it is recommended that low frequency (once every 10 years), screening level (synoptic) monitoring be undertaken to confirm that this low risk estuary has not changed its risk rating.

Waitara Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Mod-High	Very High
	Eutrophication	Minimal	Moderate

The Waitara Estuary, located at the coastal town of Waitara, is one of the region's most significant long length, shallow, well-flushed tidal river estuary whose mouth (flanked either side by man-made boulder/rock wall) is always open. It has a very high freshwater inflow and is dominated by a relatively wide (30-40 m) subtidal channel (73% of estuary). Intertidal habitat is characterised by soft muds (2.7 ha, 26% unvegetated intertidal flats) and sands and include some saltmarsh comprising rushland (*Juncus kraussii* - Searush, *Apodasmia similis* - Jointed wirerush, *Isolepis nodosa* - Knobby clubrush) and to a lesser extent reedland (*Typha orientalis* - Raupo) and sedgeland (*Schoenoplectus pungens* - Three-square) vegetation. The estuary catchment is dominated by native forest, dairy and sheep/beef farming and exotic forest (including consented forestry) - see further summary information overleaf.

Human use, ecological and cultural values: With its good access and close proximity to the Waitara township, the estuary is valued for its aesthetic/spiritual appeal, bathing, biodiversity, and food harvesting. It is significant to Te Atiawa as it was one of the first areas to be settled in Aotearoa. The river provided an abundance of fish, īnanga, tuna/eel, piharau, kahawai, yellow eyed mullet, flounder, herrings, kōkopu, weka, pukeko and ducks. Ecologically, habitat diversity is moderate with some of its regionally significant intertidal vegetation (in this case rushland) intact. However, there is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed for grazing, flood protection and urban use.

Eutrophication status: Despite its very high nutrient load (the current estimated catchment N areal loading of 9,807 mg TN m^{-2} d^{-1} exceeds the guideline for low susceptibility tidal river estuaries of ~2000 mg TN m^{-2} d^{-1}, Robertson et al. 2016), the estuary has minimal susceptibility to eutrophication. This is primarily because of its highly flushed nature, given that it is predominantly strongly channelised with very few poorly flushed areas, has high freshwater inflow, is strongly affected by tidal currents. The overall eutrophic susceptibility of the estuary is minimal (NZ ETI Tool 1, Band A).

The synoptic survey in 2019 indicated a general absence of primary symptoms (i.e. no opportunistic macroalgal and phytoplankton blooms) from all areas of the estuary and generally clear waters in the lower and middle estuary, resulting in an NZ ETI (Tool 2) Band B (moderate eutrophication) condition rating.

However, it is important to note that such mud-impacted estuaries generally are more susceptible to eutrophication impacts, so the present survey results must be viewed in that context, and the potential for rapid ecological decline accounted for in any long-term monitoring programme.

Sedimentation (muddiness) status: The estuary is rated as moderate-highly vulnerable to muddiness issues based on the fact that, although the estimated current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL) and excess sediments are likely to be flushed to the sea during high flows, the catchment is naturally erosion prone (Suspended Sediment Yield map of sediment delivery to rivers and stream [NIWA]) and the synoptic survey showed that the estuary is impacted by muddy sediments in the less well flushed mid-lower (intertidal and subtidal) reaches. Ecologically, the overall high proportion of muds in 2019, possibly a result of recent flood activity, fits the NZ ETI Band D (very high) condition rating.

Figure 8. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Waitara Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Waitara Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 4, 56.7 ha
	Intertidal/Subtidal	73% subtidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	2-3 m, 5 km (salt wedge extent)
	Freshwater Inflow	Mean annual 57.3 m^3 s^{-1}*
	Saltmarsh, Seagrass	4.6 ha saltmarsh, no seagrass
	Soft Mud	2.7 ha (26% unvegetated intertidal area)
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Very Low-Low**
Catchment	Catchment size	1135.7 km^2
	Max Dairy Cows Permitted	51,515
	Suspended Sediment Loading	1109 kt yr^{-1}
	Total Nitrogen Loading	2030 t yr^{-1} (9,807 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	272.4 t yr^{-1}
	Dominant Landuse	38% native forest, 5% exotic forest, 30% dairy, 26% sheep/beef.
	Dominant Toprock Geology	Alluvial 2%, mudstone 2%, massive mudstone 2%, ash (older than Taupo ash) 46%, massive sandstone 42%.

*Mean flow measured at Waitara at Bertrand Rd, and includes Motukawa HEP (consented to take max 5,650 l s^{-1}, but can discharge up to 7,787 l s^{-1}) and 2x Methanex Consents.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 3 representative subtidal channel sites (see locations in Figure 8). Sampled values in Appendix B.

Monitoring and Investigations

For “long-length (mouth sometimes closed or restricted) SSRTREs” with significant areas of intertidal and subtidal habitat comprising poorly flushed/muddy substrata, moderate-high nutrient/sediment loads and high human use and cultural/ecological values, it is recommended that both broad scale habitat mapping and fine scale monitoring be undertaken on a long-term basis to assess trends in estuary ecological condition using the National Estuary Monitoring Protocol (Robertson et al. 2002), plus subsequent improvements (Robertson 2018). Outputs should be compared against relevant national standards (i.e. NZ ETI; Robertson et al. 2016a,b). In addition, sedimentation plates, which, over the long-term, will help provide an indicative measure of the rate of sedimentation in the estuary, should be deployed and monitored annually as per Hunt (2019).

Broad scale habitat mapping documents the key habitats within the estuary, and changes to these habitats over time. It is typically repeated at 5-yearly intervals. Fine scale monitoring measures the condition of the high susceptibility intertidal and subtidal habitat through physical, chemical and biological indicators. It is undertaken once annually for three consecutive years during the period Nov-March (usually at 2 intertidal and 3-4 subtidal sites), and thereafter at 5-yearly intervals. Both components have not yet been measured in this estuary.

Waiongana Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Moderate	Moderate
	Eutrophication	Minimal	Minimal

The Waiongana Estuary is a moderate length, shallow, often poorly-flushed tidal river estuary whose mouth is predominantly open. It has a moderate freshwater inflow and is located directly northeast of New Plymouth Airport. Intertidal sediments are sand and cobble dominated and include limited saltmarsh (*Schoenoplectus pungens* - Three-square, *Cyperus ustulatus* - Giant umbrella sedge) vegetation. The estuary mouth is mostly open to the sea but may become restricted during periods of lowflow, limiting tidal mixing, and consequently the estuary waters can become brackish. The estuary catchment is predominantly dairy farming but includes some mixed native forest and exotic forest (see summary information overleaf).

Human use, ecological and cultural values: The estuary is valued for its aesthetic and spiritual appeal, bathing and biodiversity. It is significant to Te Atiawa, with various foods and resources historically gathered from the river itself, its banks and the coastal reefs at the river mouth. Ecologically, habitat diversity is low-moderate with very little intertidal vegetation, saltmarsh (in this case a small pocket of rushland) intact, and the estuary contains significant habitat for native and migratory birds. There is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed primarily for grazing.

Eutrophication status: Despite its very high nutrient load (the current estimated catchment N areal loading of 16,955 mg TN m^{-2} d^{-1} exceeds the guideline for low susceptibility tidal river estuaries of ~2,000 mg TN m^{-2} d^{-1}, Robertson et al. 2016), the estuary has minimal susceptibility to eutrophication (NZ ETI Tool 1, Band A). This is primarily because of its highly flushed nature, given that it is predominantly strongly channelised with very few poorly flushed areas, and has adequate freshwater inflow.

The (one-off) synoptic survey in 2019, confirmed the absence of opportunistic macroalgal and phytoplankton blooms throughout the intertidal and subtidal estuary. The absence of primary eutrophication symptoms placed the estuary in very good (NZ ETI, Tool 2, Band A) condition with regard to eutrophication impacts.

We note that, while periodic (short-term) changes in eutrophic susceptibility are expected (particularly if the mouth becomes constricted), given the complete absence of eutrophic symptoms on the day of sampling when flushing was low (i.e. baseflow conditions), the low susceptibility rating is considered appropriate.

Sedimentation (muddiness) status: The estuary has moderate vulnerability to muddiness issues based on the facts that the current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL), the estuary is dominated by sands, but the mouth may be occasionally restricted. Ecologically, the overall moderate mud content fits the NZ ETI Band B (moderate muddiness) condition rating.

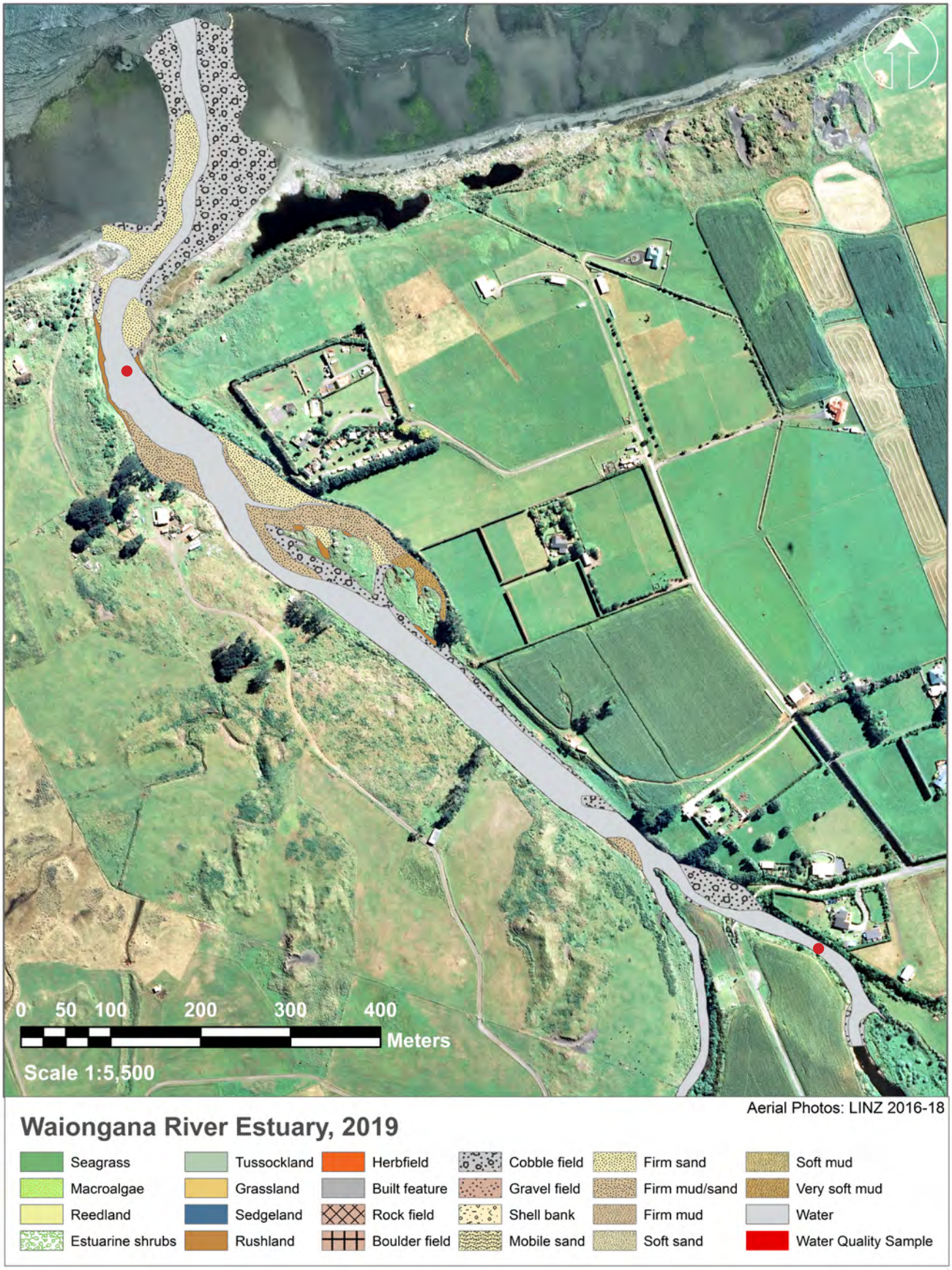


Figure 9. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Waiongana Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Waiongana Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 2, 9 ha
	Intertidal/Subtidal	53% intertidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	0.5-1 m, 2 km (salt wedge extent)
	Freshwater Inflow	Mean annual 4.8 m^3 s^{-1}*
	Saltmarsh, Seagrass	0.1 ha saltmarsh, no seagrass
	Soft Mud	0.1 ha (2% unvegetated intertidal area)
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Low-Mod**
Catchment	Catchment size	158.8 km^2
	Max Dairy Cows Permitted	20,930
	Suspended Sediment Loading	16 kt yr^{-1}
	Total Nitrogen Loading	557 t yr^{-1} (16,955 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	12.9 t yr^{-1}
	Dominant Landuse	5% native forest, 4% exotic forest, 88% dairy, 0% sheep/beef.
	Dominant Toprock Geology	Mudstone 96%, peat 1%.

*Mean flow based on combined flow from two recorder sites (Waiongana at SH3A and Mangaoraka at Corbett Rd.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 2 representative subtidal channel sites (see locations in Figure 9). Sampled values in Appendix B.

Monitoring and Investigations

The low rating for both eutrophication and sedimentation in this estuary signifies a requirement for low frequency, screening level monitoring only.

To address the low potential for eutrophication/sedimentation issues (including both benthic and water column effects), it is recommended that low frequency (once every 10 years), screening level (synoptic) monitoring be undertaken to confirm that this low risk estuary has not changed its risk rating.

Waiwhakaiho Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Moderate	Moderate
	Eutrophication	Minimal	Minimal

The Waiwhakaiho Estuary is a moderate length, shallow, tidal river estuary that extends from the sea to approximately 1 km inland. It has a high freshwater inflow and is located close to the New Plymouth suburb of Fitzroy. Intertidal sediments are cobble-dominated with some sands at the mouth, and include areas of saltmarsh (*Juncus kraussii* - Searush, *Cytisus scoparius* - Broom, *Baumea juncea* - Bare twig rush, *Typha orientalis* - Raupo) vegetation confined to several physically constricted zones of the estuary. The estuary mouth is mostly open to the sea, and is flanked to the south by man-made boulder wall. The estuary catchment is predominantly dairy farming and mixed native forest but includes some exotic forest (see summary information overleaf), and has been subject to recent significant flood activity.

Human use, ecological and cultural values: Culturally, the estuary provided various resources for the people of Te Atiawa. Ecologically, habitat diversity is low-moderate with some of its intertidal vegetation, saltmarsh (in this case small pockets of rushland) intact, although there is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed for grazing and urban use. The estuary is valued for its aesthetic and spiritual appeal, bathing, biodiversity.

Eutrophication status: Despite its high nutrient load (the current estimated catchment N areal loading of 10,408 mg TN m^{-2} d^{-1} exceeds the guideline for low susceptibility tidal river estuaries of ~2,000 mg TN m^{-2} d^{-1}, Robertson et al. 2016), the estuary has minimal susceptibility to eutrophication (NZ ETI Tool 1, Band A). This is primarily because of its highly flushed nature, given that it is predominantly strongly channelised with very few poorly flushed areas (exposed to elevated nutrients), dominated by cobble substrata rather than high susceptibility muds, and has high freshwater inflow and is often turbid.

The (one-off) synoptic survey in 2019, confirmed the absence of opportunistic macroalgal and phytoplankton blooms throughout the intertidal and subtidal estuary. The absence of primary eutrophication symptoms placed the estuary in very good (NZ ETI, Tool 2, Band A) condition with regard to eutrophication impacts.

We note that, while periodic (short-term) changes in eutrophic susceptibility are expected (particularly if the mouth becomes constricted), given the complete absence of eutrophic symptoms on the day of sampling when flushing was low (i.e. baseflow conditions), the low susceptibility rating is considered appropriate.

Sedimentation (muddiness) status: The estuary has moderate vulnerability to muddiness issues based on the facts that the current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL), the estuary is dominated by sands/cobbles, but muds in several small, physically constricted regions of the lower estuary, and the mouth may be occasionally restricted. Ecologically, the overall moderate mud content fits the NZ ETI Band B (moderate muddiness) condition rating.

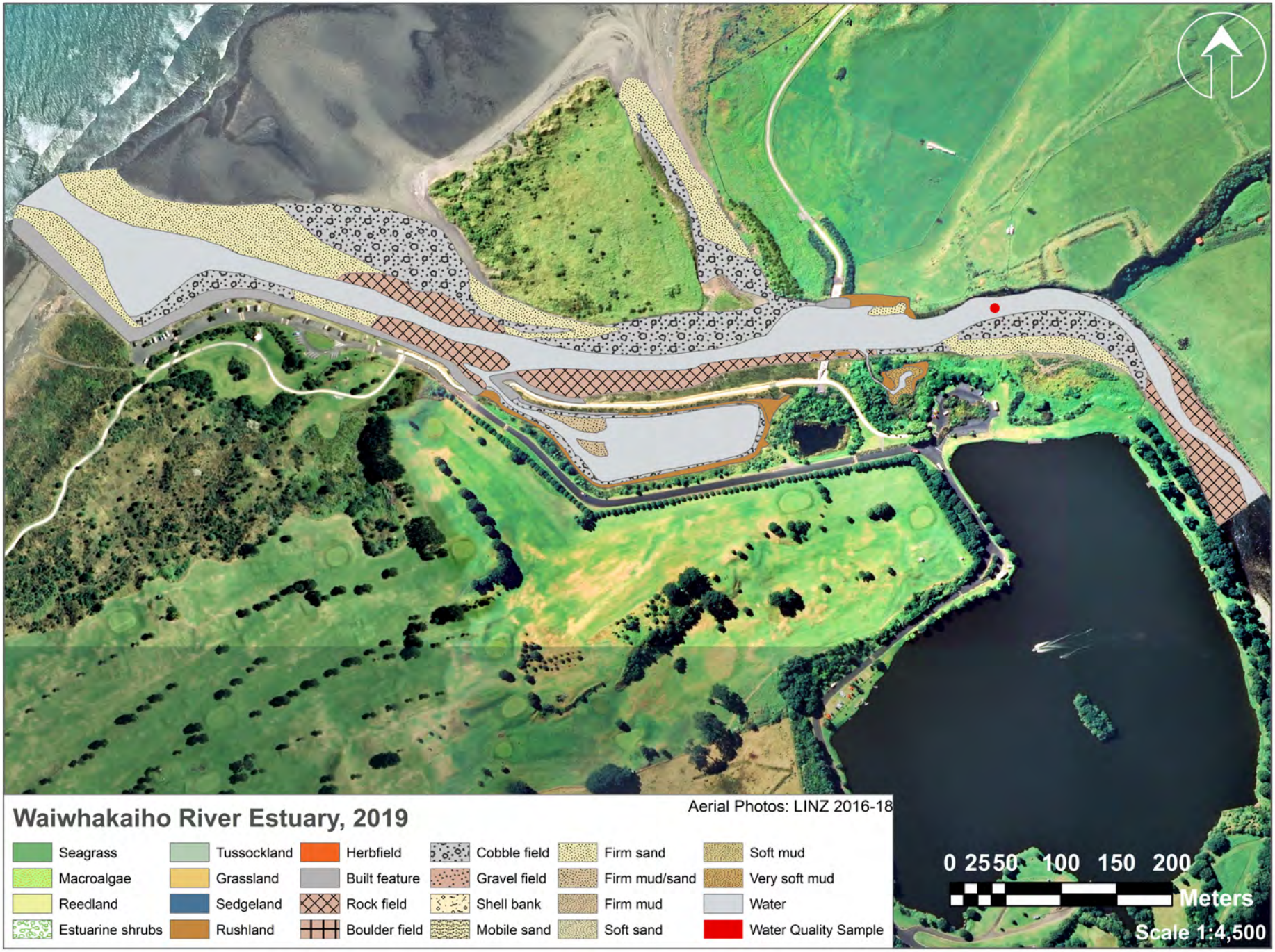


Figure 10. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sampling locations, Waiwhakaiho River Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2m) and bottom (0.5m from bottom) waters at each site.

Waiwhakaiho Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 4 (moderate length), 10.6 ha
	Intertidal/Subtidal	61% intertidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	0.5-1 m, 1.2 km (salt wedge extent)
	Freshwater Inflow	Mean annual 12.1 m^3 s^{-1}*
	Saltmarsh, Seagrass	0.3 ha saltmarsh, no seagrass
	Soft Mud	0.05 ha (1% unvegetated intertidal area)
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Very Low**
Catchment	Catchment size	145.3 km^2
	Max Dairy Cows Permitted	12,210
	Suspended Sediment Loading	26 kt yr^{-1}
	Total Nitrogen Loading	402.7 t yr^{-1} (10,408 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	21 t yr^{-1}
	Dominant Landuse	32% native forest, 4% exotic forest, 57% dairy, 0.1% sheep/beef.
	Dominant Toprock Geology	Alluvial 4%, mudstone 78%, Alluvial gravels 7%, Lahar deposits 3%, Tow 3%, Lavas & welded ignimbrites 3%.

*Mean flow measured at Rimu St. This does not include Mangorei HEP or other discharges (e.g. to lake) below this sampling station.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 1 representative subtidal channel site (see location in Figure 10). Sampled values in Appendix B.

Monitoring and Investigations

The low rating for both eutrophication and sedimentation in this estuary signifies a requirement for low frequency, screening level monitoring only.

To address the low potential for eutrophication/sedimentation issues (including both benthic and water column effects), it is recommended that low frequency (once every 10 years), screening level (synoptic) monitoring be undertaken to confirm that this low risk estuary has not changed its risk rating.

Te Henui Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Moderate	Moderate
	Eutrophication	Minimal	Minimal

The Te Henui Estuary is a short length, predominantly shallow, often poorly-flushed tidal river estuary. It has a low freshwater inflow and is located in East End Reserve, New Plymouth. Intertidal sediments in the lower estuary are characterised by coarse sand and cobble. The estuary mouth, flanked either side by man-made rockwall, is mostly open to the sea but may become restricted during periods of lowflow, limiting tidal mixing, and consequently the estuary waters can become brackish. The estuary catchment is predominantly dairy farming and includes mixed native forest, exotic forest and sheep and beef farming (see further summary information overleaf).

Human use, ecological and cultural values: The estuary is a focal part of the Te Henui Coastal Walkway and is valued for its aesthetic and spiritual appeal, bathing and biodiversity. This river mouth is a culturally significant site for Te Atiawa. Ecologically, habitat diversity is relatively low with no estuarine vegetation intact, largely due to its heavily modified (hardened for flood/storm surge protection) and naturally steep margins. There is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed for recreation/urban use.

Eutrophication status: Despite its very high nutrient load (the current estimated catchment N areal loading of 11,732 mg TN m^{-2} d^{-1} exceeds the guideline for low susceptibility tidal river estuaries of ~2,000 mg TN m^{-2} d^{-1}, Robertson et al. 2016), the estuary has minimal susceptibility to eutrophication (NZ ETI Tool 1, Band A). This is primarily because of its highly flushed nature, given that it is predominantly strongly channelised with very few poorly flushed areas, and has adequate freshwater inflow.

The (one-off) synoptic survey in 2019, confirmed the absence of opportunistic macroalgal and phytoplankton blooms throughout the intertidal and subtidal estuary. The absence of primary eutrophication symptoms placed the estuary in very good (NZ ETI, Tool 2, Band A) condition with regard to eutrophication impacts.

We note that, while periodic (short-term) changes in eutrophic susceptibility are expected (particularly if the mouth becomes constricted), given the complete absence of eutrophic symptoms on the day of sampling when flushing was low (i.e. baseflow conditions), the low susceptibility rating is considered appropriate.

Sedimentation (muddiness) status: The estuary has moderate vulnerability to muddiness issues based on the facts that the current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL), the estuary is dominated by intertidal sands, but with some subtidal muds, and the mouth may be occasionally restricted. Ecologically, the overall moderate mud content fits the NZ ETI Band B (moderate muddiness) condition rating.

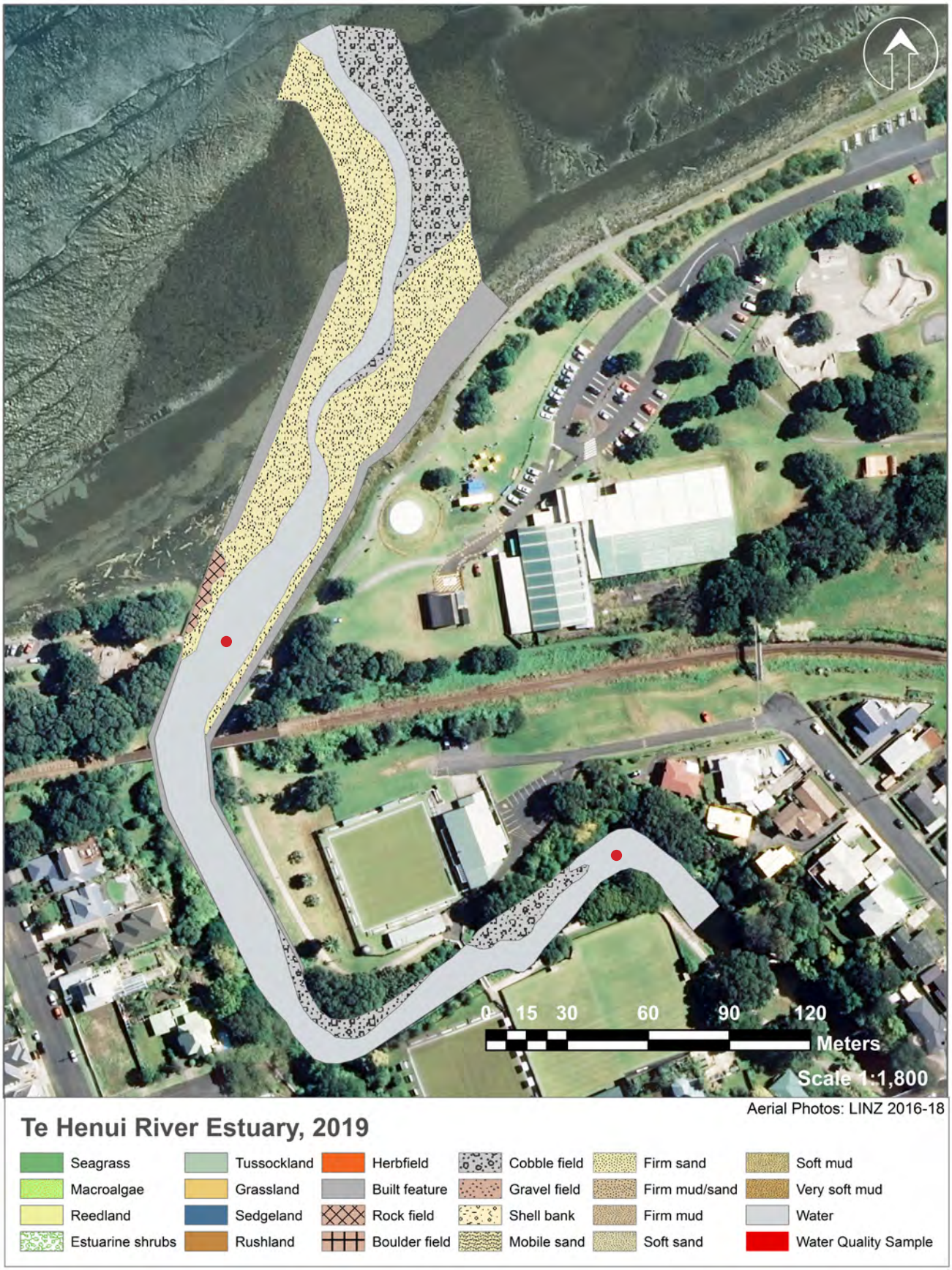


Figure 11. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Te Henui Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at lower site, but bottom (0.5 m from bottom) waters only in upper site.

Te Henui Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 2, 1.7 ha
	Intertidal/Subtidal	51% subtidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	0.5-1 m, 800 m (salt wedge extent)
	Freshwater Inflow	Mean annual 1.2 m^3 s^{-1}*
	Saltmarsh, Seagrass	No saltmarsh, no seagrass
	Soft Mud	No intertidal soft mud
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Low**
Catchment	Catchment size	28.4 km^2
	Max Dairy Cows Permitted	1,275
	Suspended Sediment Loading	3.7 kt yr^{-1}
	Total Nitrogen Loading	72.8 t yr^{-1} (11,732 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	2.2 t yr^{-1}
	Dominant Landuse	28% native forest, 1% exotic forest, 54% dairy, 0.1% sheep/beef.
	Dominant Toprock Geology	Ash (older than Taupo ash) 88%.

*Estimated mean flow at river mouth from NIWA's NZ River Maps software tool.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 2 representative subtidal channel sites (see locations in Figure 11). Sampled values in Appendix B.

Monitoring and Investigations

The low rating for both eutrophication and sedimentation in this estuary signifies a requirement for low frequency, screening level monitoring only.

To address the low potential for eutrophication/sedimentation issues (including both benthic and water column effects), it is recommended that low frequency (once every 10 years), screening level (synoptic) monitoring be undertaken to confirm that this low risk estuary has not changed its risk rating.

Tapuae Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Moderate	Moderate
	Eutrophication	Minimal	Minimal

The Tapuae Estuary, which marks the boundary of the Tapuae Marine Reserve, is a short length, shallow, often poorly-flushed tidal river estuary. It has a low freshwater inflow and is located between Oakura and New Plymouth. Intertidal habitat is sand dominated and there is a narrow band of high tide saltmarsh (*Baumea juncea* - Bare twig rush) vegetation. The estuary mouth is mostly open to the sea but may become restricted during periods of lowflow, limiting tidal mixing, and consequently the estuary waters can become brackish. The estuary catchment is predominantly dairy farming but includes some mixed native forest and exotic forest (see summary information overleaf).

Human use, ecological and cultural values: The estuary is valued for its aesthetic and spiritual appeal, bathing and biodiversity. This stream mouth is a culturally significant site for Taranaki Iwi. Ecologically, habitat diversity is low-moderate with very little estuarine vegetation (in this case a small pocket of rushland and grassland) intact. There is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed primarily for grazing. The adjacent Tapuae coastal marine area is of high importance as it contains a number of significant pā and kainga, including tauranga waka and pūkāwa (reefs).

Eutrophication status: Despite its very high nutrient load (the current estimated catchment N areal loading of 32,054 mg TN m^{-2} d^{-1} exceeds the guideline for low susceptibility tidal river estuaries of ~2,000 mg TN m^{-2} d^{-1}, Robertson et al. 2016), the estuary has minimal susceptibility to eutrophication (NZ ETI Tool 1, Band A). This is primarily because of its highly flushed nature, given that it is predominantly strongly channelised with very few poorly flushed areas, and has adequate freshwater inflow.

The (one-off) synoptic survey in 2019, confirmed the absence of opportunistic macroalgal and phytoplankton blooms throughout the intertidal and subtidal estuary. The absence of primary eutrophication symptoms placed the estuary in very good (NZ ETI, Tool 2, Band A) condition with regard to eutrophication impacts.

We note that, while periodic (short-term) changes in eutrophic susceptibility are expected (particularly if the mouth becomes constricted), given the complete absence of eutrophic symptoms on the day of sampling when flushing was low (i.e. baseflow conditions), the low susceptibility rating is considered appropriate.

Sedimentation (muddiness) status: The estuary has moderate vulnerability to muddiness issues based on the facts that the current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL), the estuary is dominated by intertidal sands (with limited subtidal muds), but the mouth may be occasionally restricted. Ecologically, the overall moderate mud extent fits the NZ ETI Band B (moderate muddiness) condition rating.

Figure 12. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Tapuae Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Tapuae Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 1, 1.0 ha
	Intertidal/Subtidal	56% subtidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	0.5-1 m, 500 m (salt wedge extent)
	Freshwater Inflow	Mean annual 1.2 $m^3 s^{-1}$*
	Saltmarsh, Seagrass	0.05 ha saltmarsh, no seagrass
	Soft Mud	No intertidal soft mud
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Low**
	[Dissolved oxygen] (subtidal channel)	Very Low**
Catchment	Catchment size	31.9 km^2
	Max Dairy Cows Permitted	4,095
	Suspended Sediment Loading	4.1 kt yr^{-1}
	Total Nitrogen Loading	117 t yr^{-1} (32,054 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	2 t yr^{-1}
	Dominant Landuse	6% native forest, 3% exotic forest, 91% dairy.
	Dominant Toprock Geology	Ash (older than Taupo ash) 100%.

*Estimated mean flow at river mouth, NIWA's NZ River Maps software tool.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 2 representative subtidal channel sites (see locations in Figure 12). Sampled values in Appendix B.

Monitoring and Investigations

The low rating for both eutrophication and sedimentation in this estuary signifies a requirement for low frequency, screening level monitoring only.

To address the low potential for eutrophication/sedimentation issues (including both benthic and water column effects), it is recommended that low frequency (once every 10 years), screening level (synoptic) monitoring be undertaken to confirm that this low risk estuary has not changed its risk rating.

Oakura Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Moderate	Moderate
	Eutrophication	Moderate	High

The Oakura Estuary is a relatively long, shallow, often poorly-flushed tidal river estuary (SSRTRE) that has a low freshwater inflow, extends approximately 1 km inland, and is located at the Oakura township. The middle estuary includes a 200 m long poorly flushed, deep (2-3 m) subtidal channel, and there is a 400 m long poorly flushed, shallow arm to the north that predominantly empties at low tide. Sediments are dominated by muddy sands in the mid-upper estuary and coarse sands in the lower. A small area of high tide saltmarsh (*Festuca arundinacea* - Tall fescue and *Plagianthus divaricatus* - Saltmarsh ribbonwood) vegetation occurs in the middle reaches. Beach duneland vegetation, primarily marram grass (*Ammophila arenaria*), dominates the terrestrial margins near the beach. The estuary mouth is mostly open to the sea, but at times it migrates along the beach and can be semi-restricted, which means the estuary is often brackish. A main feature of the estuary is that the majority of its area is located on the beach where tidal exposure is high. The estuary catchment is mixed native forest, dairy farming, and exotic forest (see summary information below).

Human use, ecological and cultural values: The estuary is valued for its aesthetic and spiritual appeal, bathing and biodiversity. This river mouth is a culturally significant site for Taranaki Iwi. Ecologically, habitat diversity is relatively low with very limited intertidal saltmarsh vegetation (in this case a narrow strip of glassland) intact, largely due to steep cliffs lining most of the mid-upper estuary margins. There is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed for recreation/urban use.

Eutrophication status: The estuary is moderately susceptible to eutrophication (both macroalgal- and phytoplankton-based) impacts based on the following:

- The estuary, although relatively small in size, has significant intertidal (48%) and subtidal (52%) habitat;
- It receives a high catchment-derived nutrient load (the current estimated catchment N areal loading of 7,692 mg TN m^{-2} d^{-1} exceeds the guideline for low susceptibility tidal river estuaries of ~2,000 mg TN m^{-2} d^{-1}, Robertson et al. 2016); and,
- It is often not well flushed, particularly its significant subtidal channel habitat, and has low freshwater inflow and is often turbid.

The (one-off) synoptic survey in 2019, confirmed the presence of nuisance phytoplankton blooms (highly elevated chlorophyll *a* coupled with super-saturated DO concentrations) throughout the entire subtidal channel, while macroalgae was absent from the intertidal reaches. The presence of primary eutrophication symptoms in the channel waters, despite the mouth being open on the day of sampling, placed the estuary in highly eutrophic (NZ ETI, Tool 2, Band C) condition. Notably, the persistence of such degraded conditions through time is likely regulated by (1) available intertidal area (i.e. influenced by mouth position), and (2) a combination of river inflow and tidal mixing, with mouth closure events reflecting a worst-case scenario in that regard. This latter point should be accounted for in any long-term estuary monitoring programme.

Sedimentation (muddiness) status: The estuary has moderate vulnerability to muddiness issues based on the facts that the current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL), the estuary is dominated by sands, but the mouth may be occasionally restricted. Ecologically, the overall moderate mud extent fits the NZ ETI Band B (moderate muddiness) condition rating.

Figure 13. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Oakura Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Oakura Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 2, 2.6 ha
	Intertidal/Subtidal	52% intertidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	1-2 m, 1 km (salt wedge extent)
	Freshwater Inflow	Mean annual 2.7 m^3 s^{-1}*
	Saltmarsh, Seagrass	0.02 ha saltmarsh, no seagrass
	Soft Mud	No intertidal soft mud
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	High**
	[Dissolved oxygen] (subtidal channel)	Very Low**
Catchment	Catchment size	44.1 km^2
	Max Dairy Cows Permitted	1,495
	Suspended Sediment Loading	8.7 kt yr^{-1}
	Total Nitrogen Loading	73 t yr^{-1} (7,692 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	4.7 t yr^{-1}
	Dominant Landuse	60% native forest, 4% exotic forest, 34% dairy.
	Dominant Toprock Geology	Ash (older than Taupo ash) 96%, lavas & welded ignimbrites 3%.

*Estimated mean flow at river mouth, NIWA's NZ River Maps software tool.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 2 representative subtidal channel sites (see locations in Figure 13). Sampled values in Appendix B.

Monitoring and Investigations

For the Oakura Estuary it is recommended that annual monitoring of targeted eutrophication indicators (intertidal and subtidal channel) be undertaken to provide data on long-term trophic state trends.

To address potential for eutrophication, it is recommended that relevant water column and sediment-based indicators be monitored monthly during the period Nov-March each year at 1-2 sites representative of general conditions (e.g. mid-upper estuary) and at the same time, intertidal/shallow subtidal macroalgal cover be assessed throughout the intertidal/shallow subtidal estuary. If, after 1-2 years, eutrophication is not found to be a persistent issue, this monitoring may cease.

Because this estuary is generally flushed regularly by high flow events, it is recommended that long-term monitoring for sedimentation be limited to low frequency (5-yearly), broad scale, screening level assessments only.

Timaru Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Moderate	Moderate
	Eutrophication	Minimal	Minimal

The Timaru Estuary is a short length, predominatly shallow, often poorly-flushed tidal river estuary. It has a low freshwater inflow and is located to the southeast of Oakura township. Intertidal sediments are coarse sand and there are several relatively small pockets of high tide saltmarsh (*Phormium tenax* - NZ flax, *Baumea juncea* - Bare twig rush) vegetation in the mid-upper reaches. The estuary mouth is mostly open to the sea but may become restricted during periods of lowflow, limiting tidal mixing, and consequently the estuary waters can become brackish. The surrounding catchment comprises an almost equal proportion of dairy farming and mixed native forest (see further summary information overleaf).

Human use, ecological and cultural values: The estuary is valued for its aesthetic and spiritual appeal, bathing and biodiversity. It is a culturally significant site for Taranaki Iwi. Ecologically, habitat diversity is low-moderate with very little estuarine vegetation (in this case small pockets of rushland) intact. There is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed for grazing.

Eutrophication status: Despite its very high nutrient load (the current estimated catchment N areal loading of 8,421 mg TN m^{-2} d^{-1} exceeds the guideline for low susceptibility tidal river estuaries of ~2,000 mg TN m^{-2} d^{-1}, Robertson et al. 2016), the estuary has minimal susceptibility to eutrophication (NZ ETI Tool 1, Band A). This is primarily because of its highly flushed nature, given that it is predominantly strongly channelised with very few poorly flushed areas, and has adequate freshwater inflow.

The (one-off) synoptic survey in 2019, confirmed the absence of opportunistic macroalgal and phytoplankton blooms throughout the intertidal and subtidal estuary. The absence of primary eutrophication symptoms placed the estuary in very good (NZ ETI, Tool 2, Band A) condition with regard to eutrophication impacts.

We note that, while periodic (short-term) changes in eutrophic susceptibility are expected (particularly if the mouth becomes constricted), given the complete absence of eutrophic symptoms on the day of sampling when flushing was low (i.e. baseflow conditions), the low susceptibility rating is considered appropriate.

Sedimentation (muddiness) status: The estuary has moderate vulnerability to muddiness issues based on the facts that the current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL), the estuary is dominated by intertidal sands and subtidal muds, but the mouth may be occasionally restricted. Ecologically, the overall moderate mud content fits the NZ ETI Band B (moderate muddiness) condition rating.

Figure 14. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Timaru Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2m) and bottom (0.5m from bottom) waters at each site.

Timaru Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 1, 1.9 ha
	Intertidal/Subtidal	64% subtidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	0.5-1 m, 800 m (salt wedge extent)
	Freshwater Inflow	Mean annual 1.8 m^3 s^{-1}*
	Saltmarsh, Seagrass	0.1 ha saltmarsh, no seagrass
	Soft Mud	No intertidal soft mud
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Low**
	[Dissolved oxygen] (subtidal channel)	Very Low**
Catchment	Catchment size	31.4 km^2
	Max Dairy Cows Permitted	1,690
	Suspended Sediment Loading	5.2 kt yr^{-1}
	Total Nitrogen Loading	58.4 t yr^{-1} (8,421 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	2.5 t yr^{-1}
	Dominant Landuse	56% native forest, 43% dairy.
	Dominant Toprock Geology	Ash (older than Taupo ash) 98%.

*Mean flow as measured at Tataraimaka (SH45).
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 3 (*n*=5, as only bottom waters sampled at lower site) representative subtidal channel sites (see locations in Figure 14). Sampled values in Appendix B.

Monitoring and Investigations

The low rating for both eutrophication and sedimentation in this estuary signifies a requirement for low frequency, screening level monitoring only.

To address the low potential for eutrophication/sedimentation issues (including both benthic and water column effects), it is recommended that low frequency (once every 10 years), screening level (synoptic) monitoring be undertaken to confirm that this low risk estuary has not changed its risk rating.

Katikara Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Moderate	Moderate
	Eutrophication	Moderate	High

The Katikara Estuary is a short, shallow, often poorly-flushed tidal river estuary (SSRTRE) that has a low freshwater inflow, extends approximately 700 m inland, and is located 6 km southeast of Oakura township. The mid-upper estuary includes a 300 m long poorly flushed, deep (1-2 m) subtidal channel, and there is a 200 m long well flushed, shallow arm to the north that predominantly empties at low tide. Sediments are dominated by muds in the subtidal mid-upper estuary and coarse sands in the lower intertidal reaches. A narrow band of high tide saltmarsh (*Isolepis nodosa* - Knobby clubrush, *Phormium tenax* - NZ Flax) vegetation occurs in the mid-upper reaches. The estuary mouth is mostly open to the sea, but at times it migrates along the beach and can be semi-restricted, which means the estuary is often brackish. The estuary catchment is predominantly dairy farming and includes mixed native forest, exotic forest and sheep and beef farming (see summary information overleaf).

Human use, ecological and cultural values: The estuary is located within the rohe of Taranaki Iwi, and is valued for its aesthetic and spiritual appeal, bathing and biodiversity. Ecologically, habitat diversity is relatively low-moderate with limited estuary vegetation (in this case a narrow strip of rushland/grassland) intact. There is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed for grazing.

Eutrophication status: The estuary has moderate susceptibility (NZ ETI Tool 1, Band B) to eutrophication impacts (primarily phytoplankton-based expression), based on the following:

- The estuary, although relatively small in size, has significant intertidal (56%) and subtidal (44%) habitat;
- It receives a high catchment-derived nutrient load (the current estimated catchment N areal loading of 10,736 mg TN m^{-2} d^{-1} exceeds the guideline for low susceptibility tidal river estuaries of ~2,000 mg TN m^{-2} d^{-1}, Robertson et al. 2016); and,
- It is often not well flushed, particularly its significant subtidal channel habitat, and has low freshwater inflow and is often turbid.

The (one-off) synoptic survey in 2019, confirmed the presence of nuisance phytoplankton blooms (highly elevated chl *a* coupled with super-saturated DO concentrations) throughout the entire subtidal channel, although macroalgae were absent from the intertidal reaches. The presence of primary eutrophication symptoms in the channel waters, despite the mouth being open on the day of sampling, placed the estuary in highly eutrophic (NZ ETI, Tool 2, Band C) condition. Notably, the persistence of such degraded conditions through time is likely regulated by a combination of river inflow and tidal mixing, with mouth closure events reflecting a worst-case scenario in that regard. This latter point should be accounted for in any long-term estuary monitoring programme.

Sedimentation (muddiness) status: The estuary has very minimal vulnerability to muddiness issues based on the facts that the current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL), the intertidal estuary is dominated by sands, but with some subtidal muds, and the mouth may be occasionally restricted. Ecologically, the overall moderate mud content fits the NZ ETI Band B (moderate muddiness) condition rating.

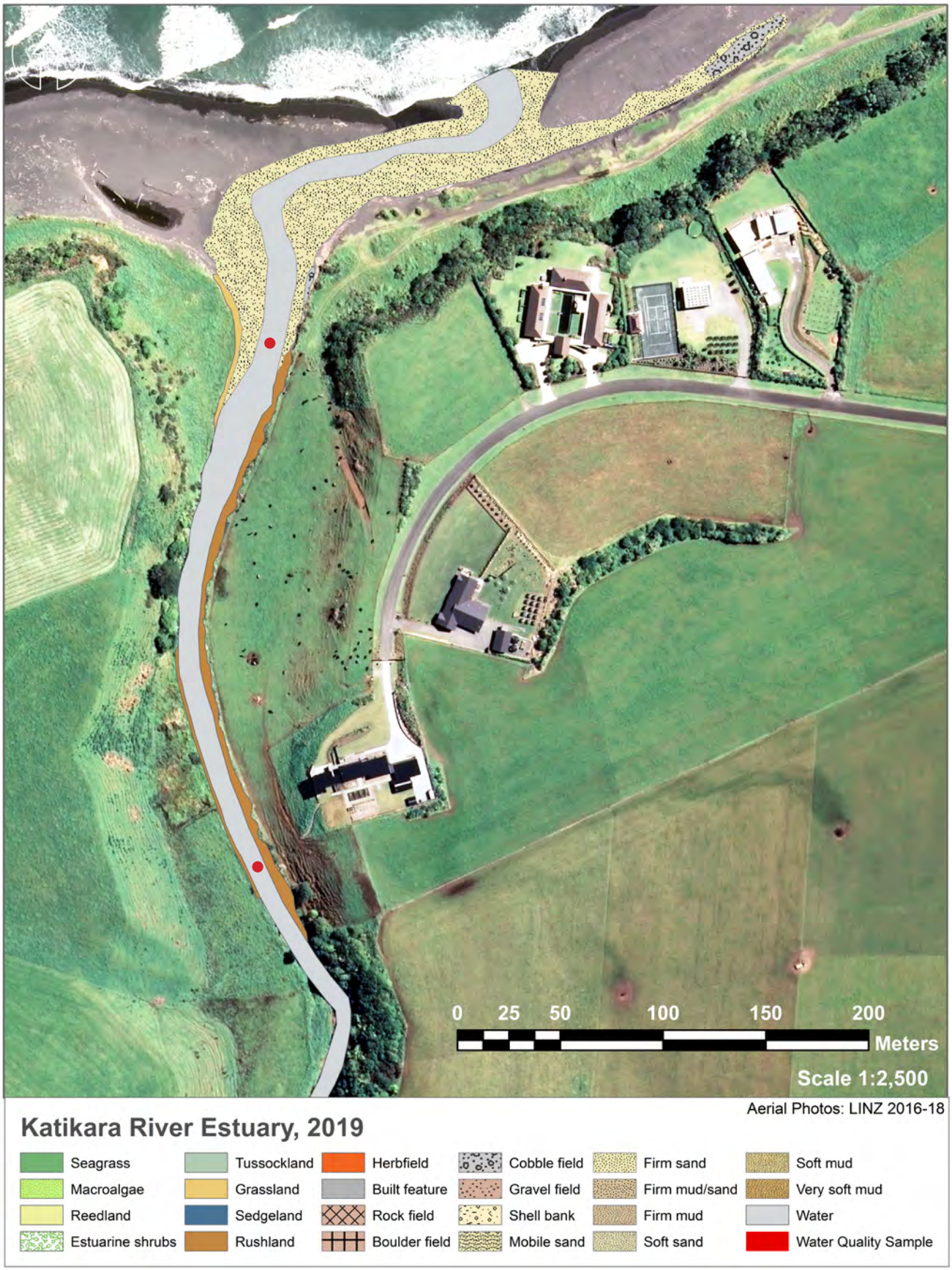


Figure 15. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Katikara Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Katikara Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 1, 1.6 ha
	Intertidal/Subtidal	56% intertidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	0.5-1 m, 700 m (salt wedge extent)
	Freshwater Inflow	Mean annual 1.0 m^3 s^{-1}*
	Saltmarsh, Seagrass	0.15 ha saltmarsh, no seagrass
	Soft Mud	No intertidal soft mud
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	High**
	[Dissolved oxygen] (subtidal channel)	Very Low**
Catchment	Catchment size	22 km^2
	Max Dairy Cows Permitted	2,250
	Suspended Sediment Loading	2.5 kt yr^{-1}
	Total Nitrogen Loading	62.7 t yr^{-1} (10,736 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	1.5 t yr^{-1}
	Dominant Landuse	26% native forest, 2% exotic forest, 71% dairy, 0.5% sheep/beef.
	Dominant Toprock Geology	Ash (older than Taupo ash) 99%.

*Estimated mean flow at river mouth from NIWA's NZ River Maps software tool.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 2 representative subtidal channel sites (see locations in Figure 15). Sampled values in Appendix B.

Monitoring and Investigations

For the Katikara Estuary it is recommended that annual monitoring of targeted eutrophication indicators (intertidal and subtidal channel) be undertaken to provide data on long-term trophic state trends.

To address potential for eutrophication, it is recommended that relevant water column and sediment-based indicators be monitored monthly during the period Nov-March each year at 1-2 sites representative of general conditions (e.g. mid-upper estuary) and at the same time, intertidal/shallow subtidal macroalgal cover be assessed throughout the intertidal/shallow subtidal estuary. If, after 1-2 years, eutrophication is not found to be a persistent issue, this monitoring may cease.

Because this estuary is generally flushed regularly by high flow events, it is recommended that long-term monitoring for sedimentation be limited to low frequency (5-yearly), broad scale, screening level assessments only.

Kaupokonui Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Moderate	Moderate
	Eutrophication	Minimal	Minimal

The Kaupokonui Estuary is a small, short length, shallow, tidal river estuary that extends from the sea to approximately 700 m inland. It has a high freshwater inflow and is located 5 km west of Hawera. Intertidal sediments are mostly cobbles with some coarse sands near the mouth, which is predominantly open to the sea. There is duneland on the northern margin but no estuarine vegetation, primarily due to lack of space with steep banks and rockwall lining the margins. The estuary mouth is mostly open to the sea but may become restricted during periods of lowflow, limiting tidal mixing, and consequently the estuary waters can become brackish. The estuary catchment is predominantly dairy farming but includes some mixed native forest, exotic forest, sheep and beef farming (see summary information overleaf).

Human use, ecological and cultural values: Although small in size and inland extent, the estuary and landscape is highly valued by locals and tourists for camping, swimming, fishing and surfing. Kaupokonui is commonly cited as the 'jewel of South Taranaki' in terms of amenity values. Ecologically, habitat diversity is low with no estuarine vegetation, steep cliffs either side, and much of the immediate natural vegetated margin has been lost and is now developed for grazing. The estuary and associated coast has significant scientific values including the remains of several species of moa and other extinct birds, includes threatened, at risk and regionally distinctive flora species, and inanga spawning sites. This estuary is particularly significant to Ngā Ruahine Iwi, and was abundant with tunaheke, piharau, kahawai, īnanga, pakotea and kōkopu.

Eutrophication status: Despite its very high nutrient load (the current estimated catchment N areal loading of 42,033 mg TN m^{-2} d^{-1} exceeds the guideline for low susceptibility tidal river estuaries of ~2,000 mg TN m^{-2} d^{-1}, Robertson et al. 2016), the estuary has minimal susceptibility to eutrophication (NZ ETI Tool 1, Band A). This is primarily because of its highly flushed nature, given that it is predominantly strongly channelised with no poorly flushed areas, and has high freshwater inflow.

The (one-off) synoptic survey in 2019, confirmed the absence of opportunistic macroalgal and phytoplankton blooms throughout the intertidal and subtidal estuary, and an NZ ETI (Tool 2) condition rating of 'minimal' (Band A) for eutrophication.

We also note that, while toxic algal blooms (e.g. benthic cyanobacteria) have been reported in the estuary in the past, often leading to public closure (e.g. November, 2018), such conditions are likely driven by short periods of mouth closure coincident with prolonged low river inflows and therefore highly ephemeral. The present survey was undertaken during baseflows and no such algal blooms were observed, so the overall low susceptibility rating is considered appropriate.

Sedimentation (muddiness) status: The estuary has moderate vulnerability to muddiness issues based on the facts that the current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL), the estuary is dominated by cobble/sand, but the mouth may be occasionally restricted. Ecologically, the overall moderate mud extent fits the NZ ETI Band B (moderate muddiness) condition rating.

Figure 16. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Kaupokonui Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Kaupokonui Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 4 (short length), 3.8 ha
	Intertidal/Subtidal	60% intertidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	0.5-1 m, 700 m (salt wedge extent)
	Freshwater Inflow	Mean annual 7.14 m^3 s^{-1}*
	Saltmarsh, Seagrass	No saltmarsh, no seagrass
	Soft Mud	No intertidal soft mud
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Very Low**
Catchment	Catchment size	146.9 km^2
	Max Dairy Cows Permitted	27,025
	Suspended Sediment Loading	15.2 kt yr^{-1}
	Total Nitrogen Loading	583 t yr^{-1} (42,033 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	14.1 t yr^{-1}
	Dominant Landuse	20% native forest, 2% exotic forest, 76% dairy, 0.4% sheep/beef.
	Dominant Toprock Geology	Ash (older than Taupo ash) 75%, lavas & welded ignimbrites 5%, Taupo & Kaharaoa breccias (older than Taupo breccia) 6%, lahar deposits 3%.

*Estimated mean flow at river mouth from NIWA's NZ River Maps software tool.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 2 (*n*=3, as only bottom waters sampled at lower site) representative subtidal channel sites (see locations in Figure 16). Sampled values in Appendix B.

Monitoring and Investigations

The low rating for both eutrophication and sedimentation in this estuary signifies a requirement for low frequency, screening level monitoring only.

To address the low potential for eutrophication/sedimentation issues (including both benthic and water column effects), it is recommended that low frequency (once every 10 years), screening level (synoptic) monitoring be undertaken to confirm that this low risk estuary has not changed its risk rating.

Waingongoro Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Moderate	Minimal
	Eutrophication	Minimal	Minimal

The Waingongoro Estuary is a small, short length, shallow, tidal river estuary that extends from the sea to approximately 500 m inland. It is slightly perched at the high water zone, has a high freshwater inflow and is located 5 km west of Hawera. Intertidal sediments are mostly cobbles with some coarse sands near the mouth, which is predominantly open to the sea. There is no estuarine vegetation, primarily due to lack of space with steep cliffs at the margins. The estuary mouth is mostly open to the sea but may become restricted during periods of lowflow, limiting tidal mixing, and consequently the estuary waters can become brackish. The estuary catchment is predominantly dairy farming but includes some mixed native forest, exotic forest, sheep and beef farming (see summary information overleaf).

Human use, ecological and cultural values: Although small in size and inland extent, the estuary is valued for its aesthetic and spiritual appeal, bathing and biodiversity. It is also significant to Ngāruahine, and was abundant with tunaheke, piharau, īnanga, pakotea and kōkopu. Ecologically, habitat diversity is low with no estuarine vegetation, steep cliffs either side, and much of the immediate natural vegetated margin has been lost and is now developed for grazing.

Eutrophication status: Despite its very high nutrient load (the current estimated catchment N areal loading of 147,808 mg TN m^{-2} d^{-1} exceeds the guideline for low susceptibility tidal river estuaries of ~2,000 mg TN m^{-2} d^{-1}, Robertson et al. 2016), the estuary has minimal susceptibility to eutrophication (NZ ETI Tool 1, Band A). This is primarily because of its highly flushed nature, given that it is predominantly strongly channelised with no poorly flushed areas, and has high freshwater inflow.

The (one-off) synoptic survey in 2019, confirmed the absence of opportunistic macroalgal and phytoplankton blooms throughout the intertidal and subtidal estuary, and an NZ ETI (Tool 2) condition rating of ‘minimal’ (Band A) for eutrophication.

We note that, while periodic (short-term) changes in eutrophic susceptibility are expected (particularly if the mouth becomes constricted), given the complete absence of eutrophic symptoms on the day of sampling when flushing was low (i.e. baseflow conditions), the low susceptibility rating is considered appropriate.

Sedimentation (muddiness) status: The estuary has moderate vulnerability to muddiness issues based on the facts that the current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL), the estuary is dominated by cobble/sand, but the mouth may be occasionally restricted. Ecologically, the overall very low mud extent fits the NZ ETI Band A (minimal muddiness) condition rating.

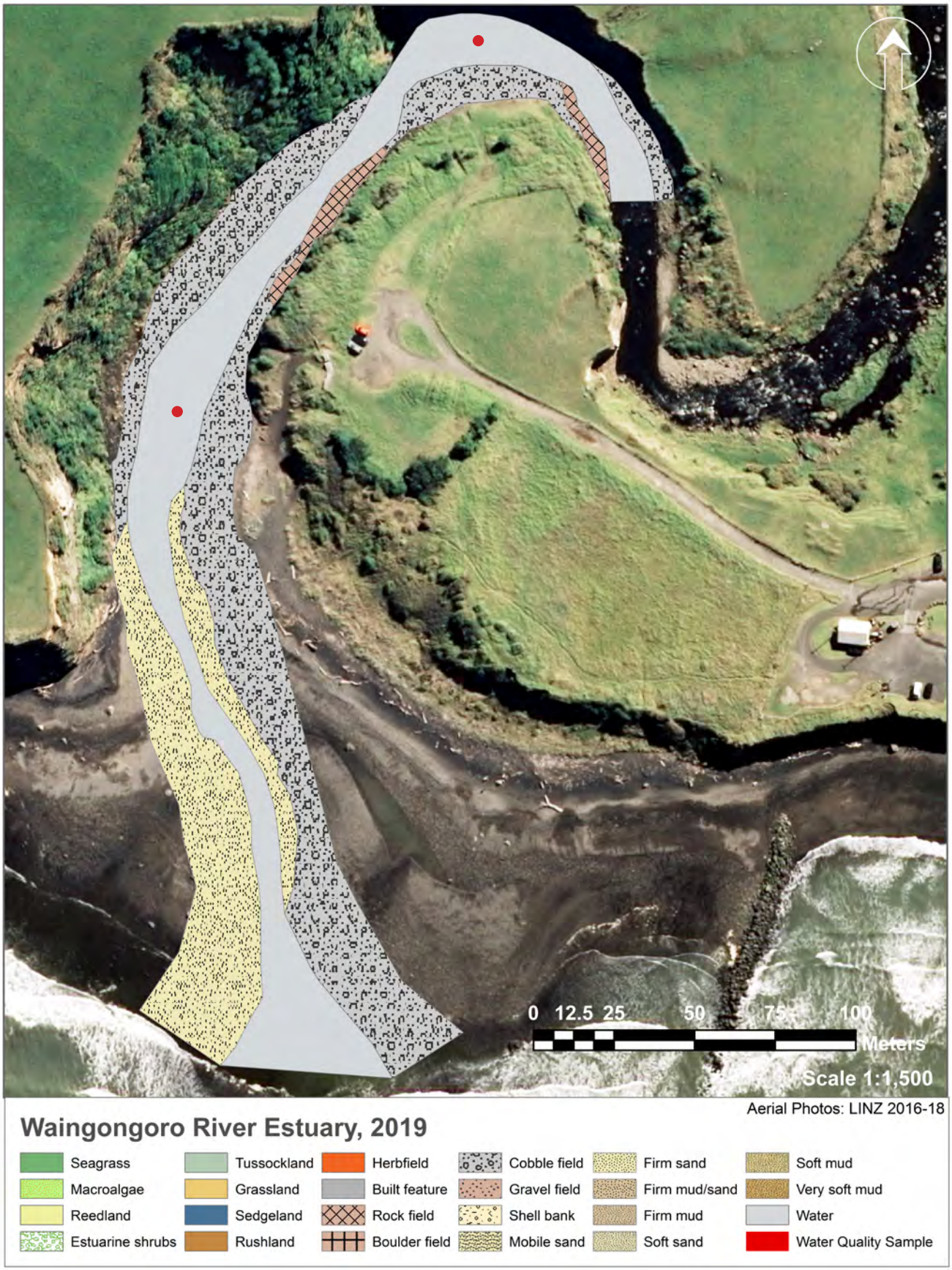


Figure 17. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Waingongoro Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Waingongoro Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 2 (short length), 1.6 ha
	Intertidal/Subtidal	65% intertidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	0.5-1 m, 500 m (salt wedge extent)
	Freshwater Inflow	Mean annual 7.2 m^3 s^{-1}*
	Saltmarsh, Seagrass	No saltmarsh, no seagrass
	Soft Mud	No intertidal soft mud
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Very Low**
Catchment	Catchment size	219.1 km^2
	Max Dairy Cows Permitted	49,259
	Suspended Sediment Loading	16.2 kt yr^{-1}
	Total Nitrogen Loading	863.2 t yr^{-1} (147,808 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	27.4 t yr^{-1}
	Dominant Landuse	7% native forest, 1% exotic forest, 91% dairy, 0.1% sheep/beef.
	Dominant Toprock Geology	Ash (older than Taupo ash) 90%, lavas & welded ignimbrites 1%, peat 5%.

*Mean flow measured at SH45.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 2 representative subtidal channel sites (see locations in Figure 17). Sampled values in Appendix B.

Monitoring and Investigations

The low rating for both eutrophication and sedimentation in this estuary signifies a requirement for low frequency, screening level monitoring only.

To address the low potential for eutrophication/sedimentation issues (including both benthic and water column effects), it is recommended that low frequency (once every 10 years), screening level (synoptic) monitoring be undertaken to confirm that this low risk estuary has not changed its risk rating.

Tangahoe Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Moderate	Moderate
	Eutrophication	Minimal	Minimal

The Tangahoe Estuary is a short length, shallow, tidal river estuary that extends from the sea to approximately 1 km inland. It is perched at the high water zone, has a moderate freshwater inflow and is located in the South Taranaki Bight (5 km southeast of Hawera). Intertidal sediments are sand-dominated and include a small area of saltmarsh (*Sarcocornia quinqueflora* - Glasswort, *Juncus kraussii* - Searush, *Juncus articulatus* - Jointed rush) vegetation. The estuary mouth is mostly open to the sea but may become restricted during periods of lowflow, limiting tidal mixing, and consequently the estuary waters can become brackish. The estuary catchment is predominantly dairy farming but includes some mixed native forest, exotic forest (including consented forestry), sheep and beef farming (see summary information overleaf).

Human use, ecological and cultural values: The estuary is valued for its aesthetic and spiritual appeal, bathing and biodiversity. It is significant to Ngāti Ruanui, with piharau, kokopu, tunaheke, patiki, and shelfish previously abundant within the estuary and on the coastal reefs at the river mouth. Ecologically, habitat diversity is low-moderate with some of its intertidal vegetation, saltmarsh (in this case small pockets of rushland and herbfield) intact, although there is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed for grazing.

Eutrophication status: Despite its very high nutrient load (the current estimated catchment N areal loading of 16,757 mg TN m^{-2} d^{-1} exceeds the guideline for low susceptibility tidal river estuaries of ~2,000 mg TN m^{-2} d^{-1}, Robertson et al. 2016), the estuary has minimal susceptibility to eutrophication (NZ ETI Tool 1, Band A). This is primarily because of its highly flushed nature, given that it is predominantly strongly channelised with very few poorly flushed areas, and has adequate freshwater inflow.

The (one-off) synoptic survey in 2019, confirmed the absence of opportunistic macroalgal and phytoplankton blooms throughout the intertidal and subtidal estuary, and an NZ ETI (Tool 2) condition rating of ‘minimal’ (Band A) for eutrophication.

We note that, while periodic (short-term) changes in eutrophic susceptibility are expected (particularly if the mouth becomes constricted), given the complete absence of eutrophic symptoms on the day of sampling when flushing was low (i.e. baseflow conditions), the low susceptibility rating is considered appropriate.

Sedimentation (muddiness) status: The estuary has moderate vulnerability to muddiness issues based on the facts that the current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL), the estuary is dominated by sands, but with some subtidal muds, and the mouth may be occasionally restricted. Ecologically, the overall moderate mud extent fits the NZ ETI Band A (moderate muddiness) condition rating.

Figure 18. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Tangahoe Estuary, March 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Tangahoe Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 3 (short length), 1.8 ha
	Intertidal/Subtidal	57% intertidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	0.5-1 m, 900 m (salt wedge extent)
	Freshwater Inflow	Mean annual 6.7 m^3 s^{-1}*
	Saltmarsh, Seagrass	0.1 ha saltmarsh, no seagrass
	Soft Mud	No intertidal soft mud
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Low-Mod**
Catchment	Catchment size	297.6 km^2
	Max Dairy Cows Permitted	24,440
	Suspended Sediment Loading	52.5 kt yr^{-1}
	Total Nitrogen Loading	110.1 t yr^{-1} (16,757 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	15.5 t yr^{-1}
	Dominant Landuse	10% native forest, 13% exotic forest, 57% dairy, 18% sheep/beef.
	Dominant Toprock Geology	Alluvial 2%, mudstone 3%, massive mudstone 55%, peat 2%, massive sandstone 33%.

*Estimated mean flow at river mouth from NIWA's NZ River Maps software tool.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 2 (*n*=3, as only bottom waters sampled at lower site) representative subtidal channel sites (see locations in Figure 18). Sampled values in Appendix B.

Monitoring and Investigations

The low rating for both eutrophication and sedimentation in this estuary signifies a requirement for low frequency, screening level monitoring only.

To address the low potential for eutrophication/sedimentation issues (including both benthic and water column effects), it is recommended that low frequency (once every 10 years), screening level (synoptic) monitoring be undertaken to confirm that this low risk estuary has not changed its risk rating.

Manawapou Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Moderate	Moderate
	Eutrophication	Minimal	Minimal

The Manawapou Estuary is a moderate length, shallow tidal river estuary, has low freshwater inflow, and is located in the South Taranaki Bight between Hawera and Patea. Intertidal sediments are dominated by sands and include several small pockets of saltmarsh (*Juncus krausii* - Searush, and *Apodasmia similis* - Jointed wirerush) and herbfield (*Sarcocornia quinqueflora* - Glasswort) vegetation which is limited to the upper reaches. The estuary mouth is mostly open to the sea but may become restricted during periods of lowflow, limiting tidal mixing, and consequently the estuary waters can become brackish. The estuary catchment is mixed native forest, exotic forest (including consented forestry), dairy and sheep and beef farming (see summary information overleaf).

Human use, ecological and cultural values: The estuary, located within the rohe of Ngāti Ruanui, is valued for its spiritual/aesthetic appeal, bathing and biodiversity. Ecologically, habitat diversity is low-moderate with some of its intertidal vegetation, saltmarsh (in this case small pockets of rushland and herbfield) intact. However, there is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed primarily for grazing.

Eutrophication status: Despite its very high nutrient load (the current estimated catchment N areal loading of 16,758 mg TN m^{-2} d^{-1} exceeds the guideline for low susceptibility tidal river estuaries of ~2,000 mg TN m^{-2} d^{-1}, Robertson et al. 2016), the estuary has minimal susceptibility to eutrophication (NZ ETI Tool 1, Band A). This is primarily because of its highly flushed nature, given that it is predominantly strongly channelised with very few poorly flushed areas, and has adequate freshwater inflow.

The (one-off) synoptic survey in 2019, confirmed the absence of opportunistic macroalgal and phytoplankton blooms throughout the intertidal and subtidal estuary, and an NZ ETI (Tool 2) condition rating of 'minimal' (Band A) for eutrophication impacts.

Sedimentation (muddiness) status: The estuary has moderate vulnerability to muddiness issues based on the facts that the current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL), the estuary is dominated by sands, but the mouth may be occasionally restricted. Ecologically, the overall moderate mud extent fits the NZ ETI Band B (moderate muddiness) condition rating.

Figure 19. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Manawapou Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2m) and bottom (0.5m from bottom) waters at each site.

Manawapou Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 2, 1.8 ha
	Intertidal/Subtidal	57% intertidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	0.5-1 m, 1 km (salt wedge extent)
	Freshwater Inflow	Mean annual 2.9 m^3 s^{-1}*
	Saltmarsh, Seagrass	0.1 ha saltmarsh, no seagrass
	Soft Mud	No intertidal soft mud
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Low-Mod**
Catchment	Catchment size	122.3 km^2
	Max Dairy Cows Permitted	9,000
	Suspended Sediment Loading	52.5 kt yr^{-1}
	Total Nitrogen Loading	110.1 t yr^{-1} (16,758 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	15.5 t yr^{-1}
	Dominant Landuse	32% native forest, 7% exotic forest, 43% dairy, 17.8% sheep/beef.
	Dominant Toprock Geology	Alluvial 2%, mudstone 54%, massive sandstone 37%, unconsolidated gravels/sands 6%.

*Estimated mean flow at river mouth from NIWA's NZ River Maps software tool.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 2 (*n*=3, as only bottom waters sampled at lower site) representative subtidal channel sites (see locations in Figure 19). Sampled values in Appendix B.

Monitoring and Investigations

The low rating for both eutrophication and sedimentation in this estuary signifies a requirement for low frequency, screening level monitoring only.

To address the low potential for eutrophication/sedimentation issues (including both benthic and water column effects), it is recommended that low frequency (once every 10 years), screening level (synoptic) monitoring be undertaken to confirm that this low risk estuary has not changed its risk rating.

Patea Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Mod-High	Very High
	Eutrophication	Very High	Moderate

The Patea Estuary is a highly modified, long length, shallow, well-flushed tidal river estuary located in the South Taranaki Bight near the town of Patea. It has a high freshwater inflow (regulated somewhat by upriver hydro-schemes), an always open mouth, and is dominated by a relatively wide (~30 m) subtidal channel (63% of estuary).

Intertidal habitat is characterised by soft muds (3.4 ha, 23% unvegetated intertidal area) and sands and include some saltmarsh dominated by rushland (*Juncus kraussii* - Searush, *Apodasmia similis* - Jointed wirerush, *Isolepis cernua* - Slender clubrush) and to a lesser extent herbfield (*Sarcocornia quinqueflora* - Glasswort) vegetation.

The estuary catchment is dominated by native forest, dairy and sheep/beef farming and, to a much lesser extent, exotic forest (including consented forestry) - see summary information overleaf.

Human use, ecological and cultural values: The estuary has good access and is valued for its spiritual value, aesthetic appeal, bathing and biodiversity. It is significant to the people of both Ngāti Ruanui and Ngaa Rauru Kiitahi. Food sources, gathered from the entire length of this river, included kaakahi, kuku, tuna, kanae, piharau, whitebait, smelt, flounder, place, sole, kahawai, taamure, shark and stingray. Ecologically, habitat diversity is moderate-high with some of its intertidal vegetation, saltmarsh (in this case rushland and herbfield) intact. However, there is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed for grazing and urban use.

Eutrophication status: The estuary is very highly (NZ ETI Tool 1, Band D) susceptible to macroalgal-based eutrophication at times based on (1) its relatively high proportion (>37%) of intertidal habitat, including two physically constricted arms in the middle estuary, and (2) its very high nutrient load (the current estimated N areal loading of 7,020 mg TN m^{-2} d^{-1} exceeds the tentative guideline for low susceptibility SSRTREs of ~2000 mg TN m^{-2} d^{-1}).

Despite the very high rating, the 2019 field survey resulted in an NZ ETI (Tool 2) condition rating of moderate (Band B), with minimal sign of primary eutrophication symptoms (nuisance opportunistic macroalgae). Their absence was most likely related to turbidity-induced light limitation (during hightide) and/or flushing during flood periods. In addition, synoptic (one-off) sampling of the main subtidal channel waters (surface and bottom) indicated an absence of nuisance phytoplankton blooms (very low [chl *a*]), again reflecting light limitation and/or flushing in that part of the system. However, on occasions during low flows when the estuary is stratified and turbidity is low, nuisance algal/macrophyte growth may occur.

We note that such mud-impacted estuaries generally are more susceptible to eutrophication impacts, so the present survey results must be viewed in that context, and the potential for rapid ecological decline accounted for in any long-term monitoring programme.

Sedimentation (muddiness) status: The estuary is rated as moderate-highly vulnerable to muddiness issues based on the fact that, although the estimated current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL) and excess sediments are likely to be flushed to the sea during high flows, the catchment is naturally erosion prone (Suspended Sediment Yield map of sediment delivery to rivers and stream [NIWA]) and the synoptic survey showed that the estuary is dominated by muddy sediments in the less well flushed mid-upper (intertidal and subtidal) reaches. Ecologically, the overall high mud content fits the NZ ETI Band D (very high) condition rating.

Figure 20. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Patea Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Patea Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 4, 49.1 ha
	Intertidal/Subtidal	63% subtidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	2.0-3.0 m, 4 km (salt wedge extent)
	Freshwater Inflow	Mean annual 29.5 m^3 s^{-1}*
	Saltmarsh, Seagrass	3.7 ha saltmarsh, no seagrass
	Soft Mud	3.4 ha (23% unvegetated intertidal area)
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Low-Mod**
Catchment	Catchment size	1045.8 km^2
	Max Dairy Cows Permitted	49,291
	Suspended Sediment Loading	469.6 kt yr^{-1}
	Total Nitrogen Loading	1258 t yr^{-1} (7,020 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	123.5 t yr^{-1}
	Dominant Landuse	35% native forest, 7% exotic forest, 27% dairy, 31% sheep/beef.
	Dominant Toprock Geology	Alluvial 5%, ash (older than Taupo ash) 36%, peat 1%, massive sandstone 56%.

*Mean flow measured at Patea at McColls Bridge and does not include Patea HEP (Lake Rotorangi), but they on average discharge at 29 m3 s^{-1} or 2,505,946 m^3 d^{-1}.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 3 representative subtidal channel sites (see locations in Figure 20). Sampled values in Appendix B.

Monitoring and Investigations

For “long-length (mouth sometimes closed or restricted) SSRTREs” with significant intertidal and subtidal habitat comprising poorly flushed/muddy substrata, moderate-high nutrient/sediment loads and high human use and cultural/ecological values, it is recommended that both broad scale habitat mapping and fine scale monitoring be undertaken on a long-term basis to assess trends in estuary ecological condition using the National Estuary Monitoring Protocol (Robertson et al. 2002), plus subsequent improvements (Robertson 2018). Outputs should be compared against relevant national standards (i.e. NZ ETI; Robertson et al. 2016a,b). In addition, sedimentation plates, which, over the long-term, will help provide an indicative measure of the rate of sedimentation in the estuary, should be deployed and monitored annually as per Hunt (2019).

Broad scale habitat mapping documents the key habitats within the estuary, and changes to these habitats over time. It is typically repeated at 5-yearly intervals. Fine scale monitoring measures the condition of the high susceptibility intertidal and subtidal habitat through physical, chemical and biological indicators. It is undertaken once annually for three consecutive years during the period Nov-March (usually at 2 intertidal and 3-4 subtidal sites), and thereafter at 5-yearly intervals. Both components have not yet been measured in this estuary.

Whenuakura Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Moderate	Moderate
	Eutrophication	Very High	Minimal

The Whenuakura River Estuary is a large, shallow, generally well-flushed, tidal river estuary (SSRTRE) that is located southeast of Patea and extends approximately 5 km inland. It has a high freshwater inflow which, along with tidal inflow, is expected to flush most of the catchment-derived nutrients and sediment from the estuary. Intertidal substrata are dominated by sand, are generally well oxygenated and comprise small areas of saltmarsh. The estuary includes areas of high tide saltmarsh (*Typha orientalis* - Raupo, *Schoenoplectus pungens* - Three-square, *Apodasmia similis* - Jointed wirerush) and herbfield (*Sarcocornia quinqueflora* - Glasswort) vegetation. The estuary mouth is mostly open to the sea but may become restricted during periods of lowflow, limiting tidal mixing, and consequently the estuary waters can become brackish. The estuary catchment is mostly native forest, but also developed predominantly for sheep, beef and dairy farming and smaller areas of consented exotic forest (see summary information overleaf).

Human use, ecological and cultural values: The estuary is recognised as a "Key Native Ecosystem" (KNE) with relatively good access, it is valued for its spiritual/aesthetic appeal, bathing and biodiversity. It is also significant to the people of both Ngāti Ruanui and Ngaa Rauru Kiitahi. Food sources, gathered from the entire length of this river, included tuna, whitebait, smelt, flounder, and sole. In terms of ecological value, habitat diversity is moderate-high with some of its intertidal vegetation, saltmarsh (in this case rushland and herbfield) intact. However, there is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed for farming. The estuary is recognized as an important nursery area for birds including the 'Threatened (Nationally Vulnerable)' Caspian tern (*Sterna caspia*), northern New Zealand dotterel (*Charadrius obscurus aquilonius*) and banded do terel (*Charadrius bicinctus*) and the 'At Risk' (Declining) New Zealand pipit (*Anthus novaeseelandiae*), and is included in the migratory route of several bird species including the variable oystercatcher (*Haematopus unicolor*) and royal spoonbill (*Platalea regia*).

Eutrophication status: The estuary has very high (NZ ETI Tool 1, Band D) susceptibility to macroalgal-based eutrophication, reflecting its relatively high proportion (>40%) of intertidal habitat and high nutrient load (the current estimated N areal loading of 2,207 mg TN m^{-2} d^{-1} exceeds the tentative guideline for low susceptibility SSRTREs of ~2000 mg TN m^{-2} d^{-1}).

Despite the very high rating, the 2019 field survey of intertidal and subtidal habitat showed no signs of primary eutrophication symptoms. This result was likely driven by the estuary's highly flushed nature, given that it is predominantly strongly channelised with very few poorly flushed areas, has high freshwater inflow, is strongly affected by tidal currents and is often turbid. The absence of primary eutrophication symptoms on the day of sampling placed the estuary in very good (NZ ETI, Tool 2, Band A) condition with regard to eutrophication impacts.

However, on occasions during low flows when the estuary is stratified and turbidity is low, nuisance algal/macrophyte growth may occur within intertidal and/or subtidal habitat, particularly if the mouth becomes constricted, hence the very high eutrophic susceptibility rating is considered appropriate.

Sedimentation (muddiness) status: The estuary has moderate vulnerability to muddiness issues based on the facts that estimated current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL), the estuary is dominated by coarse sediments (NZ ETI, Band A), but some subtidal muds, and the mouth may be occasionally restricted. Ecologically, the overall moderate mud content fits the NZ ETI Band B (moderate muddiness) condition rating.

Figure 21. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sites, Whenuakura Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Whenuakura Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 4, 32.2 ha
	Intertidal/Subtidal	54% intertidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	1.0-2.0, 5 km (salt wedge extent)
	Freshwater Inflow	Mean annual 10.2 m^3 s^{-1}*
	Saltmarsh, Seagrass	5 ha saltmarsh, no seagrass
	Soft Mud	0.2 ha (2% unvegetated intertidal area)
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Low-Mod**
Catchment	Catchment size	468.6 km^2
	Max Dairy Cows Permitted	15,100
	Suspended Sediment Loading	326 kt yr^{-1}
	Total Nitrogen Loading	260 t yr^{-1} (2,207 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	67 t yr^{-1}
	Dominant Landuse	66% native forest, 4% exotic forest, 16% dairy, 13% sheep/beef.
	Dominant Toprock Geology	Alluvial 1%, massive mudstone 21%, massive sandstone 77%.

*Mean flow measured at Whenuakura at Nicholson Rd.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 3 representative subtidal channel sites (see locations in Figure 21). Sampled values in Appendix B.

Monitoring and Investigations

For the Whenuakura Estuary it is recommended that annual monitoring of targeted eutrophication indicators (intertidal and subtidal channel) be undertaken to provide data on long-term trophic state trends.

To address potential for eutrophication, it is recommended that relevant water column and sediment-based indicators be monitored monthly during the period Nov-March each year at 1-2 sites representative of general conditions (e.g. mid-upper estuary) and at the same time, intertidal/shallow subtidal macroalgal cover be assessed throughout the intertidal/shallow subtidal estuary. If, after 1-2 years, eutrophication is not found to be a persistent issue, this monitoring may cease.

Because this estuary is generally flushed regularly by high flow events, it is recommended that long-term monitoring for sedimentation be limited to low frequency (5-yearly), broad scale, screening level assessments only.

Waitotara Estuary	Issue	Susceptibility	Condition Rating (2019)
	Sedimentation	Mod-High	Very High
	Eutrophication	Minimal	Minimal

The Waitotara Estuary is a long length, shallow tidal river estuary whose mouth is predominantly open. It has a high freshwater inflow and is located on the South Taranaki Bight. Intertidally, sediments are characterised by soft muds (14.5 ha, 34% non-vegetated intertidal flats) and sands and include saltmarsh comprising herbfield (*Sarcocornia quinqueflora* - Glasswort) and to a lesser extent rushland (*Isolepis nodosa* - Knobby clubrush, *Juncus articulatus* - Jointed rush, *Isolepis cernua* - Slender clubrush, and *Schoenoplectus pungens* - Three-square) vegetation. While the estuary mouth is mostly open to the sea, it may become restricted during periods of lowflow, limiting tidal mixing, and consequently the estuary waters can become brackish. The estuary catchment is dominated by dairy farming and to a much lesser extent mixed native forest, exotic forest (including consented forestry) - see summary information overleaf.

Human use, ecological and cultural values: The estuary is valued for its aesthetic appeal, spiritual values, bathing and biodiversity. It is significant to Ngaa Rauru Kiitahi, with many hapū located along or near the river. Food sources, gathered from its entire length, included kaakahi, tuna, whitebait, smelt, kahawai, flounder, and sole. A piliocene section along bank of Waitotara River together with fossilised totara stumps and ventifacts provides high scientific and educational interest. Ecologically, habitat diversity is moderate-high with some of its intertidal vegetation, saltmarsh (in this case rushland, sedgeland and herbfield) intact. However, there is no high-value seagrass (intertidal or subtidal) habitat and much of the natural vegetated margin has been lost and is now developed for grazing. The wider reserve also provides habitat for coastal and migratory birds and is occasionally visited by the ‘ Threatened (Nationally Critical)’ kotuku or white heron (*Ardea modesta*). Human activity is minimal associated with low key recreation use, and the visitor experience maintains a high sense of wildness and remoteness retained along the coastal edge.

Eutrophication status: The overall eutrophic susceptibility of the estuary is minimal (NZ ETI Tool 1, Band A) based on (1) its well flushed nature (mouth not often restricted), and (2) its relatively low nutrient load (the current estimated N areal loading of 1,228 mg TN m^{-2} d^{-1} does not exceed the tentative guideline for low susceptibility SSRTREs of ~2000 mg TN m^{-2} $d^{-1;}$ Robertson et al. 2016).

The synoptic (one-off) survey in 2019 confirmed the absence of opportunistic macroalgae in all areas of the intertidal estuary and generally clear subtidal waters in the lower and middle estuary with very low phytoplankton (chl *a*) and dissolved oxygen concentrations. Overall, the estuary fits the NZ ETI (Tool 2) condition rating of ‘minimal’ (Band A) in terms of eutrophication.

Although periodic (short-term) changes in eutrophic susceptibility are expected (particularly if the mouth becomes constricted), given the general lack of primary symptoms on the day of sampling when flushing was low (i.e. baseflow conditions), the low susceptibility rating is considered appropriate. However, it is important to note mud-impacted estuaries generally are more susceptible to eutrophication impacts, so the present survey results must be viewed in that context, and the potential for rapid ecological decline accounted for in any long-term monitoring programme.

Sedimentation (muddiness) status: The estuary is rated as highly vulnerable to muddiness issues based on the fact that, although the estimated current suspended sediment load (CSSL) is <5 times the estimated natural state SS load (NSSL) and excess sediments are likely to be flushed to the sea during high flows, the catchment is naturally erosion prone (Suspended Sediment Yield map of sediment delivery to rivers and stream [NIWA]) and the synoptic survey showed that the estuary is dominated by muddy sediments in the less well flushed mid-upper (intertidal and subtidal) reaches. Ecologically, the overall high extent of muds fits the NZ ETI Band D (very high) condition rating.

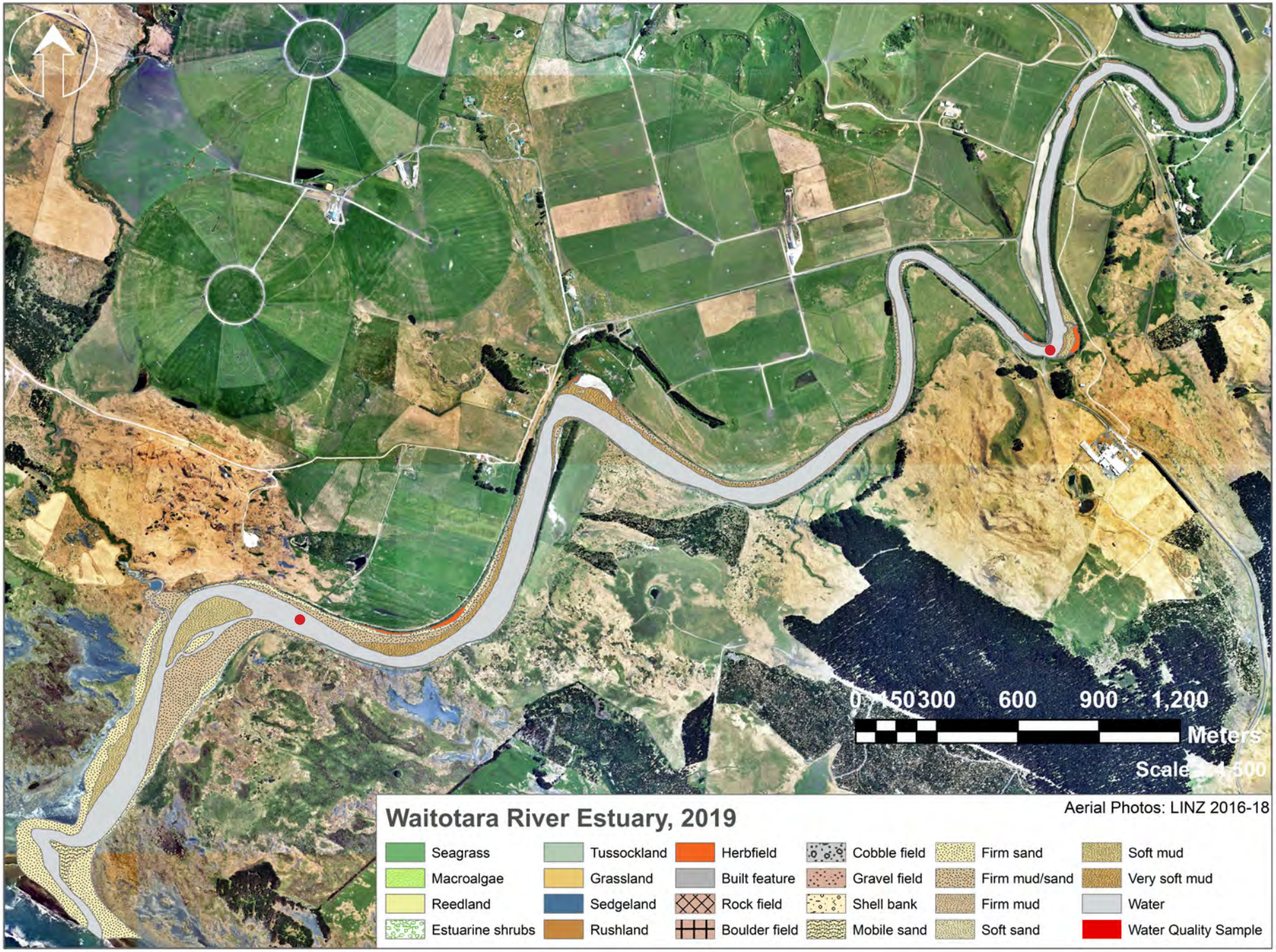


Figure 22. Distribution of intertidal substrata, macrophyte and saltmarsh, and water quality sampling locations, Waitotara River Estuary, 2019. Water quality sampling involved assessment of conditions in both surface (0.2 m) and bottom (0.5 m from bottom) waters at each site.

Waitotara Estuary - Summary Data		
Estuarine	Estuary Type/Area	SSRTRE Type 4, 98 ha
	Intertidal/Subtidal	45% intertidal
	Mouth Status (on day of survey)	Open
	Mean Depth, Length	0.5-1.0 m, 5 km (salt wedge extent)
	Freshwater Inflow	Mean annual 44.3 m^3 s^{-1}*
	Saltmarsh, Seagrass	1.4 ha saltmarsh, no seagrass
	Soft Mud	14.5 ha (34% unvegetated intertidal area)
	Macroalgae	No intertidal macroalgae
	[Chlorophyll *a*] (subtidal channel)	Very Low**
	[Dissolved oxygen] (subtidal channel)	Low-Mod**
Catchment	Catchment size	1183 km^2
	Max Dairy Cows Permitted	10820
	Suspended Sediment Loading	1131.7 kt yr^{-1}
	Total Nitrogen Loading	439.2 t yr^{-1} (1,228 mg TN m^{-2} d^{-1})
	Total Phosphorus Loading	139.1 t yr^{-1}
	Dominant Landuse	68% native forest, 7% exotic forest, 5% dairy, 20% sheep/beef.
	Dominant Toprock Geology	Alluvial 3%, mudstone 1%, massive mudstone 1%, ash (older than Taupo ash) 9%, massive sandstone 82%, windblown sand 3%.

*Estimated mean flow at river mouth from NIWA's NZ River Maps software tool.
**NZ ETI (Tool 2) condition bandings based on discrete (bottom and surface) water quality samples obtained from 3 representative subtidal channel sites (see locations in Figure 22 - note uppermost site not within map view). Sampled values in Appendix B.

Monitoring and Investigations

For "long-length (mouth sometimes closed or restricted) SSRTREs" with significant intertidal and subtidal habitat comprising poorly flushed/muddy substrata, low nutrient but high sediment loads and high human use and cultural/ecological values, it is recommended that both broad scale habitat mapping and fine scale monitoring be undertaken on a long-term basis to assess trends in estuary ecological condition using the National Estuary Monitoring Protocol (Robertson et al. 2002), plus subsequent improvements (Robertson 2018). Outputs should be compared against relevant national standards (i.e. NZ ETI; Robertson et al. 2016a,b). In addition, sedimentation plates, which, over the long-term, will help provide an indicative measure of the rate of sedimentation in the estuary, should be deployed and monitored annually as per Hunt (2019).

Broad scale habitat mapping documents the key habitats within the estuary, and changes to these habitats over time. It is typically repeated at 5-yearly intervals. Fine scale monitoring measures the condition of the high susceptibility intertidal and subtidal habitat through physical, chemical and biological indicators. It is undertaken once annually for three consecutive years during the period Nov-March (usually at 2 intertidal and 3-4 subtidal sites), and thereafter at 5-yearly intervals. Both components have not yet been measured in this estuary.

4 Summary

Intertidal habitat mapping and associated sampling undertaken in Feb-March 2019, combined with NZ ETI-based estuary typing and condition ratings, have been used to evaluate overall vulnerability of twenty estuaries in the Taranaki Region to sedimentation and eutrophication impacts, and also inform future monitoring recommendations (Section 5).

Estuary Vulnerability to Eutrophication and Sedimentation

As is characteristic of estuaries on the West Coast of NZ, all twenty of the Taranaki Region estuaries assessed were shallow, short residence time, tidal river estuaries (SSRTREs), each variable in size and partially separated from the sea by a range of physical features. The results showed that each estuary fits into one of four sub-types (based on physical attributes and freshwater inflow), each with different vulnerabilities to nutrients and fine sediment and therefore long-term monitoring requirements, as follows:

Estuary Type 1. Short length, low flow SSRTREs - <1 km long, beach located, low freshwater inflows (<1 m^3 s^{-1}), mouth sometimes restricted/closed. Taranaki Region estuaries that fit into this sub-group included Tapuae, Timaru, Te Henui, and Katikara Estuaries.

- **Physical characteristics:** Very short length, predominantly beach located SSRTREs consist of relatively narrow channels situated between the upper edge of the beach and the tidal level. In some situations the channel meanders along the back of the beach for a small distance before entering the sea, whereas in others the discharge path is more direct. A few expand into small lagoons around the upper high water area. In very high tides and storm surges, saline water enters the stream inland of the beach for a small distance. At times the mouth is often restricted and can sometimes close for short periods, during which time the upper beach lagoon may expand and show eutrophication/sedimentation symptoms. Of the 20 Taranaki Region estuaries included in this EVA, four were very small Type 1 systems.
- **Overall vulnerability:** With the exception of Katikara Estuary, which was shown to be highly vulnerable to eutrophication impacts, Type 1 estuaries were the least vulnerable of the Taranaki Region estuaries to eutrophication and sedimentation. The main reason for this was their small size, comparatively low ecological diversity, and regular periods of high flushing (even though some examples experience periodic mouth closure/restriction). Consequently, although estimated nutrient and sediment loads to the estuaries were generally large, they are unlikely to be subjected to prolonged periods of eutrophication and muddiness. Synoptic surveys of this estuary type in March 2019 confirmed the absence of symptoms of eutrophication (i.e. opportunistic macroalgal and/or phytoplankton blooms) or sedimentation (extensive areas of soft muddy sediments), while Katikara Estuary had phytoplankton issues as indicated by highly elevated chlorophyll *a* concentrations throughout the subtidal channel habitat.

Estuary Type 2. Moderate length, low flow SSRTREs - 1-3 km long, low freshwater inflows (<2 m^3 s^{-1}), mouth sometimes restricted/closed. Taranaki Region estuaries that fit into this sub-group included Waiongana, Mimi, Manawapou, Onaero, Waingongoro, Kaupokonui, Oakura Estuaries.

- **Physical characteristics:** Moderate length SSRTREs consist of relatively narrow channels situated between the tidal level and approximately 1-3 km inland. In some situations the channel meanders along the back of the beach for a distance before entering the sea, whereas in others the discharge path is more direct. A few expand into small lagoons around the upper high water area. The estuary mouth is generally open to the sea but in others it is often closed (e.g. Onaero Estuary).
- **Overall vulnerability:** Type 2 estuaries which had excessive nutrient/sediment loads and whose mouths were mostly closed (and therefore very poorly flushed) were identified as moderately to highly vulnerable. Those that had excessive nutrient/sediment loads, but were mostly open to the sea were rated as moderately vulnerable. When nutrient/sediment loads were low and estuaries were open to the sea, estuaries had minimal vulnerability.

- Characteristic symptoms of eutrophication were opportunistic macroalgal blooms and/or elevated chlorophyll *a* symptomatic of phytoplankton blooms, with symptoms of sedimentation being extensive areas of soft fine muddy sediments. The expression of such symptoms was variable because of the flushing regime - being highly flushed during high flow events, and poorly flushed during summer low flows when their mouths become restricted and the upstream waters stratify. This meant that under high nutrient/sediment loads, the estuaries were likely to exhibit eutrophication and muddiness symptoms only during periods of mouth constriction and/or poor flushing.

Estuary Type 3. Long length, moderate flow SSRTREs - 3-12 km long, moderate freshwater inflows (4-6 m^3 s^{-1}), mouth always open. Taranaki Region estuaries that fit into this sub-group included Tangahoe, Urenui, and Mōhakatino Estuaries.

- **Physical characteristics**: Long SSRTREs, with moderate freshwater inflows and mouths always open, consist of a relatively narrow channel that extends inland for approximately 3-12 km. In some situations the channel meanders along the back of the beach for a distance before entering the sea, whereas in others the discharge path is more direct.
- **Overall vulnerability**: Type 3 estuaries all had moderate-high vulnerability (apart from Tangahoe Estuary), primarily reflecting their high sediment loads and soft mud habitat. The main reason for the moderate eutrophication rating was that, for estuaries where the nutrient load was excessive, the estuary was likely to oscillate between low and moderate-high levels of eutrophication; i.e. low levels of eutrophication and sedimentation in winter, and immediately during and following high flow events in the warmer months, and moderately eutrophic conditions with some sedimentation during summer base-flow conditions. This latter situation arises from the extensive estuary length and moderate freshwater inflow, which means that the residence time for water and nutrients is sufficient to allow for phytoplankton blooms under baseflow conditions (given that the time taken for a parcel of water to travel the length of the estuary under baseflow is ~1-3 days for these estuaries).

Estuary Type 4. Long length, high flow SSRTREs - 3-12 km long, high freshwater inflows (7-220 m^3 s^{-1}), mouth always open. Taranaki Region estuaries that fit into this sub-group included Waitotara, Waitara, Patea, Whenuakura, Tongaporutu, and Waiwhakaiho Estuaries.

- **Physical characteristics**: Long SSRTREs, with high freshwater inflows and mouths always open, consist of relatively narrow channels situated between the tidal level and approximately 3-12 km inland. In some smaller estuaries the channel meanders along the back of the beach for a distance before entering the sea, whereas in others the discharge path is more direct. Some of the smaller estuaries expand into lagoons around the upper high water area. In the larger examples (e.g. Tongaporutu, Waitara and Patea Estuaries), significant areas of intertidal flats are found in the mid-lower estuary.
- **Overall vulnerability**: Most of the Type 4 estuaries had high overall vulnerability. This rating reflects their high nutrient/sediment loads and, in most cases, significant intertidal habitat already affected by sedimentation (extensive areas of soft muddy sediments), despite the fact that flushing in these estuaries was found to be high, even during summer low flows (a consequence of the high freshwater inflows, extensive tidal intrusion, mouths always open and narrow channels). Although synoptic surveys of each estuary in March 2019 generally indicated the absence of symptoms of eutrophication (i.e. opportunistic macroalgal and/or phytoplankton blooms), eutrophic susceptibilities remain high for several of these long length/high flow systems. It is also noted that the vulnerability of the inshore coastal habitats from the river plumes of these large estuaries has not been assessed in this report, given it was outside the study brief.

5 Monitoring Recommendations

To maintain the value of the twenty surveyed Taranaki Region estuaries, and to ensure sufficient information is available to manage each in relation to the identified vulnerability to eutrophication and sedimentation, long-term monitoring is recommended for each estuary below and summarised in Table 2.

For Tongaporutu, Mimi, Urenui, Mōhakatino, Waitotara, Waitara and Patea Estuaries, all with significant intertidal and subtidal habitat comprising poorly flushed/muddy substrata, moderate-high nutrient/sediment loads and high human use and cultural/ecological values, the following four components are recommended:

- **Broad scale habitat mapping** to document dominant estuary features (e.g. substratum, seagrass, saltmarsh, macroalgae) and monitor changes over time. It is typically repeated at 5-yearly intervals;
- **Fine scale monitoring** measures the condition of representative intertidal sediments (usually the dominant substrata type as well as deposition zones where sedimentation and eutrophication symptoms are more likely to be expressed) and subtidal channel habitat using a suite of physical, chemical and biological indicators. It is undertaken once annually for three consecutive years during the period Nov-March (usually at 2 intertidal and 3-4 subtidal sites), and thereafter at 5-yearly intervals;
- **Annual sedimentation rate (including grain size) monitoring** measures sedimentation trends within the estuary over time. Sediment plates should be deployed and monitored annually as per Hunt (2019);
- **High level data on dominant changes in catchment landuse** to track changes in high risk activities (e.g. land disturbance, point source discharges), and facilitate estimates of changes to naturally occurring catchment inputs of sediment, nutrients and other stressors (e.g. pathogens) likely from human influenced land disturbance.

For Katikara, Oakura and Whenuakura Estuaries, where overall eutrophication vulnerability is high, it is recommended that:

- **Annual monitoring of targeted eutrophication indicators** (intertidal and subtidal channel) be undertaken to provide data on long-term trophic state trends. To address potential for eutrophication, it is recommended that relevant water column and sediment-based indicators be monitored monthly during the period Nov-March each year at 1-2 sites representative of general conditions (e.g. mid-upper estuary) and at the same time, intertidal/shallow subtidal macroalgal cover be assessed throughout the intertidal/shallow subtidal estuary. This monitoring may cease if, after 1-2 years, eutrophication is not found to be a persistent issue in the estuaries. Because these estuaries are generally flushed regularly by high flow events, it is recommended that long-term monitoring for sedimentation be limited to low frequency (5-yearly), broad scale, screening level assessments only.

For Tapuae, Timaru, Te Henui, Waiongana, Manawapou, Onaero, Waingongoro, Kaupokonui, Tangahoe and Waiwhakaiho Estuaries, all of which had very low overall vulnerabilities to both sedimentation and eutrophication, we recommend:

- **Low frequency, screening level monitoring only**. To address the low potential for eutrophication/sedimentation issues (including both benthic and water column effects), it is recommended that low frequency (once every 10 years), screening level (synoptic) monitoring be undertaken to confirm that these low risk estuaries have not changed their vulnerability ratings.

The monitoring proposed, based on the NEMP framework, has been successfully applied to establish estuary monitoring priorities throughout NZ, and underpins the NZ ETI. Adopting a nationally consistent approach ensures the TRC benefit directly from work undertaken in other regions, as well as from established tools and existing national data, indicators and thresholds.

Table 2. Summary of NZ ETI-based susceptibility, current condition and overall vulnerability ratings, and monitoring recommendations, for twenty Taranaki Region estuaries, 2019. * See further details in 'Estuary Monitoring Recommendations' (Section 4.2).

Sub-Type[1]	Estuary	Coastal Stressor				Overall Vulner-ability	Recommended Monitoring*	Monitoring Frequency
		Sedimentation		Eutrophication				
		Suscepti-bility	Current Condition (2019)	Suscepti-bility	Current Condition (2019)			
SSRTRE Type 1	Tapuae	Moderate	Moderate	Minimal	Minimal	Moderate	Synoptic monitoring only	10-yearly
	Timaru	Moderate	Moderate	Minimal	Minimal	Moderate		
	Te Henui	Moderate	Moderate	Minimal	Minimal	Moderate		
	Katikara	Moderate	Moderate	Moderate	High	Mod-High	Eutrophication-targeted monitoring	Annually
SSRTRE Type 2	Waiongana	Moderate	Moderate	Minimal	Minimal	Moderate	Synoptic monitoring only	10-yearly
	Mimi	Mod-High	Very High	Very High	Moderate	High	Broad- & fine-scale monitoring	3-year baseline, 5-yearly
	Manawapou	Moderate	Moderate	Minimal	Minimal	Moderate	Synoptic monitoring only	10-yearly
	Onaero	Moderate	Moderate	Minimal	Moderate	Moderate		
	Waingongoro	Moderate	Minimal	Minimal	Minimal	Minimal		
	Kaupokonui	Moderate	Moderate	Minimal	Minimal	Moderate		
	Oakura	Moderate	Moderate	Moderate	High	Mod-High	Eutrophication-targeted monitoring	Annually
SSRTRE Type 3	Tangahoe	Moderate	Moderate	Minimal	Minimal	Moderate	Synoptic monitoring only	10-yearly
	Urenui	Mod-High	Very High	Very High	Moderate	High	Broad- & fine-scale monitoring	3-year baseline, 5-yearly
	Mōhakatino	Mod-High	Very High	Moderate	Moderate	High		
SSRTRE Type 4	Waitotara	Mod-High	Very High	Minimal	Minimal	Mod-High		
	Waitara	Mod-High	Very High	Minimal	Moderate	Mod-High		
	Patea	Mod-High	Very High	Very High	Moderate	High		
	Whenuakura	Moderate	Moderate	Very High	Minimal	Mod-High	Eutrophication-targeted monitoring	Annually
	Tongaporutu	Mod-High	Very High	High	Moderate	High	Broad- & fine-scale monitoring	3-year baseline, 5-yearly
	Waiwhakaiho	Moderate	Moderate	Minimal	Minimal	Moderate	Synoptic monitoring only	10-yearly

6 References

Atkinson, I.A.E. 1985. Derivation of vegetation mapping units for an ecological survey of Tongariro National Park, North Island, New Zealand. New Zealand Journal of Botany 23: 361-378.

Elliot, A.H., Semadeni-Davies, A.F., Shankar, U., Zeldis, J.R., Wheeler, D.M., Plew, D.R., Rys and S.R. Harris. 2009. A national-scale GIS-based system for modelling impacts of land use on water quality. Environmental Modelling & Software.

Hume, T. 2016. The fit of the ETI trophic state susceptibility typology to the NZ coastal hydrosystems typology. Prepared by Hume Consulting Ltd. NIWA Client report.

Howes, B.L., Samimy, R. and Dudley, B. 2003. Site-Specific Nitrogen Thresholds for Southeastern Massachusetts Embayments: Critical Indicators Interim Report. Prepared by Massachusetts Estuaries Project for the Massachusetts Department of Environmental Protection. http://yosemite.epa.gov/OA/EAB_WEB_Docket.nsf/Verity%20View/DE93FF445FFADF1285257527005AD4A9/$File /Memorandum%20in%20Opposition%20...89.pdf

Hunt, S. 2019. Regional Estuary Monitoring Programme (REMP) intertidal sedimentation measurements, results and review of methodologies. Waikato Regional Council Technical Report 2019/04.

Kreiling, R., Schubauer-Berigan, J., Richardson, W., Bartsch L,, Hughes, P., Cavanaugh, J., and Strauss, E. 2013. Wetland Management Reduces Sediment and Nutrient Loading to the Upper Mississippi River. Journal of Environmental Quality.

McKergow, L.A., Gallant, J.C., and Dowling, T.I. 2007. Modelling wetland extent using terrain indices, Lake Taupo, NZ. MODSIM 2007: International congress on modelling and simulation: land, water and environmental management: integrated systems for sustainability, 1335–1341.

Plew, D., Zeldis, J., Dudley, B., Whitehead, A., Stevens, L., Robertson, B.M., and Robertson, B.P. Assessing the eutrophic susceptibility of New Zealand Estuaries. Under Review (2019).

Plew, D., Zeldis, J., Shankar, U., and Elliott A. 2018. Using Simple Dilution Models to Predict New Zealand Estuarine Water Quality. doi:10.1007/s12237-018-0387-6

Robertson, B.M., Gillespie, P.A., Asher, R.A., Frisk, S., Keeley, N.B., Hopkins, G.A., Thompson, S.J., and 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., Stevens, L.M., Robertson, B.P., Zeldis, J., Green, M., Madarasz-Smith, A., Plew, D., Storey, R., Hume, T. and Oliver, M. 2016a. NZ Estuary Trophic Index. Screening Tool 1. Determining eutrophication susceptibility using physical and nutrient load data. Prepared for Envirolink Tools Project: Estuarine Trophic Index MBIE/NIWA Contract No: C01X1420. 47p.

Robertson, B.M., Stevens, L.M., Robertson, B.P., Zeldis, J., Green, M., Madarasz-Smith, A., Plew, D., Storey, R., Hume, T. and Oliver, M. 2016b. NZ Estuary Trophic Index. Screening Tool 2. Screening Tool 2. Determining Monitoring Indicators and Assessing Estuary Trophic State. Prepared for Envirolink Tools Project: Estuarine Trophic Index MBIE/NIWA Contract No: C01X1420. 68p.

Robertson, B.P. 2019. Havelock Estuary 2019 Broad Scale Habitat Mapping and Ecological Assessment. Prepared for Marlborough District Council. 76p.

Robertson, B.P. 2018. Optimising ecological condition indicators in shallow tidal estuaries as a function of nitrogen loading. PhD thesis - University of Otago. 125p. Available at: https://ourarchive.otago.ac.nz/bitstream/handle/10523/8300/RobertsonBenP2018PhD. pdf?sequence=3&isAllowed=y

Robertson, B. P., and C. Savage. 2018. Mud-entrained macroalgae utilise porewater and overlying water column nutrients to grow in a eutrophic intertidal estuary. Biogeochemistry 139: 53-68. Available at: https://doi.org/10.1007/s10533-018-0454-x

Robertson, B.P. 2018. Optimising ecological condition indicators in shallow tidal estuaries as a function of nitrogen loading. PhD thesis - University of Otago. 125p. Available at: https://ourarchive.otago.ac.nz/bitstream/handle/10523/8300/RobertsonBenP2018PhD. pdf?sequence=3&isAllowed=y

Robertson, B.P. 2013. Determining the sensitivity of macroinvertebrates to fine sediments in representative New Zealand estuaries. Honours dissertation, Victoria University of Wellington - Note: In preparation for journal publication.

Robertson, B. P., and C. Savage. 2018. Mud-entrained macroalgae utilise porewater and overlying water column nutrients to grow in a eutrophic intertidal estuary. Biogeochemistry 139: 53-68. Available at: https://doi.org/10.1007/s10533-018-0454-x

Sakamaki ,T., and Nishimura, O. 2009. Is sediment mud content a significant predictor of macrobenthos abundance in low-mud-content tidal flats? Marine and Freshwater Research, 60, 160.

Stevens, L.M. and Robertson, B.P. 2017. Nelson Region Estuaries: Vulnerability Assessment and Monitoring Recommendations. Prepared by Wriggle Coastal Management for Nelson City Council. 36p + appendices.

Taranaki Regional Council. 2015. Regional landscape study of the Taranaki coastal environment. Available at: https://www.trc.govt.nz/assets/Documents/Environment/Coast/reg-landscape-study-of-naki-coastal-enviro.pdf.

Taranaki Regional Council. 2018. Schedule 5B of the Proposed Coastal Plan for Taranaki. Available at: https://www.trc.govt.nz/assets/Documents/Plans-policies/CoastalPlan/Proposed2018/PCP-Sched5b-NgatiTama.pdf.

Wehkamp, S. and Fischer, P. 2012. Impact of hard-bottom substrata on the small-scale distribution of fish and decapods in shallow subtidal temperate waters. Helgoland Marine Research, 67, 59–72.

WFD-UKTAG (Water Framework Directive – United Kingdom Technical Advisory Group). (2014). UKTAG Transitional and Coastal Water Assessment Method Macroalgae Opportunistic Macroalgal Blooming Tool. Retrieved from http://www.wfduk.org/sites/default/files/Media/Characterisation of the water environment/Biological Method Statements/TraC Macroalgae OMBT UKTAG Method Statement.PDF.

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

References for Table 1

Abrahim, G. 2005. Holocene sediments of Tamaki Estuary: characterisation and impact of recent human activity on an urban estuary in Auckland, NZ. PhD Thesis, University of Auckland, Auckland, NZ, p 361.

Anderson, D., Gilbert, P. and Burkholder, J. 2002. Harmful algal blooms and eutrophication: nutrient sources, composition, and consequences. Estuaries 25, 704–726.

Ferreira, J., Andersen, J. and Borja, A. 2011. Overview of eutrophication indicators to assess environmental status within the European Marine Strategy Framework Directive. Estuarine, Coastal and Shelf Science 93, 117–131.

Gibb, J.G., and Cox, G.J. 2009. Patterns & Rates of Sedimentation within Porirua Harbour. Consultancy Report (CR 2009/1) prepared for Porirua City Council. 38p plus appendices.

Gibbs, M., and Hewitt, J. 2004. Effects of sedimentation on macrofaunal communities : a synthesis of research studies for ARC. Prepared for Auckland Regional Council. NIWA Client Report: HAM2004-060. 48p.

IPCC. 2007. Intergovernmental Panel on Climate Change web site. https://www.ipcc.ch/publications_and_data/ar4/wg1/ (accessed December 2009).

IPCC. 2013. Intergovernmental Panel on Climate Change web site. https://www.ipcc.ch/report/ar5/wg1/ (accessed March 2014).

Kennish, M.J. 2002. Environmental threats and environmental future of estuaries. Environmental Conservation 29, 78–107.

National Research Council. 2000. Clean coastal waters: understanding and reducing the effects of nutrient pollution. Ocean Studies Board and Water Science and Technology Board, Commission on Geosciences, Environment, and Resources. Washington, DC: National Academy Press. 405p.

Painting, S.J., Devlin, M.J., Malcolm, S.J., Parker, E.R., Mills, D.K., Mills, C., and Winpenny, K. 2007. Assessing the impact of nutrient enrichment in estuaries: susceptibility to eutrophication. Marine pollution bulletin 55(1-6), 74–90.

Robertson, B.M., and Stevens, L.M. 2007. Waikawa Estuary 2007 Fine Scale Monitoring and Historical Sediment Coring. Prepared for Environment Southland. 29p.

Robertson, B.M., and Stevens, L.M. 2010. New River Estuary: Fine Scale Monitoring 2009/10. Report prepared by Wriggle Coastal Management for Environment Southland. 35p.

de Salas, M.F., Rhodes, L.L., Mackenzie, L.A., and Adamson, J.E. 2005. Gymnodinoid genera Karenia and Takayama (Dinophyceae) in New Zealand coastal waters. New Zealand Journal of Marine and Freshwater Research 39,135–139.

Stewart, J.R., Gast, R.J., Fujioka, R.S., Solo-Gabriele, H.M., Meschke, J.S., Amaral-Zettler, L.A., Castillo, E. Del., Polz, M.F., Collier, T.K., Strom, M.S., Sinigalliano, C.D., Moeller, P.D.R. and Holland, A.F. 2008. The coastal environment and human health: microbial indicators, pathogens, sentinels and reservoirs. Environmental Health 7 Suppl 2, S3.

Swales, A., and Hume, T. 1995. Sedimentation history and potential future impacts of production forestry on the Wharekawa Estuary, Coromandel Peninsula. Prepared for Carter Holt Harvey Forests Ltd. NIWA report no. CHH004.

Valiela, I., McClelland, J., Hauxwell, J., Behr, P., Hersh, D., and Foreman, K. 1997. Macroalgal blooms in shallow estuaries: Controls and ecophysiological and ecosystem consequences. Limnology and Oceanography 42, 1105–1118.

Wade, T.J., Pai, N., Eisenberg, J.N.S., and Colford, J.M. 2003. Do U.S. Environmental Protection Agency Water Quality Guidelines for Recreational Waters Prevent Gastrointestinal Illness? A Systematic Review and Meta-analysis. Environmental Health Perspective 111, 1102–1109.

7 Limitations

This document does not include any comprehensive assessment or consideration of ecological conditions within the subtidal benthic environment of the Taranaki Region estuaries assessed, and water quality sampling was carried out at a site-specific scale and represent a single point in time only. Regarding the latter, from a technical perspective, the overlying water environment outside of areas sampled may present substantial uncertainty. It is a changeable, heterogeneous, complex environment, in which small changes in environmental conditions can have substantial impacts on associated physicochemical conditions and biology. We also note that the vulnerability of the inshore coastal habitats from the river plume has not been assessed in this report, given it was outside the study brief. Robertson Environmental's professional opinions are based on its professional judgement, experience, and training. These opinions are also based upon data derived from the monitoring and analysis described in this document, with the support of relevant national standards (e.g. NZ ETI; Robertson et al. 2016a,b). It is possible that additional testing and analyses might produce different results and/or different opinions. Should additional information become available, this report should be updated accordingly. Robertson Environmental Limited has relied upon information provided by the Client to inform parts of this document, some of which has not been fully verified by Robertson Environmental Limited. This document may be transmitted, reproduced or disseminated only in its entirety.

Appendix A:

Major Issues Facing NZ Estuaries

Eutrophication is a process that adversely affects the high value biological components of an estuary, in particular through the increased growth, primary production and biomass of phytoplankton, macroalgae (or both); loss of seagrass, changes in the balance of organisms; and water quality degradation. The consequences of eutrophication are undesirable if they appreciably degrade ecosystem health and/or the sustainable provision of goods and services (Ferriera et al. 2011). Susceptibility of an estuary to eutrophication is controlled by factors related to hydrodynamics, physical conditions and biological processes (National Research Council, 2000) and hence is generally estuary-type specific. However, the general consensus is that, subject to available light, excessive nutrient input causes growth and accumulation of opportunistic fast growing primary producers (i.e. phytoplankton and opportunistic red or green macroalgae and/or epiphytes - Painting et al. 2007). In nutrient-rich estuaries, the relative abundance of each of these primary producer groups is largely dependent on flushing, proximity to the nutrient source, and light availability. Notably, phytoplankton blooms are generally not a major problem in well flushed estuaries (Valiela et al. 1997), and hence are not common in the majority of NZ estuaries. Of greater concern are the mass blooms of green and red macroalgae, mainly of the genera *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, both within the estuary and adjacent coastal areas. Blooms also have major ecological impacts on water and sediment quality (e.g. reduced clarity, physical smothering, lack of oxygen), affecting or displacing the animals that live there (Anderson et al. 2002, Valiela et al. 1997).

Recommended Indicators	Method
Macroalgal Cover/Biomass	Broad scale mapping - macroalgal cover/biomass over time.
Phytoplankton (water column)	Chlorophyll *a* concentration (water column).
Sediment Organic and Nutrient Enrichment	Chemical analysis of sediment total nitrogen, total phosphorus, and total organic carbon concentrations.
Water Column Nutrients	Chemical analysis of various forms of N and P (water column).
Redox Profile	Redox potential discontinuity profile (RPD) using visual method (i.e. apparent Redox Potential Depth - aRPD) and/or redox probe. Note: Total Sulphur is also a robust indicator of benthic trophic status.
Biodiversity of Bottom Dwelling Animals	Type and number of animals living in the upper 15 cm of sediments (infauna in 0.0133 m^2 replicate cores), and on the sediment surface (epifauna in 0.25 m^2 replicate quadrats).

Sedimentary changes influence the ecology of estuaries. Because they are a sink for sediments, their natural cycle is to slowly infill with fine muds and clays. Prior to European settlement they were most likely dominated by sandy sediments and had low sedimentation rates (e.g. <1 mm/year). In the last 150 years, with catchment clearance, wetland drainage, and land development for agriculture and settlements, NZ's estuaries have begun to infill rapidly with fine sediments. Today, average sedimentation rates in our estuaries are typically 10 times or more higher than before humans arrived (e.g. see Abrahim 2005, Gibb and Cox 2009, Robertson and Stevens 2007a, 2010b, and Swales and Hume 1995). Soil erosion and sedimentation can also contribute to turbid conditions and poor water quality, particularly in shallow, wind-exposed estuaries where re-suspension is common. These changes to water and sediment result in negative impacts to estuarine ecology that are difficult to reverse. They include:

- habitat loss such as the infilling of saltmarsh and tidal flats;
- prevention of sunlight from reaching aquatic vegetation such as seagrass meadows;
- increased toxicity and eutrophication by binding toxic contaminants (e.g. heavy metals and hydrocarbons) and nutrients;
- a shift towards mud-tolerant benthic organisms which often means a loss of sensitive shellfish (e.g. pipi) and other filter feeders;
- making the water unappealing to swimmers.

Recommended Indicators	Method
Soft Mud Area	GIS Based Broad scale mapping - estimates the area and change in soft mud habitat over time.
Seagrass Area/Biomass	GIS Based Broad scale mapping - estimates the area and change in seagrass habitat over time.
Saltmarsh Area	GIS Based Broad scale mapping - estimates the area and change in saltmarsh habitat over time.
Mud Content	Grain size - estimates the % mud content of sediment.
Water Clarity/Turbidity	Secchi disc water clarity or turbidity.
Sediment Toxicants	Sediment heavy metal concentrations (see toxicity section).
Sedimentation Rate	Fine scale measurement of sediment infilling rate (e.g. using sediment plates).
Biodiversity of Bottom Dwelling Animals	Type and number of animals living in the upper 15 cm of sediments (infauna in 0.0133 m^2 replicate cores), and on the sediment surface (epifauna in 0.25 m^2 replicate quadrats).

Habitat Loss impacts estuaries and their many different types of high value habitats including shellfish beds, seagrass meadows, saltmarshes (rushlands, herbfields, reedlands etc.), tidal flats, 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 such habitat negatively affects 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 common-place with the major causes being 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 (IPCC 2007 and 2013, Kennish 2002).

Recommended Indicators	Method
Saltmarsh Area	Broad scale mapping - estimates the area and change in saltmarsh habitat over time.
Seagrass Area	Broad scale mapping - estimates the area and change in seagrass habitat over time.
Vegetated Terrestrial Buffer	Broad scale mapping - estimates the area and change in buffer habitat over time.
Shellfish Area	Broad scale mapping - estimates the area and change in shellfish habitat over time.
Unvegetated Habitat Area	Broad scale mapping - estimates the area and change in unvegetated habitat over time, broken down into the different substrata types.
Sea level	Measure sea level change.
Others e.g. Freshwater Inflows, Fish Surveys, Floodgates, Wastewater Discharges	Various survey types.

Toxic Contamination has become an issue in the last 60 years, as NZ has seen a huge range of synthetic chemicals introduced to the coastal environment through urban and agricultural stormwater runoff, groundwater contamination, industrial discharges, oil spills, antifouling agents, leaching from boat hulls, and air pollution. Many of them are toxic even in minute concentrations, and of particular concern are polycyclic aromatic hydrocarbons (PAHs), heavy metals, polychlorinated biphenyls (PCBs), endocrine disrupting compounds, and pesticides. When they enter estuaries these chemicals collect in sediments and bio-accumulate in fish and shellfish, causing health risks to marine life and humans. In addition, natural toxins can be released by macroalgae and phytoplankton, often causing mass closures of shellfish beds, potentially hindering the supply of food resources, as well as introducing economic implications for people depending on various shellfish stocks for their income. For example, in 1993, a nationwide closure of shellfish harvesting was instigated in NZ after 180 cases of human illness following the consumption of various shellfish contaminated by a toxic dinoflagellate, which also lead to wide-spread fish and shellfish deaths (de Salas et al. 2005). Decay of organic matter in estuaries (e.g. macroalgal blooms) can also cause the production of sulphides and ammonia at concentrations exceeding ecotoxicity thresholds.

Recommended Indicators	Method
Shellfish and Bathing Water faecal coliforms, viruses, protozoa etc.	Bathing water and shellfish disease risk monitoring. Note disease risk indicators on the Marlborough coast are assessed separately in MDC's recreational water quality monitoring programme.
Biota Contaminants	Chemical analysis of suspected contaminants in body of at-risk biota (e.g. fish, shellfish).
Biodiversity of Bottom Dwelling Animals	Type and number of animals living in the upper 15 cm of sediments (infauna in 0.0133 m^2 replicate cores), and on the sediment surface (epifauna in 0.25 m^2 replicate quadrats).

Appendix B:

Detailed Data Taranaki Region Estuaries

Estimated catchment-derived TN, TP, TSS loading rates[1] (under natural and current landuse) for the 20 Taranaki Region Estuaries assessed.

Estuary	SSRTRE SUBTYPE	HW estuary Area (km^2)	Natural State Loads[2]			Current State Loads				
			Total Nitrogen	Total Phosphorus	Total Suspended Sediment	Total Nitrogen	Total Phosphorus	Total Suspended Sediment	Areal Total Nitrogen	Current State Sediment Load / Natural State Sediment Load ratio (CSSL/NSSL ratio)[2]
			t yr^{-1}		kt yr^{-1}	t yr^{-1}		kt yr^{-1}	mg m^{-2} d^{-1}	
Mōhakatino	3	0.321	47	17	131	54	20	173	457	2.6
Tongaporutu	4	0.582	98	38	280	134	48	362	630	2.6
Mimi	2	0.103	50	31	106	91	43	186	2429	3.5
Urenui	3	0.212	52	56	92	85	66	149	1102	3.2
Onaero	2	0.026	34	26	36	69	36	75	7302	4.2
Waitara	4	0.567	519	198	561	2030	272	1109	9807	4.0
Waiongana	2	0.09	72	9	5	557	13	16	16956	6.4
Waiwhakaiho	4	0.106	97	19	13	403	21	26	10408	3.9
Te Henui	1	0.017	16	2	2	73	2	4	11732	4.1
Tapuae	1	0.01	18	2	1	117	2	4	32055	6.3
Oakura	2	0.026	22	4	5	73	5	9	7692	3.5
Timaru	1	0.019	16	2	3	58	3	5	8421	3.1
Katikara	1	0.016	13	1	1	63	2	3	10736	4.5
Kaupokonui	2	0.038	83	10	6	583	14	15	42033	5.2
Waingongoro	2	0.016	116	27	5	863	27	16	147808	6.5
Tangahoe	3	0.018	43	5	31	110	16	52	16758	3.4
Manawapou	2	0.018	41	5	30	110	16	53	16758	3.5
Patea	4	0.491	375	65	241	1258	124	469	7020	3.9
Whenuakura	4	0.323	155	51	259	260	66	326	2207	2.5
Waitotara	4	0.98	356	94	812	439	139	1132	1228	2.8

[1] Estimates sourced from NIWA's CLUES - REC2 default setting (current loads) and all landuse set to native forest cover (natural state loads).

[2] 50% reduction applied to natural state component to account for expected nutrient uptake and retention in wetlands present under natural state.

Input data for NZ ETI Tool 1: Determining susceptibility of estuaries to eutrophication. Detailed metadata descriptions available at https://shiny.niwa.co.nz/Estuaries-Screening-Tool-1/. Field data was used to inform parameter values (V, P, Intertidal, est_area_m2, mean_depth) as appropriate.

Est_name	ETI_class	Qf[2]	TN river	TP river	V	P	b	A[1]	B[1]	R_NO3	R_DRP	Ocean-Salinity_mean	N Ocean	P Ocean	Intertidal	TI	est_area_m2	mean_depth	tidal_height
Waitotara	SSRTRE	44.3	439	139	1960000	1372000	NA	-0.466876	164.38	0.7	0.7	35	16.6	7.3	45.0	NA	980000	2.0	1.4
Waitara	SSRTRE	57.3	2030	272	1701000	1190700	NA	-0.504925	172.42	0.7	0.7	35	18.6	7.1	27.0	NA	567000	3.0	2.1
Patea	SSRTRE	29.5	1258	124	1473000	1031100	NA	-0.507392	196.82	0.7	0.7	35	16.2	7.3	37.0	NA	491000	3.0	2.1
Whenuakura	SSRTRE	10.2	260	66	646000	452200	NA	-0.517324	161.16	0.7	0.7	35	16.2	7.3	54.0	NA	323000	2.0	1.4
Tangahoe	SSRTRE	6.7	110	16	27000	18900	NA	-0.495041	179.46	0.7	0.7	35	18.7	7.2	57.0	NA	18000	1.5	1.1
Tongaporutu	SSRTRE	9.3	134	48	1164000	814800	NA	-0.518357	171.02	0.7	0.7	35	21.1	7.1	63.0	NA	582000	2.0	1.4
Waiongana	SSRTRE	4.8	557	13	135000	94500	NA	-0.451837	184.75	0.7	0.8	35	18.3	7.1	53.0	NA	90000	1.5	1.1
Waiwhakaiho	SSRTRE	12.1	403	21	15900	11130	NA	-0.501954	182.35	0.7	0.7	35	18.7	7.2	61.0	NA	10600	1.5	1.1
Mimi River	SSRTRE	3.6	91	43	257500	180250	NA	-0.538245	174.16	0.6	0.7	35	20.2	7.1	49.0	NA	103000	2.5	1.8
Urenui River	SSRTRE	4.4	85	66	530000	371000	NA	-0.440671	171.69	0.5	0.7	35	20.0	7.1	69.0	NA	212000	2.5	1.8
Mōhakatino	SSRTRE	5.0	54	20	963000	674100	NA	-0.496849	228.30	0.7	0.7	35	21.2	7.1	52.0	NA	321000	3.0	2.1
Manawapou	SSRTRE	2.9	110	16	27000	18900	NA	-0.495041	179.46	0.7	0.7	35	18.7	7.2	57.0	NA	18000	1.5	1.1
Onaero	SSRTRE	2.4	69	36	39000	27300	NA	-0.495041	179.46	0.7	0.7	35	18.7	7.2	37.0	NA	26000	1.5	1.1
Waingongoro	SSRTRE	7.2	863	27	24000	16800	NA	-0.495041	179.46	0.7	0.7	35	18.7	7.2	65.0	NA	16000	1.5	1.1
Kaupokonui	SSRTRE	3.1	583	14	57000	39900	NA	-0.495041	179.46	0.7	0.7	35	18.7	7.2	60.0	NA	38000	1.5	1.1
Oakura	SSRTRE	2.7	73	5	65000	45500	NA	-0.495041	179.46	0.7	0.7	35	18.7	7.2	52.0	NA	26000	2.5	1.8
Tapuae	SSRTRE	1.2	117	2	15000	10500	NA	-0.495041	179.46	0.7	0.7	35	18.7	7.2	44.0	NA	10000	1.5	1.1
Timaru	SSRTRE	1.8	58	3	19000	13300	NA	-0.495041	179.46	0.7	0.7	35	18.7	7.2	36.0	NA	19000	1.0	0.7
Te Henui	SSRTRE	1.2	73	2	25500	17850	NA	-0.495041	179.46	0.7	0.7	35	18.7	7.2	49.0	NA	17000	1.5	1.1
Katikara	SSRTRE	1.0	63	2	24000	16800	NA	-0.495041	179.46	0.7	0.7	35	18.7	7.2	56.0	NA	16000	1.5	1.1

[1] Estimated based on Taranaki Region SSRTREs with comparable physical properties and freshwater inflows.

[2] Supplied by Taranaki Region Council.

Input data for NZ ETI Tool 2: ETI Tool 2: Assessing estuary trophic state using measured trophic indicators. Detailed metadata descriptions available at https://shiny.niwa.co.nz/Estuaries-Screening-Tool-2/.											
estuary_name	CHLA[1]	macroal-gae_GNA_ha	macroal-gae_GNA_percent	macroal-gae_EQR	DO[1]	REDOX	TOC	TN	AMBI	soft_mud	estuary_type
Urenui	3.49	0	0	0.97	6.12	-50	NA	NA	NA	0.392	SSRTRE
Mimi	3.28	0	0	1	5.97	-47	NA	NA	NA	0.229	SSRTRE
Waitotara	3.02	0	0	1	7.84	-61	NA	NA	NA	0.34	SSRTRE
Waitara	2.42	0	0	1	9.22	-70	NA	NA	NA	0.26	SSRTRE
Patea	1.95	0	0	1	7.77	-41	NA	NA	NA	0.23	SSRTRE
Whenuakura	2.47	0	0	1	7.36	-34	NA	NA	NA	0.02	SSRTRE
Tangahoe	2.65	0	0	1	8.25	-23	NA	NA	NA	0	SSRTRE
Tongaporutu	1.32	0	0	1	6.06	-69	NA	NA	NA	0.23	SSRTRE
Waiongana	2.25	0	0	1	7.77	-41	NA	NA	NA	0.02	SSRTRE
Waiwhakaiho	1.68	0	0	1	10.96	-46	NA	NA	NA	0.01	SSRTRE
Mōhakatino	3.88	0	0	1	7.15	-54	NA	NA	NA	0.34	SSRTRE
Manawapou	2.67	0	0	1	8.06	-43	NA	NA	NA	0	SSRTRE
Onaero	8.28	0	0	1	5.41	-35	NA	NA	NA	0	SSRTRE
Waingongoro	2.3	0	0	1	11.37	34	NA	NA	NA	0	SSRTRE
Kaupokonui	1.58	0	0	1	8.18	-22	NA	NA	NA	0	SSRTRE
Oakura	20.33	0	0	1	9.27	-9	NA	NA	NA	0	SSRTRE
Tapuae	9.95	0	0	1	13.95	-21	NA	NA	NA	0	SSRTRE
Timaru	8.03	0	0	1	8.81	-14	NA	NA	NA	0	SSRTRE
Te Henui	2.48	0	0	1	9.35	-39	NA	NA	NA	0	SSRTRE
Katikara	21.53	0	0	1	13.9	-10	NA	NA	NA	0	SSRTRE

[1] 1-day mean based on measurement of surface and bottom waters within subtidal channel habitat, March 2019.

Summary of geology in catchments surrounding the Taranaki Region estuaries assessed[1].							
		Area (km^2)				Area (km^2)	
Urenui	Catchment	132.7	% catchment	Waiongana	Catchment	158.9	% catchment
	Massive mudstone	71.8	54%		Mudstone	152.1	96%
	Ash (older than Taupo ash)	22.0	17%		Peat	1.0	1%
	Massive sandstone	32.5	24%	Waiwhakaiho	Catchment	145.1	% catchment
Mimi	Catchment	133.4	% catchment		Alluvial / Gravels	5.3	11%
	Alluvial	11.3	9%		Mudstone	112.6	78%
	Massive mudstone	26.7	20%		Lahar deposits	1.3	3%
	Ash (older than Taupo ash)	28.8	22%	Mōhakatino	Catchment	122.6	% catchment
	Massive sandstone	66.5	50%		Alluvial	8.5	7%
Waitotora	Catchment	1185.0	% catchment		Mudstone	7.4	6%
	Alluvial	30.8	3%		Massive sand-stone	106.7	87%
	Loess	4.3	0%	Manawapou	Catchment	122.3	% catchment
	Mudstone	14.3	1%		Alluvial	1.9	2%
	Massive mudstone	15.4	1%		Mudstone	66.6	54%
	Ash (older than Taupo ash)	111.7	9%		Massive sand-stone	45.8	37%
	Peat	0.9	0%		Unconsolidated gravels and sands	7.7	6%
	Massive sandstone	973.8	82%	Onaero	Catchment	89.8	% catchment
	Windblown sand	31.6	3%		Alluvial	4.4	5%
Waitara	Catchment	1139.3	% catchment		Massive mudstone	34.1	38%
	Alluvial	26.4	2%		Massive sand-stone	11.0	12%
	Mudstone	27.8	2%		Ash (older than Taupo ash)	40.3	45%
	Massive mudstone	22.5	2%	Waingongoro	Catchment	219.1	% catchment
	Ash (older than Taupo ash)	528.2	46%		Ash (older than Taupo ash)	196.3	90%
	Massive sandstone	474.2	42%		Lavas & welded ignimbrites	2.9	1%
Patea	Catchment	1046.3	% catchment		Peat	10.2	5%
	Alluvial	48.3	5%	Kaupokonui	Catchment	146.9	% catchment
	Mudstone	0.0	0%		Ash (older than Taupo ash)	110.4	75%
	Massive mudstone	3.3	0%		Lavas & welded ignimbrites	6.9	5%
	Ash (older than Taupo ash)	373.8	36%		Taupo & Kaha-raoa breccias older than Taupo breccia	8.6	6%
	Peat	14.6	1%		Lahar deposits	4.7	3%
	Massive sandstone	591.1	56%				

[1] Data provided by Taranaki Regional Council.

Summary of geology in catchments surrounding the Taranaki Region estuaries assessed[1].							
		Area (km^2)				Area (km^2)	
Whenu-akura	Catchment	468.6	% catchment	Oakura	Catchment	44.1	% catchment
	Alluvial	7.0	1%		Ash (older than Taupo ash)	42.2	96%
	Massive mudstone	98.6	21%		Lavas & welded ignimbrites	1.4	3%
	Massive sandstone	359.5	77%	Tapuae	Catchment	31.9	% catchment
Tangahoe	Catchment	297.6	% catchment		Ash (older than Taupo ash)	31.8	100%
	Alluvial	4.8	2%		Lavas & welded ignimbrites	0.1	0.3%
	Mudstone	9.0	3%	Timaru	Catchment	31.4	% catchment
	Massive mudstone	164.9	55%		Ash (older than Taupo ash)	30.7	98%
	Peat	6.7	2%		Lavas & welded ignimbrites	0.5	2%
	Massive sandstone	99.1	33%	Te Henui	Catchment	28.4	% catchment
Tonga-porutu	Catchment	271.3	% catchment		Ash (older than Taupo ash)	24.9	88%
	Alluvial	8.5	3%		Massive sand-stone	3.5	12%
	Mudstone	0.3	0%	Katikara	Catchment	22.0	% catchment
	Massive mudstone	32.9	12%		Ash (older than Taupo ash)	21.9	99%
	Peat	0.0	0%		Massive sand-stone	0.1	1%
	Massive sandstone	229.7	85%				

[1] Data provided by Taranaki Regional Council.

Summary of subtidal water quality data[1].						
Estuary	Site	Parameter	Water Column Position		Location	
			Bottom	Surface	NZTM North	NZTM East
Urenui	Low Estuary	Depth (m)	0.6	0.2	1720484	5683261
		Temp (°C)	20.4	-		
		DO (%)	106.8	-		
		DO (mg m^{-3})	7.8	-		
		Salinity (ppt)	30.6	-		
		PC RFU	0.0	-		
		Chla (ug l^{-1})	1.5	-		
	Middle Estuary	Depth (m)	1.3	0.2	1720484	5683259
		Temp (°C)	20.5	20.5		
		DO (%)	106.6	107.1		
		DO (mg m^{-3})	7.8	7.8		
		Salinity (ppt)	30.7	5.9		
		PC RFU	0.0	0.0		
		Chla (ug l^{-1})	1.2	1.4		
	Upper Estuary	Depth (m)	2.3	0.2	1722523	5682929
		Temp (°C)	20.3	22.3		
		DO (%)	80.3	91.0		
		DO (mg m^{-3})	6.1	7.6		
		Salinity (ppt)	28.2	2.7		
		PC RFU	0.1	0.3		
		Chla (ug l^{-1})	4.2	6.3		
Mimi	Low Estuary	Depth (m)	2.0	0.2	1724812	5686241
		Temp (°C)	19.2	18.5		
		DO (%)	93.4	86.9		
		DO (mg m^{-3})	7.2	7.7		
		Salinity (ppt)	35.2	10.8		
		PC RFU	0.1	0.1		
		Chla (ug l^{-1})	1.8	2.1		
	Middle Estuary	Depth (m)	1.2	0.2	1725022	5686348
		Temp (°C)	19.5	18.7		
		DO (%)	90.1	85.9		
		DO (mg m^{-3})	6.8	7.6		
		Salinity (ppt)	30.2	10.5		
		PC RFU	0.1	0.2		
		Chla (ug l^{-1})	3.3	3.3		
	Upper Estuary	Depth (m)	2.3	0.2	1725634	5686117
		Temp (°C)	19.5	17.6		
		DO (%)	79.1	79.1		
		DO (mg m^{-3})	6.0	7.4		
		Salinity (ppt)	30.7	4.5		
		PC RFU	0.1	0.2		
		Chla (ug l^{-1})	3.0	3.5		

[1] All sampling undertaken at mid-low tide using an EXO1 (Sonde 15F103960; Serial Number: 15F103960; Firmware Version: 1.0.73), Feb 26th - March 4th 2019, Taranaki.

Summary of subtidal water quality data[1].						
Estuary	Site	Parameter	Water Column Position		Location	
			Bottom	Surface	NZTM North	NZTM East
Waitotara	Low Estuary	Depth (m)	2.0	0.2	1744999	5588387
		Temp (°C)	19.4	20.7		
		DO (%)	86.7	91.2		
		DO (mg m^{-3})	7.1	7.6		
		Salinity (ppt)	19.4	10.8		
		PC RFU	0.1	0.4		
		Chla (ug l^{-1})	2.5	5.2		
	Middle Estuary	Depth (m)	2.2	0.2	1747836	5589260
		Temp (°C)	20.4	20.2		
		DO (%)	84.3	83.2		
		DO (mg m^{-3})	7.6	7.5		
		Salinity (ppt)	0.2	0.3		
		PC RFU	0.3	0.5		
		Chla (ug l^{-1})	3.2	4.4		
	Upper Estuary	Depth (m)	2.0	0.2	1748593	5592321
		Temp (°C)	20.1	20.1		
		DO (%)	95.1	94.6		
		DO (mg m^{-3})	8.6	8.6		
		Salinity (ppt)	0.2	0.2		
		PC RFU	0.1	0.0		
		Chla (ug l^{-1})	1.4	1.4		
Waitara	Low Estuary	Depth (m)	4.0	0.2	1706451	5683599
		Temp (°C)	19.3	20.5		
		DO (%)	106.6	104.1		
		DO (mg m^{-3})	8.0	9.2		
		Salinity (ppt)	35.2	3.8		
		PC RFU	0.2	0.1		
		Chla (ug l^{-1})	2.5	2.1		
	Middle Estuary	Depth (m)	2.2	0.2	1707200	5682576
		Temp (°C)	20.4	20.5		
		DO (%)	111.7	110.3		
		DO (mg m^{-3})	9.5	9.7		
		Salinity (ppt)	10.1	10.0		
		PC RFU	0.1	0.1		
		Chla (ug l^{-1})	2.4	2.5		
	Upper Estuary	Depth (m)	2.0	0.2	1707493	5681336
		Temp (°C)	19.1	19.1		
		DO (%)	103.1	104.7		
		DO (mg m^{-3})	9.4	9.6		
		Salinity (ppt)	2.2	2.3		
		PC RFU	0.1	0.1		
		Chla (ug l^{-1})	2.4	2.6		

[1] All sampling undertaken at mid-low tide using an EXO1 (Sonde 15F103960; Serial Number: 15F103960; Firmware Version: 1.0.73), Feb 26th - March 4th 2019, Taranaki.

Summary of subtidal water quality data[1].						
Estuary	Site	Parameter	Water Column Position		Location	
			Bottom	Surface	NZTM North	NZTM East
Patea	Low Estuary	Depth (m)	4.0	0.2	1727540	5596823
		Temp (°C)	19.6	20.4		
		DO (%)	94.2	95.9		
		DO (mg m^{-3})	7.7	7.8		
		Salinity (ppt)	34.6	17.7		
		PC RFU	0.1	0.1		
		Chla (ug l^{-1})	1.9	1.9		
	Middle Estuary	Depth (m)	5.0	0.2	1727262	5597497
		Temp (°C)	19.7	20.3		
		DO (%)	94.2	95.9		
		DO (mg m^{-3})	7.7	7.8		
		Salinity (ppt)	17.7	17.7		
		PC RFU	0.1	0.1		
		Chla (ug l^{-1})	1.9	1.9		
	Upper Estuary	Depth (m)	2.0	0.2	1726837	5598645
		Temp (°C)	19.8	19.6		
		DO (%)	95.1	94.0		
		DO (mg m^{-3})	8.0	7.6		
		Salinity (ppt)	12.8	16.1		
		PC RFU	0.1	0.1		
		Chla (ug l^{-1})	1.6	2.5		
Whenuakura	Low Estuary	Depth (m)	2.0	0.2	1729461	5595530
		Temp (°C)	19.2	18.5		
		DO (%)	93.4	86.9		
		DO (mg m^{-3})	7.2	7.7		
		Salinity (ppt)	35.2	10.8		
		PC RFU	0.1	0.1		
		Chla (ug l^{-1})	1.8	2.1		
	Middle Estuary	Depth (m)	3.0	0.2	1730317	5595794
		Temp (°C)	18.3	20.7		
		DO (%)	95.3	97.9		
		DO (mg m^{-3})	7.3	8.6		
		Salinity (ppt)	34.8	3.5		
		PC RFU	0.2	0.2		
		Chla (ug l^{-1})	4.1	1.6		
	Upper Estuary	Depth (m)	3.0	0.2	1730222	5596645
		Temp (°C)	19.5	17.6		
		DO (%)	79.1	79.1		
		DO (mg m^{-3})	6.0	7.4		
		Salinity (ppt)	30.7	4.5		
		PC RFU	0.1	0.2		
		Chla (ug l^{-1})	4.0	1.2		

[1] All sampling undertaken at mid-low tide using an EXO1 (Sonde 15F103960; Serial Number: 15F103960; Firmware Version: 1.0.73), Feb 26th - March 4th 2019, Taranaki.

Summary of subtidal water quality data[1].						
Estuary	Site	Parameter	Water Column Position		Location	
			Bottom	Surface	NZTM North	NZTM East
Tangahoe	Low Estuary	Depth (m)	0.2		1715938	5609523
		Temp (°C)	16.2			
		DO (%)	110.7			
		DO (mg m^{-3})	10.9			
		Salinity (ppt)	0.2			
		PC RFU	0.1			
		Chla (ug l^{-1})	1.7			
	Middle Estuary	Depth (m)	1.5	0.2	1715965	5609607
		Temp (°C)	15.9	15.0		
		DO (%)	110.0	113.7		
		DO (mg m^{-3})	10.9	11.2		
		Salinity (ppt)	0.2	0.2		
		PC RFU	0.2	0.2		
		Chla (ug l^{-1})	5.7	3.2		
	Upper Estuary	Depth (m)				
		Temp (°C)				
		DO (%)				
		DO (mg m^{-3})				
		Salinity (ppt)				
		PC RFU				
		Chla (ug l^{-1})				
Tongaporutu	Low Estuary	Depth (m)	0.2		1738684	57021128
		Temp (°C)	19.2			
		DO (%)	99.4			
		DO (mg m^{-3})	7.3			
		Salinity (ppt)	35.2			
		PC RFU	0.0			
		Chla (ug l^{-1})	0.9			
	Middle Estuary	Depth (m)	3.0	0.2	1738586	5701588
		Temp (°C)	20.5	20.4		
		DO (%)	99.4	99.4		
		DO (mg m^{-3})	7.3	7.3		
		Salinity (ppt)	34.2	33.1		
		PC RFU	0.0	0.0		
		Chla (ug l^{-1})	1.1	1.2		
	Upper Estuary	Depth (m)	3.0	0.2	1738890	5699500
		Temp (°C)	18.9	19.9		
		DO (%)	90.1	89.3		
		DO (mg m^{-3})	7.0	7.5		
		Salinity (ppt)	28.4	14.9		
		PC RFU	0.1	0.1		
		Chla (ug l^{-1})	2.3	2.4		

[1] All sampling undertaken at mid-low tide using an EXO1 (Sonde 15F103960; Serial Number: 15F103960; Firmware Version: 1.0.73), Feb 26th - March 4th 2019, Taranaki.

Summary of subtidal water quality data[1].						
Estuary	Site	Parameter	Water Column Position		Location	
			Bottom	Surface	NZTM North	NZTM East
Waiongana	Low Estuary	Depth (m)	0.2		1702464	5682884
		Temp (°C)	20.0			
		DO (%)	119.2			
		DO (mg m^{-3})	10.5			
		Salinity (ppt)	4.7			
		PC RFU	0.2			
		Chla (ug l^{-1})	3.8			
	Middle Estuary	Depth (m)	3.0	0.2	1703188	5682285
		Temp (°C)	17.9	18.3		
		DO (%)	108.1	106.0		
		DO (mg m^{-3})	10.2	9.9		
		Salinity (ppt)	0.1	0.1		
		PC RFU	0.2	0.2		
		Chla (ug l^{-1})	3.7	1.5		
	Upper Estuary	Depth (m)				
		Temp (°C)				
		DO (%)				
		DO (mg m^{-3})				
		Salinity (ppt)				
		PC RFU				
		Chla (ug l^{-1})				
Waiwhakaiho	Low Estuary	Depth (m)	2.0	0.2	1696403	5678453
		Temp (°C)	19.8	21.5		
		DO (%)	120.9	123.9		
		DO (mg m^{-3})	11.0	10.9		
		Salinity (ppt)	0.1	0.1		
		PC RFU	0.1	0.5		
		Chla (ug l^{-1})	1.5	1.8		
	Middle Estuary	Depth (m)				
		Temp (°C)				
		DO (%)				
		DO (mg m^{-3})				
		Salinity (ppt)				
		PC RFU				
		Chla (ug l^{-1})				
	Upper Estuary	Depth (m)				
		Temp (°C)				
		DO (%)				
		DO (mg m^{-3})				
		Salinity (ppt)				
		PC RFU				
		Chla (ug l^{-1})				

[1] All sampling undertaken at mid-low tide using an EXO1 (Sonde 15F103960; Serial Number: 15F103960; Firmware Version: 1.0.73), Feb 26th - March 4th 2019, Taranaki.

Summary of subtidal water quality data[1].						
Estuary	Site	Parameter	Water Column Position		Location	
			Bottom	Surface	NZTM North	NZTM East
Mōhakatino	Low Estuary	Depth (m)	1.0	0.2	1740302	5711749
		Temp (°C)	19.1	19.1		
		DO (%)	93.1	93.0		
		DO (mg m^{-3})	7.1	7.1		
		Salinity (ppt)	32.0	32.0		
		PC RFU	0.2	0.2		
		Chla (ug l^{-1})	5.5	4.8		
	Middle Estuary	Depth (m)	2.0	0.2	1740739	5710974
		Temp (°C)	17.9	17.9		
		DO (%)	93.7	93.8		
		DO (mg m^{-3})	7.2	7.2		
		Salinity (ppt)	35.3	35.1		
		PC RFU	0.1	0.2		
		Chla (ug l^{-1})	2.1	3.1		
	Upper Estuary	Depth (m)				
		Temp (°C)				
		DO (%)				
		DO (mg m^{-3})				
		Salinity (ppt)				
		PC RFU				
		Chla (ug l^{-1})				
Manawapou	Low Estuary	Depth (m)	1.0		1715938	5609524
		Temp (°C)	16.0			
		DO (%)	110.5			
		DO (mg m^{-3})	10.1			
		Salinity (ppt)	0.1			
		PC RFU	0.1			
		Chla (ug l^{-1})	1.7			
	Middle Estuary	Depth (m)	2.0	0.2	1715968	5609607
		Temp (°C)	15.9	15.0		
		DO (%)	110.6	113.7		
		DO (mg m^{-3})	10.9	11.2		
		Salinity (ppt)	0.1	0.1		
		PC RFU	0.3	0.2		
		Chla (ug l^{-1})	5.8	3.2		
	Upper Estuary	Depth (m)				
		Temp (°C)				
		DO (%)				
		DO (mg m^{-3})				
		Salinity (ppt)				
		PC RFU				
		Chla (ug l^{-1})				

[1] All sampling undertaken at mid-low tide using an EXO1 (Sonde 15F103960; Serial Number: 15F103960; Firmware Version: 1.0.73), Feb 26th - March 4th 2019, Taranaki.

Summary of subtidal water quality data[1].						
Estuary	Site	Parameter	Water Column Position		Location	
			Bottom	Surface	NZTM North	NZTM East
Onaero	Low Estuary	Depth (m)	0.5		1718288	5682899
		Temp (°C)	22.0			
		DO (%)	54.5			
		DO (mg m^{-3})	3.9			
		Salinity (ppt)	33.1			
		PC RFU	0.3			
		Chla (ug l^{-1})	8.1			
	Middle Estuary	Depth (m)	0.5		1718300	5682691
		Temp (°C)	21.7			
		DO (%)	81.2			
		DO (mg m^{-3})	6.9			
		Salinity (ppt)	26.9			
		PC RFU	0.5			
		Chla (ug l^{-1})	8.5			
	Upper Estuary	Depth (m)				
		Temp (°C)				
		DO (%)				
		DO (mg m^{-3})				
		Salinity (ppt)				
		PC RFU				
		Chla (ug l^{-1})				
Waingongoro	Low Estuary	Depth (m)	2.0	0.2	1702391	5617525
		Temp (°C)	16.3	16.4		
		DO (%)	110.7	114.9		
		DO (mg m^{-3})	10.9	11.2		
		Salinity (ppt)	0.1	0.1		
		PC RFU	0.1	0.1		
		Chla (ug l^{-1})	1.7	2.4		
	Middle Estuary	Depth (m)	2.5	0.2	1702469	5617650
		Temp (°C)	17.2	16.5		
		DO (%)	126.2	114.2		
		DO (mg m^{-3})	12.3	11.1		
		Salinity (ppt)	0.1	0.1		
		PC RFU	0.2	0.2		
		Chla (ug l^{-1})	2.9	2.2		
	Upper Estuary	Depth (m)				
		Temp (°C)				
		DO (%)				
		DO (mg m^{-3})				
		Salinity (ppt)				
		PC RFU				
		Chla (ug l^{-1})				

[1] All sampling undertaken at mid-low tide using an EXO1 (Sonde 15F103960; Serial Number: 15F103960; Firmware Version: 1.0.73), Feb 26th - March 4th 2019, Taranaki.

Summary of subtidal water quality data[1].						
Estuary	Site	Parameter	Water Column Position		Location	
			Bottom	Surface	NZTM North	NZTM East
Kaupokonui	Low Estuary	Depth (m)	2.0	0.2	1691152	5619874
		Temp (°C)	15.9	15.7		
		DO (%)	108.1	111.0		
		DO (mg m^{-3})	10.7	11.0		
		Salinity (ppt)	0.1	0.1		
		PC RFU	0.2	0.1		
		Chla (ug l^{-1})	3.1	1.2		
	Middle Estuary	Depth (m)	0.5	-	1691145	5620002
		Temp (°C)	15.7			
		DO (%)	112.0			
		DO (mg m^{-3})	11.0			
		Salinity (ppt)	0.1			
		PC RFU	0.2			
		Chla (ug l^{-1})	2.0			
	Upper Estuary	Depth (m)				
		Temp (°C)				
		DO (%)				
		DO (mg m^{-3})				
		Salinity (ppt)				
		PC RFU				
		Chla (ug l^{-1})				
Oakura	Low Estuary	Depth (m)	1.5	0.2	1682702	5670485
		Temp (°C)	21.0	19.9		
		DO (%)	>150	122.0		
		DO (mg m^{-3})	>15.0	11.1		
		Salinity (ppt)	19.9	0.1		
		PC RFU	2.1	0.1		
		Chla (ug l^{-1})	30.7	1.9		
	Middle Estuary	Depth (m)	2.0	0.2	1682779	5670404
		Temp (°C)	21.0	19.6		
		DO (%)	100.5	107.5		
		DO (mg m^{-3})	8.1	9.8		
		Salinity (ppt)	17.2	171.8		
		PC RFU	3.0	0.1		
		Chla (ug l^{-1})	47.7	1.0		
	Upper Estuary	Depth (m)				
		Temp (°C)				
		DO (%)				
		DO (mg m^{-3})				
		Salinity (ppt)				
		PC RFU				
		Chla (ug l^{-1})				

[1] All sampling undertaken at mid-low tide using an EXO1 (Sonde 15F103960; Serial Number: 15F103960; Firmware Version: 1.0.73), Feb 26th - March 4th 2019, Taranaki.

Summary of subtidal water quality data[1].						
Estuary	Site	Parameter	Water Column Position		Location	
			Bottom	Surface	NZTM North	NZTM East
Tapuae	Low Estuary	Depth (m)	1.5	0.2	1684537	5671624
		Temp (°C)	20.5	20.6		
		DO (%)	109.3	104.3		
		DO (mg m^{-3})	7.2	6.7		
		Salinity (ppt)	0.1	0.1		
		PC RFU	0.1	0.1		
		Chla (ug l^{-1})	1.9	1.7		
	Middle Estuary	Depth (m)	1.0	0.2	1684558	5671501
		Temp (°C)	22.0	20.7		
		DO (%)	>150	132.0		
		DO (mg m^{-3})	30.1	11.8		
		Salinity (ppt)	15.2	0.1		
		PC RFU	1.4	0.1		
		Chla (ug l^{-1})	35.0	1.2		
	Upper Estuary	Depth (m)				
		Temp (°C)				
		DO (%)				
		DO (mg m^{-3})				
		Salinity (ppt)				
		PC RFU				
		Chla (ug l^{-1})				
Te Henui	Low Estuary	Depth (m)	0.5		1694204	5676999
		Temp (°C)	17.7			
		DO (%)	96.6			
		DO (mg m^{-3})	9.2			
		Salinity (ppt)	0.1			
		PC RFU	0.2			
		Chla (ug l^{-1})	3.3			
	Middle Estuary	Depth (m)	2.0	0.2	1694363	5676943
		Temp (°C)	17.4	17.8		
		DO (%)	96.2	99.8		
		DO (mg m^{-3})	9.2	9.5		
		Salinity (ppt)	165.5	135.9		
		PC RFU	0.2	0.1		
		Chla (ug l^{-1})	4.8	0.9		
	Upper Estuary	Depth (m)				
		Temp (°C)				
		DO (%)				
		DO (mg m^{-3})				
		Salinity (ppt)				
		PC RFU				
		Chla (ug l^{-1})				

[1] All sampling undertaken at mid-low tide using an EXO1 (Sonde 15F103960; Serial Number: 15F103960; Firmware Version: 1.0.73), Feb 26th - March 4th 2019, Taranaki.

Summary of subtidal water quality data[1].						
Estuary	Site	Parameter	Water Column Position		Location	
			Bottom	Surface	NZTM North	NZTM East
Katikara	Low Estuary	Depth (m)	1.5	0.2	1676574	5667865
		Temp (°C)	22.0	19.6		
		DO (%)	>150	107.2		
		DO (mg m^{-3})	17.6	9.8		
		Salinity (ppt)	4.5	0.1		
		PC RFU	1.3	0.2		
		Chla (ug l^{-1})	37.3	2.9		
	Middle Estuary	Depth (m)	1.0	0.2	1676534	5667773
		Temp (°C)	22.0	18.4		
		DO (%)	>150	125.4		
		DO (mg m^{-3})	16.5	11.7		
		Salinity (ppt)	12.5	0.1		
		PC RFU	1.3	0.1		
		Chla (ug l^{-1})	42.8	3.1		
	Upper Estuary	Depth (m)				
		Temp (°C)				
		DO (%)				
		DO (mg m^{-3})				
		Salinity (ppt)				
		PC RFU				
		Chla (ug l^{-1})				
Timaru	Low Estuary	Depth (m)	0.5		1679659	5669540
		Temp (°C)	17.9			
		DO (%)	100.8			
		DO (mg m^{-3})	9.5			
		Salinity (ppt)	0.05			
		PC RFU	0.05			
		Chla (ug l^{-1})	1.02			
	Middle Estuary	Depth (m)	3	0.2	1679592	5669461
		Temp (°C)	21.4	18.3		
		DO (%)	67.1	98.9		
		DO (mg m^{-3})	4.9	9.2		
		Salinity (ppt)	29.8	0.05		
		PC RFU	0.3	0.02		
		Chla (ug l^{-1})	18.9	0.38		
	Upper Estuary	Depth (m)	2	0.2	1679597	5669299
		Temp (°C)	21.5	19.5		
		DO (%)	142	104		
		DO (mg m^{-3})	11	9.1		
		Salinity (ppt)	21.3	0.05		
		PC RFU	0.5	0.1		
		Chla (ug l^{-1})	26.5	0.8		

[1] All sampling undertaken at mid-low tide using an EXO1 (Sonde 15F103960; Serial Number: 15F103960; Firmware Version: 1.0.73), Feb 26th - March 4th 2019, Taranaki.

Appendix C:

Vulnerability Matrices
Taranaki Region Estuaries (Section 2.2)

MŌHAKATINO ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: MŌHAKATINO ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS			
Minimal		High	
Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Minimal
Macroalgal susceptibility:	Moderate
Overall Susceptibility to Eutrophication Rating	Moderate (Band B)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

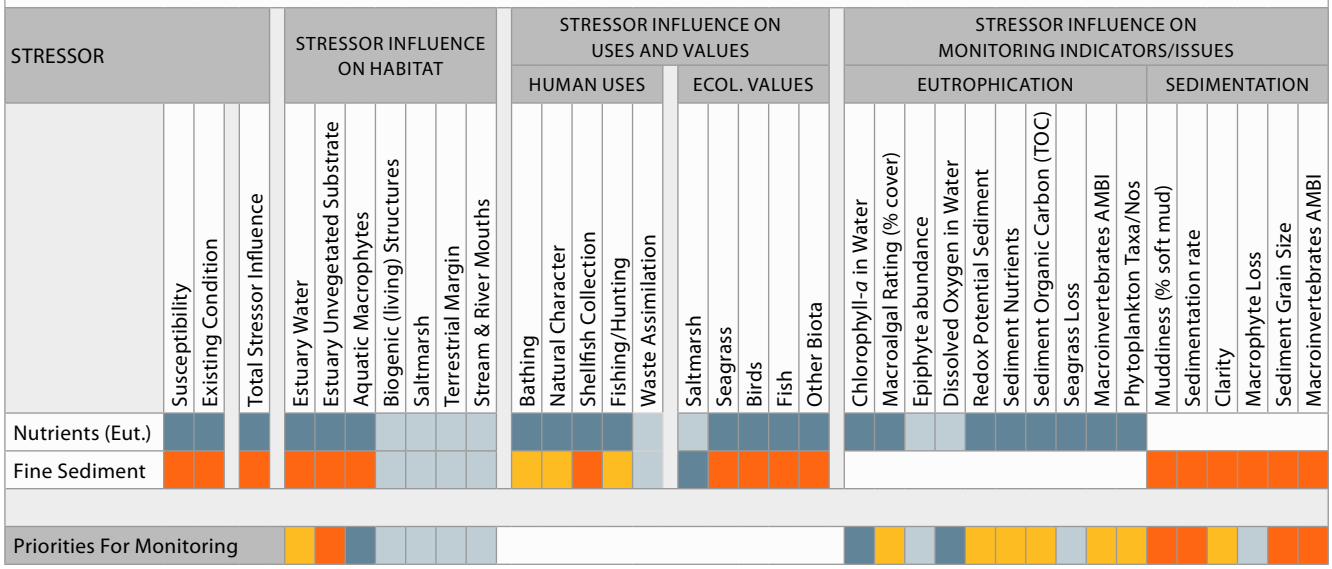
Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 2 subtidal sites, n=4) = 3.88 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 2 subtidal sites, n=4) = 7.15 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low throughout estuary	Moderate
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -54 mV	Moderate
Sediment % Mud	34% of unvegetated intertidal estuary was soft mud	Very High
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 60% of estuary	
Overall Existing Condition Eutrophication Rating		Moderate (Band B)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	2.6	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - poorly flushed at low flows.	High
Overall Sedimentation Susceptibility Rating		Mod-High

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	34% of unvegetated intertidal estuary and approximately 50-60% of subtidal area was soft muds.	Very High
Overall Sedimentation Existing Condition Rating		Very High



TONGAPORUTU ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: TONGAPORUTU ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Minimal
Macroalgal susceptibility:	High
Overall Susceptibility to Eutrophication Rating	High (Band C)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 3 subtidal sites, n=5) = 1.32 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 3 subtidal sites, n=5) = 6.06 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -69 mV	Moderate
Sediment % Mud	23% of unvegetated intertidal estuary soft mud	Very High
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 60% of estuary	
Overall Existing Condition Eutrophication Rating		Moderate (Band B)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	2.6	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - mid-upper intertidal regions poorly flushed at low flows.	Mod-High
Overall Sedimentation Susceptibility Rating		Mod-High

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	23% of unvegetated intertidal estuary and approximately 30-40% of subtidal area was soft muds.	Very High
Overall Sedimentation Existing Condition Rating		Very High

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES															
											HUMAN USES						ECOL. VALUES					EUTROPHICATION											SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

MIMI ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: MIMI ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Minimal
Macroalgal susceptibility:	Very High
Overall Susceptibility to Eutrophication Rating	Very High

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 3 subtidal sites, n=6) = 2.38 ug l^{-1}	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 3 subtidal sites, n=6) = 7.1 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -47 mV	Moderate
Sediment % Mud	26% of unvegetated intertidal estuary was soft mud	Very High
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		Moderate

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	3.5	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - poorly flushed at low flows.	High
Overall Sedimentation Susceptibility Rating		Mod-High

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	26% of unvegetated intertidal estuary and approximately 50-60% of subtidal area was soft muds.	Very High
Overall Sedimentation Existing Condition Rating		Very High

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																	
											HUMAN USES					ECOL. VALUES					EUTROPHICATION										SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-*a* in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																					
Fine Sediment																																					
Priorities For Monitoring																																					

URENUI ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: URENUI ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Minimal
Macroalgal susceptibility:	Very High
Overall Susceptibility to Eutrophication Rating	Very High (Band D)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 3 subtidal sites, n=5) = 3.08 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 3 subtidal sites, n=5) = 7.5 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Localised patches, but very low throughout estuary	Moderate
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -50 mV	Moderate
Sediment % Mud	39.2% of unvegetated intertidal estuary soft mud	Very High
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 60% of estuary	
Overall Existing Condition Eutrophication Rating		Moderate

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	3.2	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - poorly flushed at low flows.	High
Overall Sedimentation Susceptibility Rating		Mod-High

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	39.2% of unvegetated intertidal estuary and approximately 50-60% of subtidal area was soft muds. Local residents indicated that the estuary had got muddier in recent years. But sandy in lower estuary.	Very High
Overall Sedimentation Existing Condition Rating		Very High

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																
											HUMAN USES					ECOL. VALUES					EUTROPHICATION									SEDIMENTATION							
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-*a* in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

ONAERO ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: ONAERO ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Minimal
Macroalgal susceptibility:	Minimal
Overall Susceptibility to Eutrophication Rating	Minimal (Band A)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (bottom water - @0.5 m - at 2 subtidal sites, n=2) = 8.28 ug l^{-1} - indicative value only	Moderate
Dissolved Oxygen	1-day mean (bottom water - @0.5 m - at 2 subtidal sites, n=2) = 5.41 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -35 mV	Minimal
Sediment % Mud	No intertidal soft mud	Minimal
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		Moderate (Band B)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	4.2	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - possibly poorly flushed at low flows.	Moderate
Overall Sedimentation Susceptibility Rating		Moderate

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	No intertidal soft mud, but approximately 20-30% subtidal benthos in soft muds.	Moderate
Overall Sedimentation Existing Condition Rating		Moderate

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																	
											HUMAN USES					ECOL. VALUES					EUTROPHICATION										SEDIMENTATION							
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-*a* in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																					
Fine Sediment																																					
Priorities For Monitoring																																					

WAITARA ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: WAITARA ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Minimal
Macroalgal susceptibility:	Minimal
Overall Susceptibility to Eutrophication Rating	Minimal (Band A)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 3 subtidal sites, n=6) = 2.42 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 3 subtidal sites, n=6) = 9.22 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -70 mV	Moderate
Sediment % Mud	26% of unvegetated intertidal estuary was soft mud	Very High
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 60% of estuary	
Overall Existing Condition Eutrophication Rating		Moderate (Band B)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	4.0	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - intertidal regions poorly flushed at low flows.	Mod-High
Overall Sedimentation Susceptibility Rating		Mod-High

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	26% of unvegetated intertidal estuary and approximately 20-30% of subtidal area was soft muds.	Very High
Overall Sedimentation Existing Condition Rating		Very High

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																
											HUMAN USES						ECOL. VALUES					EUTROPHICATION										SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-*a* in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

WAIONGANA ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: WAIONGANA ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility	Minimal
Macroalgal susceptibility	Minimal
Overall Susceptibility to Eutrophication Rating	Minimal (Band A)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 2 subtidal sites, n=3) = 2.25 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 2 subtidal sites, n=3) = 7.66 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low (cover/biomass) throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -41 mV	Minimal
Sediment % Mud	2% intertidal estuary in soft mud	Minimal
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		Minimal (Band A)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	6.4	Very High
Presence of Poorly Flushed Habitat	Well flushed during flood periods - possibly poorly flushed at low flows	Minimal
Overall Sedimentation Susceptibility Rating		Moderate

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	2% intertidal and approximately 30-40% subtidal benthos (mid-upper estuary) in soft muds	Moderate
Overall Sedimentation Existing Condition Rating		Moderate

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																
											HUMAN USES						ECOL. VALUES					EUTROPHICATION										SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-*a* in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

WAIWHAKAIHO ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: WAIWHAKAIHO ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility	Minimal
Macroalgal susceptibility	Minimal
Overall Susceptibility to Eutrophication Rating	Minimal (Band A)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 1 subtidal sites, n=2) = 1.68 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 1 subtidal sites, n=2) = 10.96 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low (cover/biomass) throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -46 mV	Minimal
Sediment % Mud	1% intertidal estuary in soft mud	Minimal
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		Minimal (Band A)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	3.9	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - possibly poorly flushed at low flows	Minimal
Overall Sedimentation Susceptibility Rating		Moderate

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	1% intertidal area and approximately 10-20% subtidal benthos (constricted arm in lower estuary) in soft muds	Moderate
Overall Sedimentation Existing Condition Rating		Moderate

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																
											HUMAN USES					ECOL. VALUES					EUTROPHICATION										SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

TE HENUI ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: TE HENUI ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Minimal
Macroalgal susceptibility:	Minimal
Overall Susceptibility to Eutrophication Rating	Minimal (Band A)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 2 subtidal sites, n=3) = 2.48 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 2 subtidal sites, n=3) = 9.35 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low (cover/biomass) throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -39 mV	Minimal
Sediment % Mud	No intertidal soft mud	Minimal
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		Minimal (Band A)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	4.1	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - possibly poorly flushed at low flows.	Moderate
Overall Sedimentation Susceptibility Rating		Moderate

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	No intertidal soft mud, but approximately 30-40% subtidal benthos (mid-upper estuary) in soft muds.	Moderate
Overall Sedimentation Existing Condition Rating		Moderate

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																
											HUMAN USES					ECOL. VALUES					EUTROPHICATION										SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

TAPUAE ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: TAPUAE ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Minimal
Macroalgal susceptibility:	Minimal
Overall Susceptibility to Eutrophication Rating	Minimal (Band A)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 2 subtidal sites, n=4) = 9.95 ug l^{-1} - indicative value only	Moderate
Dissolved Oxygen	1-day mean (surface and bottom water at 2 subtidal sites, n=4) = 13.95 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low (cover/biomass) throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -21 mV	Minimal
Sediment % Mud	No intertidal soft mud	Minimal
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		Minimal (Band A)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	3.2	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - possibly poorly flushed at low flows.	Moderate
Overall Sedimentation Susceptibility Rating		Moderate

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	No intertidal soft mud, but approximately 30-40% subtidal benthos (mid-upper estuary) in soft muds.	Moderate
Overall Sedimentation Existing Condition Rating		Moderate

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																
											HUMAN USES						ECOL. VALUES					EUTROPHICATION											SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

OAKURA ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: OAKURA ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Moderate
Macroalgal susceptibility:	Moderate
Overall Susceptibility to Eutrophication Rating	Moderate (Band B)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 2 subtidal sites, n=4) = 20.33 ug l^{-1} - indicative value only	High
Dissolved Oxygen	1-day mean (surface and bottom water at 2 subtidal sites, n=4) = 9.27 mg l^{-1} - indicative value only	Minimal
Macroalgae (EQR)	Very low throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -9 mV	Minimal
Sediment % Mud	No intertidal soft mud	Minimal
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		High (Band C)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	3.5	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - possibly poorly flushed at low flows.	Moderate
Overall Sedimentation Susceptibility Rating		Moderate

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	No intertidal soft mud, but approximately 30-40% subtidal benthos in soft muds.	Moderate
Overall Sedimentation Existing Condition Rating		Moderate

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																
											HUMAN USES					ECOL. VALUES					EUTROPHICATION										SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

TIMARU ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: TIMARU ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility	Minimal
Macroalgal susceptibility	Minimal
Overall Susceptibility to Eutrophication Rating	Minimal (Band A)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 3 subtidal sites, n=5) = 8.03 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 3 subtidal sites, n=5) = 8.81 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low (cover/biomass) throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -14 mV	Minimal
Sediment % Mud	No intertidal soft mud	Minimal
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		Minimal (Band A)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	3.1	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - possibly poorly flushed at low flows	Moderate
Overall Sedimentation Susceptibility Rating		Moderate

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	No intertidal soft mud, but approximately 30-40% subtidal benthos (mid-upper estuary) in soft muds	Moderate
Overall Sedimentation Existing Condition Rating		Moderate

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																
											HUMAN USES						ECOL. VALUES					EUTROPHICATION											SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

KATIKARA ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: KATIKARA ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Moderate
Macroalgal susceptibility:	Minimal
Overall Susceptibility to Eutrophication Rating	Moderate (Band B)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 2 subtidal sites, n=4) = 21.53 ug l^{-1} - indicative value only	High
Dissolved Oxygen	1-day mean (surface and bottom water at 2 subtidal sites, n=4) = 13.9 mg l^{-1} - indicative value only	Minimal
Macroalgae (EQR)	Very low throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -10 mV	Minimal
Sediment % Mud	No intertidal soft mud	Minimal
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		High (Band C)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	4.5	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - possibly poorly flushed at low flows.	Moderate
Overall Sedimentation Susceptibility Rating		Moderate

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	No intertidal soft mud, but approximately 30-40% subtidal benthos in soft muds.	Moderate
Overall Sedimentation Existing Condition Rating		Moderate

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																
											HUMAN USES					ECOL. VALUES					EUTROPHICATION									SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

KOUPOKONUI ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: KAUPOKONUI ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Minimal
Macroalgal susceptibility:	Minimal
Overall Susceptibility to Eutrophication Rating	Minimal (Band A)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 2 subtidal sites, n=3) = 1.58 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 2 subtidal sites, n=3) = 8.18 mg l^{-1} - indicative value only	Minimal
Macroalgae (EQR)	Very low (cover/biomass) throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -22 mV	Minimal
Sediment % Mud	No intertidal soft mud	Minimal
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		Minimal (Band A)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	5.2	Very High
Presence of Poorly Flushed Habitat	Well flushed during flood periods - possibly poorly flushed at low flows.	Moderate
Overall Sedimentation Susceptibility Rating		Moderate

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	No intertidal soft mud, but approximately 30-40% subtidal benthos in soft muds.	Moderate
Overall Sedimentation Existing Condition Rating		Moderate

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																
											HUMAN USES					ECOL. VALUES					EUTROPHICATION										SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

WAINGONGORO ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: WAINGONGORO ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility	Minimal
Macroalgal susceptibility	Minimal
Overall Susceptibility to Eutrophication Rating	Minimal (Band A)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 2 subtidal sites, n=4) = 2.30 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 2 subtidal sites, n=4) = 11.37 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low (cover/biomass) throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = +34 mV (coarse sands)	Minimal
Sediment % Mud	No intertidal soft mud	Minimal
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		Minimal (Band A)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	6.5	Very High
Presence of Poorly Flushed Habitat	Very well flushed during flood periods - possibly poorly flushed at low flows	Minimal
Overall Sedimentation Susceptibility Rating		Moderate

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	No intertidal or subtidal soft muds	Minimal
Overall Sedimentation Existing Condition Rating		Minimal

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																
											HUMAN USES						ECOL. VALUES					EUTROPHICATION										SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

TANGAHOE ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: TANGAHOE ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Minimal
Macroalgal susceptibility:	Minimal
Overall Susceptibility to Eutrophication Rating	Minimal (Band A)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 2 subtidal sites, n=3) = 2.65 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 2 subtidal sites, n=3) = 8.25 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low (cover/biomass) throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -23 mV	Minimal
Sediment % Mud	No intertidal soft mud	Minimal
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		Minimal (Band A)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	3.4	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - possibly poorly flushed at low flows.	Moderate
Overall Sedimentation Susceptibility Rating		Moderate

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	No intertidal soft mud, but approximately 30-40% subtidal benthos (mid-upper estuary) in soft muds.	Moderate
Overall Sedimentation Existing Condition Rating		Moderate

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES															
											HUMAN USES					ECOL. VALUES					EUTROPHICATION										SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																			
Fine Sediment																																			
Priorities For Monitoring																																			

MANAWAPOU ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: MANAWAPOU ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Minimal
Macroalgal susceptibility:	Minimal
Overall Susceptibility to Eutrophication Rating	Minimal (Band A)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 2 subtidal sites, n=3) = 2.67 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 2 subtidal sites, n=3) = 8.06 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low (cover/biomass) throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -43 mV	Minimal
Sediment % Mud	No intertidal soft mud	Minimal
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		Minimal (Band A)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	3.5	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - possibly poorly flushed at low flows.	Minimal
Overall Sedimentation Susceptibility Rating		Moderate

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	No intertidal soft mud, but approximately 30-40% subtidal benthos in soft muds.	Moderate
Overall Sedimentation Existing Condition Rating		Moderate

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																
											HUMAN USES						ECOL. VALUES					EUTROPHICATION											SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

PATEA ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: PATEA ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Minimal
Macroalgal susceptibility:	Very High
Overall Susceptibility to Eutrophication Rating	Very High (Band D)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 3 subtidal sites, n=6) = 1.95 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 3 subtidal sites, n=6) = 7.77 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -41 mV	Moderate
Sediment % Mud	23% of unvegetated intertidal estuary soft mud	Very High
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 60% of estuary	
Overall Existing Condition Eutrophication Rating		Moderate

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	3.9	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - poorly flushed at low flows.	High
Overall Sedimentation Susceptibility Rating		Mod-High

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	23% of unvegetated intertidal estuary and approximately 50-60% of subtidal area was soft muds.	Very High
Overall Sedimentation Existing Condition Rating		Very High

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES																
											HUMAN USES					ECOL. VALUES					EUTROPHICATION										SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

WHENUAKURA ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: WHENUAKURA ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility	Minimal
Macroalgal susceptibility	Very High
Overall Susceptibility to Eutrophication Rating	Very High (Band D)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

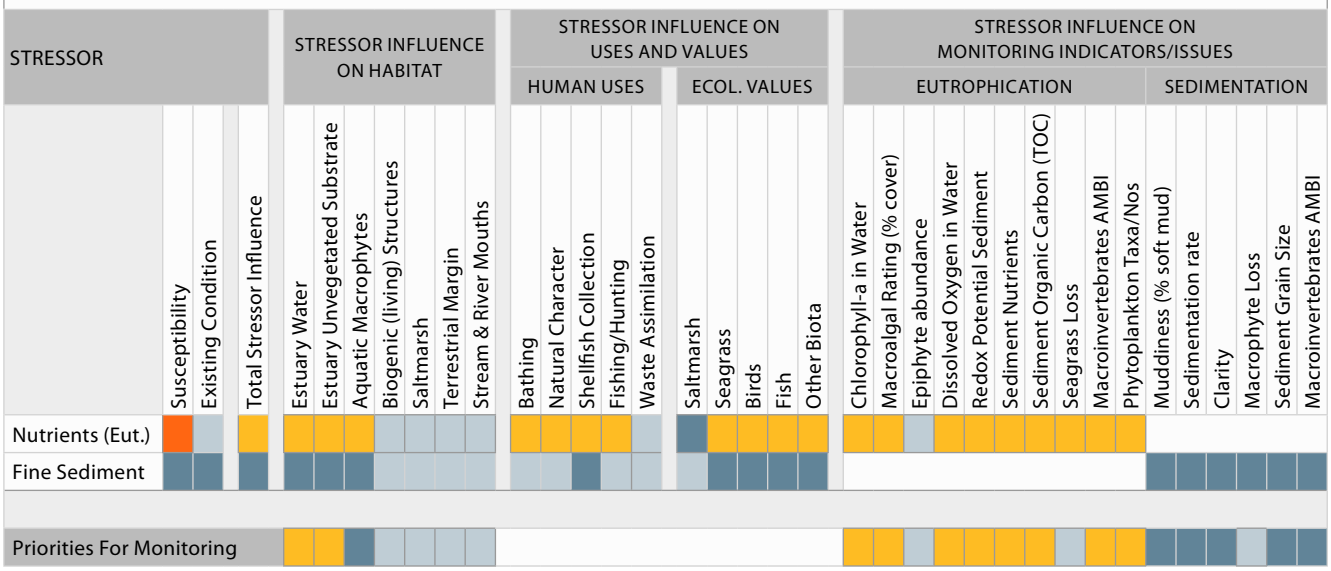
Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 3 subtidal sites, n=6) = 2.47 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 3 subtidal sites, n=6) = 7.36 mg l^{-1} - indicative value only	Min-Moderate
Macroalgae (EQR)	Very low (cover/biomass) throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -34 mV	Minimal
Sediment % Mud	2% intertidal estuary in soft mud	Minimal
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 40% of estuary	
Overall Existing Condition Eutrophication Rating		Minimal (Band A)

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	2.5	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - possibly poorly flushed at low flows	Moderate
Overall Sedimentation Susceptibility Rating		Moderate

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	2% intertidal area and approximately 30-40% subtidal benthos in soft muds	Moderate
Overall Sedimentation Existing Condition Rating		Moderate



WAITOTARA ESTUARY - VULNERABILITY TO EUTROPHICATION AND SEDIMENTATION DETAILS

SITE: WAITOTARA ESTUARY
DATE: (MARCH 2019)

KEY FOR NZ ETI-BASED RATINGS				
	Minimal		High	
	Moderate		Very High	

SUSCEPTIBILITY AND EXISTING CONDITION RATINGS

1. NZ ETI (TOOL 1) EUTROPHICATION RATINGS BASED ON SUSCEPTIBILITY TO NUTRIENT LOADS AND PHYSICAL CHARACTERISTICS

Phytoplankton susceptibility:	Minimal
Macroalgal susceptibility:	Minimal
Overall Susceptibility to Eutrophication Rating	Minimal (Band A)

2. NZ ETI (TOOL 2) EUTROPHICATION RATINGS BASED ON EXISTING CONDITION

Primary Indicators		
Chlorophyll *a*	1-day mean (surface and bottom water at 3 subtidal sites, n=6) = 3.02 ug l^{-1} - indicative value only	Minimal
Dissolved Oxygen	1-day mean (surface and bottom water at 3 subtidal sites, n=6) = 7.84 mg l^{-1} - indicative value only	Moderate
Macroalgae (EQR)	Very low throughout estuary	Minimal
Supporting Indicators		
Redox Potential	Mean of measured RP at 1 cm depth (representative the most impacted sediments in at least 10% of estuary area) = -61 mV	Minimal
Sediment % Mud	34% of unvegetated intertidal estuary was soft mud	Very High
Seagrass	No seagrass in estuary	Not Used
Clarity (SD, cm)	SD not visible on bed over 60% of estuary	
Overall Existing Condition Eutrophication Rating		Minimal

3. SUSCEPTIBILITY TO SEDIMENTATION RATINGS BASED ON SEDIMENT LOADS AND PHYSICAL CHARACTERISTICS

Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	2.8	Moderate
Presence of Poorly Flushed Habitat	Well flushed during flood periods - poorly flushed at low flows.	High
Overall Sedimentation Susceptibility Rating		Mod-High

4. SEDIMENTATION RATINGS BASED ON EXISTING CONDITION

Percentage of estuary with soft mud (~>25% sediment mud content)	34% of unvegetated intertidal estuary and approximately 50-60% of subtidal area was soft muds.	Very High
Overall Sedimentation Existing Condition Rating		Very High

STRESSOR				STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES															
											HUMAN USES					ECOL. VALUES					EUTROPHICATION										SEDIMENTATION						
	Susceptibility	Existing Condition	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Redox Potential Sediment	Sediment Nutrients	Sediment Organic Carbon (TOC)	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Taxa/Nos	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates AMBI
Nutrients (Eut.)																																				
Fine Sediment																																				
Priorities For Monitoring																																				

Appendix D:

Broad Scale Habitat Classifications

Vegetation was classified using an interpretation of the Atkinson (1985) system, whereby dominant plant species were coded by using the two first letters of their Latin genus and species names e.g. marram grass, *Ammophila arenaria*, was coded as Amar. An indication of dominance is provided by the use of ( ) to distinguish subdominant species e.g. Amar(Caed) indicates that marram grass was dominant over ice plant (*Carpobrotus edulis*). The use of ( ) is not always based on percentage cover, but the subjective observation of which vegetation is the dominant or subdominant species within the patch. A measure of vegetation height can be derived from its structural class (e.g. rushland, scrub, forest).

Vegetation (mapped separately to the substrata they overlie):

Forest: Woody vegetation in which the cover of trees and shrubs in the canopy is >80% and in which tree cover exceeds that of shrubs. Trees are woody plants ≥10 cm diameter at breast height (dbh). Tree ferns ≥10 cm dbh are treated as trees. Commonly sub-grouped into native, exotic or mixed forest.

Treeland: Cover of trees in the canopy is 20-80%. Trees are woody plants >10 cm dbh. Commonly sub-grouped into native, exotic or mixed treeland.

Scrub: Cover of shrubs and trees in the canopy is >80% and in which shrub cover exceeds that of trees (c.f. FOREST). Shrubs are woody plants <10 cm dbh. Commonly sub-grouped into native, exotic or mixed scrub.

Shrubland: Cover of shrubs in the canopy is 20-80%. Shrubs are woody plants <10 cm dbh. Commonly sub-grouped into native, exotic or mixed shrubland.

Tussockland: Vegetation in which the cover of tussock in the canopy is 20-100% and in which the tussock cover exceeds that of any other growth form or bare ground. Tussock includes all grasses, sedges, rushes, and other herbaceous plants with linear leaves (or linear non-woody stems) that are densely clumped and >100 cm height. Examples of the growth form occur in all species of *Cortaderia, Gahnia*, and *Phormium*, and in some species of *Chionochloa, Poa, Festuca, Rytidosperma, Cyperus, Carex, Uncinia, Juncus, Astelia, Aciphylla*, and *Celmisia* spp..

Duneland: Vegetated sand dunes in which the cover of vegetation in the canopy (commonly *Spinifex*, *Pingao* or Marram grass) is 20-100% and in which the vegetation cover exceeds that of any other growth form or bare ground.

Grassland: Vegetation in which the cover of grass (excluding tussock-grasses) in the canopy is 20-100%, and in which the grass cover exceeds that of any other growth form or bare ground.

Sedgeland: Vegetation in which the cover of sedges (excluding tussock-sedges and reed-forming sedges) in the canopy is 20-100% and in which the sedge cover exceeds that of any other growth form or bare ground. Sedges vary from grass by feeling the stem. If the stem is flat or rounded, it's probably a grass or a reed, if the stem is clearly triangular, it's a sedge. Sedges include many species of *Carex, Uncinia*, and *Scirpus*.

Rushland: Vegetation in which the cover of rushes (excluding tussock-rushes) in the canopy is 20-100% and where rush cover exceeds that of any other growth form or bare ground. A tall grasslike, often hollow-stemmed plant, included in rushland are some species of *Juncus* and all species of *Leptocarpus*.

Reedland: Vegetation in which the cover of reeds in the canopy is 20-100% and in which the reed cover exceeds that of any other growth form or open water. Reeds are herbaceous plants growing in standing or slowly-running water that have tall, slender, erect, unbranched leaves or culms that are either round and hollow – somewhat like a soda straw, or have a very spongy pith. Unlike grasses or sedges, reed flowers will each bear six tiny petal-like structures. Examples include *Typha, Bolboschoenus, Scirpus lacutris, Eleocharis sphacelata*, and *Baumea articulata*.

Cushionfield: Vegetation in which the cover of cushion plants in the canopy is 20-100% and in which the cushion-plant cover exceeds that of any other growth form or bare ground. Cushion plants include herbaceous, semi-woody and woody plants with short densely packed branches and closely spaced leaves that together form dense hemispherical cushions.

Herbfield: Vegetation in which the cover of herbs in the canopy is 20-100% and where herb cover exceeds that of any other growth form or bare ground. Herbs include all herbaceous and low-growing semi-woody plants that are not separated as ferns, tussocks, grasses, sedges, rushes, reeds, cushion plants, mosses or lichens.

Lichenfield: Vegetation in which the cover of lichens in the canopy is 20-100% and where lichen cover exceeds that of any other growth form or bare ground.

Introduced weeds: Vegetation in which the cover of introduced weeds in the canopy is 20-100% and in which the weed cover exceeds that of any other growth form or bare ground.

Seagrass meadows: Seagrasses are the sole marine representatives of the Angiospermae. They all belong to the order Helobiae, in two families: Potamogetonaceae and Hydrocharitaceae. Although they may occasionally be exposed to the air, they are predominantly submerged, and their flowers are usually pollinated underwater. A notable feature of all seagrass plants is the extensive underground root/rhizome system which anchors them to their substrata. Seagrasses are commonly found in shallow coastal marine locations, salt-marshes and estuaries and are mapped separately to the substrata they overlie.

Macroalgal bed: Algae are relatively simple plants that live in freshwater or saltwater environments. In the marine environment, they are often called seaweeds. Although they contain cholorophyll, they differ from many other plants by their lack of vascular tissues (roots, stems, and leaves). Many familiar algae fall into three major divisions: Chlorophyta (green algae), Rhodophyta (red algae), and Phaeophyta (brown algae). Macroalgae are algae observable without using a microscope. Macroalgal density, biomass and entrainment are classified and mapped separately to the substrata they overlie.

Substrata (physical and biogenic habitat):

Artificial structures: Introduced natural or man-made materials that modify the environment. Includes rip-rap, rock walls, wharf piles, bridge supports, walkways, boat ramps, sand replenishment, groynes, flood control banks, stopgates.

Cliff: A steep face of land which exceeds the area covered by any one class of plant growth-form. Cliffs are named from the dominant substrata type when unvegetated or the leading plant species when plant cover is ≥1%.

Rock field: Land in which the area of residual rock exceeds the area covered by any one class of plant growth-form. They are named from the leading plant species when plant cover is ≥1%.

Boulder field: Land in which the area of unconsolidated boulders (>200 mm diam.) exceeds the area covered by any one class of plant growth-form. Boulder fields are named from the leading plant species when plant cover is ≥1%.

Cobble field: Land in which the area of unconsolidated cobbles (20-200 mm diam.) exceeds the area covered by any one class of plant growth-form. Cobble fields are named from the leading plant species when plant cover is ≥1%.

Gravel field: Land in which the area of unconsolidated gravel (2-20 mm diameter) exceeds the area covered by any one class of plant growth-form. Gravel fields are named from the leading plant species when plant cover is ≥1%.

Mobile sand: Granular beach sand characterised by a rippled surface layer from strong tidal or wind-generated currents. Often forms bars and beaches.

Firm or soft sand: Sand flats may be mud-like in appearance but are granular when rubbed between the fingers and no conspicuous fines are evident when sediment is disturbed e.g. a mud content <1%. Classified as firm sand if an adult sinks <2 cm or soft sand if an adult sinks >2 cm.

Firm muddy sand: A sand/mud mixture dominated by sand with a moderate mud fraction (e.g. 1-10%), the mud fraction conspicuous only when sediment is mixed in water. The sediment appears brown, and may have a black anaerobic layer below. From a distance appears visually similar to firm sandy mud, firm or soft mud, and very soft mud. When walking you'll sink 0-2 cm. Granular when rubbed between the fingers.

Firm sandy mud: A sand/mud mixture dominated by sand with an elevated mud fraction (e.g. 10-25%), the mud fraction visually conspicuous when walking on it. The surface appears brown, and may have a black anaerobic layer below. From a distance appears visually similar to firm muddy sand, firm or soft mud, and very soft mud. When walking you'll sink 0-2 cm. Granular when rubbed between the fingers, but with a smoother consistency than firm muddy sand.

Firm or soft mud: A mixture of mud and sand where mud is a major component (e.g. >25% mud). Sediment rubbed between the fingers retains a granular component but is primarily smooth/silken. The surface appears grey or brown, and may have a black anaerobic layer below. From a distance appears visually similar to firm muddy sand, firm sandy mud, and very soft mud. Classified as firm mud if an adult sinks <5 cm (usually if sediments are dried out or another component e.g. gravel prevents sinking) or soft mud if an adult sinks >5 cm.

Very soft mud: A mixture of mud and sand where mud is the major component (e.g. >50% mud), the surface appears brown, and may have a black anaerobic layer below. When walking you'll sink >5 cm unless another component e.g. gravel prevents sinking. From a distance appears visually similar to firm muddy sand, firm sandy mud, and firm or soft mud. Sediment rubbed between the fingers may retain a slight granular component but is primarily smooth/silken.

Cockle bed/Mussel reef/Oyster reef: Area that is dominated by both live and dead cockle shells, or one or more mussel or oyster species respectively.

Sabellid field: Area that is dominated by raised beds of sabellid polychaete tubes.

Shell bank: Area that is dominated by dead shells.

Appendix E:

Field Photographs

Mohakatino Estuary

Tongaporutu Estuary

Mimi Estuary

Urenui Estuary

Onaero Estuary

Waitara Estuary

Waiongana Estuary

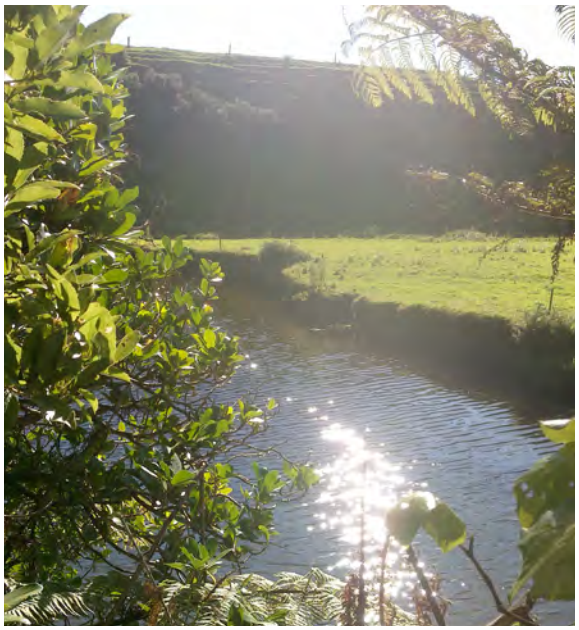
Waiwhakaiho Estuary

Te Henui Estuary

Tapuae Estuary

Oakura Estuary

Timaru Estuary



Katikara Estuary

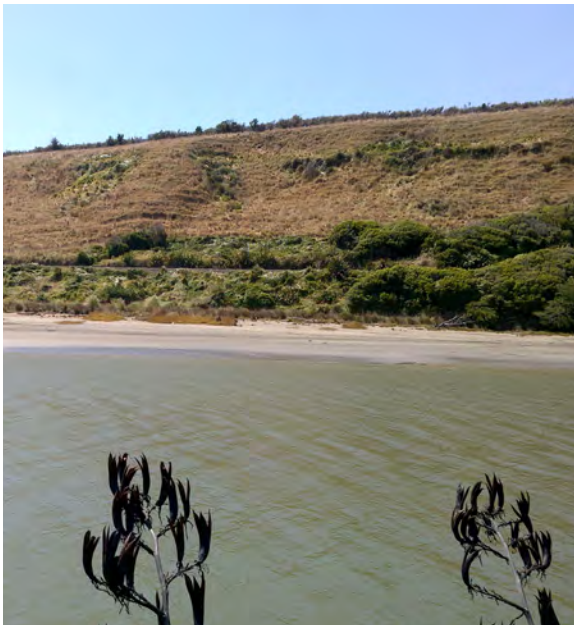
Kaupokonui Estuary

Waingongoro Estuary

Tangahoe Estuary

Manawapou Estuary

Patea Estuary



Whenuakura Estuary

Waitotara Estuary

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