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Whareama Estuary

Intertidal Sediment Monitoring 2015/16

Prepared for Greater Wellington Regional Council May 2016

Cover Photo: Whareama Estuary - Site WhaB, January 2016.

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Intertidal Sediment Monitoring 2015/16

Prepared for
Greater Wellington Regional Council

By

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1. INTRODUCTION AND METHODS

Whareama Estuary

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Vulnerability Assessment
Identifies issues and recommends monitoring and management. Completed in 2007 (Robertson and Stevens 2007)

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Whareama Estuary Issues
Moderate eutrophication
Excessive sedimentation
Habitat Loss (terrestrial margin)

↓

Monitoring

Broad Scale Mapping	Fine Scale Monitoring
Sediment type Saltmarsh Seagrass Macroalgae Land margin	Grain size, RPD, Organic Content Nutrients, Metals, Invertebrates, Macroalgae
5 -10 yearly First undertaken in 2007. Next due 2017. Macroalgae not yet undertaken.	**3yr Baseline then 5 yearly** Baseline completed 2010. **Sedimentation** 5 yearly. Next survey 2020.

↓

Condition Ratings
Area soft mud, Area saltmarsh, Area seagrass, Area terrestrial margin, RPD depth, Benthic Community, Organic content, N and P, Toxicity, Sedimentation rate.

Other Information
Previous reports, Observations, Expert opinion

↓

ESTUARY CONDITION
Moderate Eutrophication
Excessive Sedimentation
Low Toxicity
Habitat Degraded (terrestrial margin)

↓

Recommended Management

- Manage sediment and nutrient inputs.
- Set nutrient, sediment guidelines.
- Margin vegetation enhancement.
- Manage weeds and pests.

Soil erosion is a major issue in New Zealand and the resulting suspended sediment impacts are of particular concern in estuaries which act as a sink for fine sediments or muds. Where fine sediment inputs exceed the assimilative capacity of an estuary, high value habitat (e.g. seagrass, saltmarsh, shellfish beds) can be displaced, and the estuary can infill (often rapidly). Excess mud will also commonly result in adverse conditions including reduced sediment oxygenation, production of toxic sulphides, increased nuisance macroalgal growth, increased turbidity (from re-suspension), and a shift towards a degraded invertebrate and plant community. Such changes greatly reduce its value for fish, birdlife, and its amenity value for humans. As a consequence of a soft rock type catchment dominated by steep hills, combined with a primary landuse of pastoral grazing, Whareama Estuary receives elevated inputs of fine sediments, has turbid waters, and muddy intertidal flats.

Fine scale monitoring (Robertson and Stevens 2008-2010) showed the intertidal flats had high sedimentation rates, poorly oxygenated sediments with a high mud content, and a benthic invertebrate community dominated by mud and organic enrichment tolerant species. In response to these indicators of excessive muddiness and poor sediment oxygenation, annual monitoring of sedimentation rate, grain size, and Redox Potential Discontinuity (RPD) depth has been undertaken. The current report summarises the intertidal sediment monitoring results for these primary indicators in Whareama Estuary, one of the key estuaries in the Greater Wellington Regional Council (GWRC) coastal monitoring programme. The report presents the results from sampling on 26 January 2016, and uses sediment "risk indicator ratings" developed for Wellington's estuaries to help assess monitoring results (see page 2).

Detailed descriptions of sampling sites and methods are provided in (Robertson and Stevens 2008), and are briefly summarised below.

Sedimentation Rate

To monitor ongoing sedimentation rates 4 concrete plates were buried within intertidal sediments in 2008 at fine scale site WhaB (Figure 1), with changes in sediment levels over the plates monitored annually since that time. Localised spatial and temporal variation from natural processes such as wind generated waves, tidal flows, and river inputs are accounted for by deriving a mean annual sedimentation rate across all plates located in the primary settlement area in the lower estuary.

Grain Size

To monitor changes in the mud content of sediments, a single composite sample of the top 20mm of sediment was collected from 10 plots at fine scale site WhaA and WhaB) and analysed by Hill Laboratories for grain size (% mud, sand, gravel).

Redox Potential Discontinuity (RPD) depth

To assess sediment oxygenation, the depth to the RPD was measured at 10 plots at each fine scale site by digging down from the surface with a hand trowel until the visually apparent RPD transition was located.

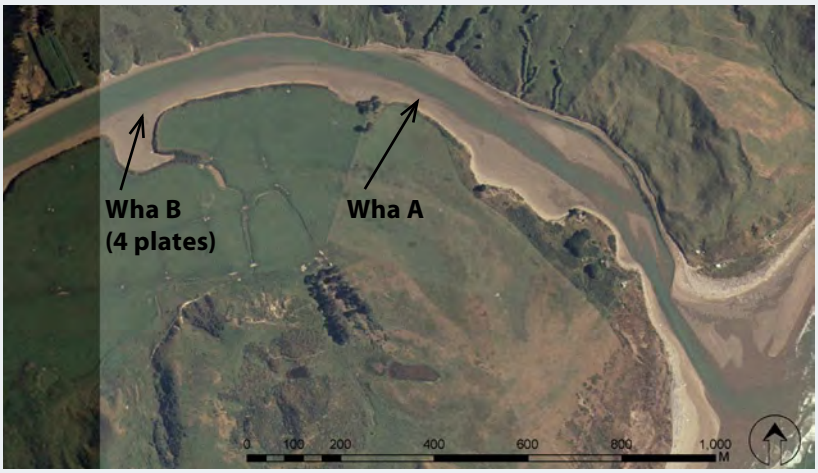

Figure 1. Location of fine scale sites and buried sediment plates in Whareama Estuary.

Risk Indicator Ratings

The National Estuary Monitoring Protocol (NEMP, Robertson et al. 2002), and subsequent additions (e.g. Robertson and Stevens 2006, 2007, 2012), recommend a defensible, cost-effective monitoring design for assessing the long term condition of shallow, intertidally-dominated, NZ estuarine systems. The design is based on the use of indicators that have a documented strong relationship with water or sediment quality. The approach is intended to help quickly identify the likely presence of the predominant issues affecting NZ estuaries (i.e. eutrophication, sedimentation, disease risk, toxicity and habitat change). In order to facilitate this process, "risk indicator ratings" have been proposed that assign a relative level of risk of adversely affecting estuary conditions (e.g. very low, low, moderate, high, very high) to each indicator (see examples below). Each risk indicator rating is designed to be used in combination with relevant information and other risk indicator ratings, and under expert guidance, to assess overall estuary condition in relation to key issues. When interpreting risk indicator results we emphasise:

- The importance of taking into account other relevant information and/or indicator results before making management decisions regarding the presence or significance of any estuary issue.
- That rating and ranking systems can easily mask or oversimplify results. For instance, large changes can occur within a within a risk category, but small changes near the edge of one risk category may shift the rating to the next risk level.
- Most issues will have a mix of primary and secondary ratings, primary ratings being given more weight in assessing the significance of indicator results.
- Ratings for most indicators have not been established using statistical measures, primarily because of the extensive additional work and cost this requires. In the absence of funding, professional judgment, based on our wide experience from monitoring >300 NZ estuaries, has been used in making initial interpretations. Our hope is that where a high level of risk is identified, the following steps are taken:
    1. Statistical measures be used to refine indicators and guide monitoring and management for priority issues.
    2. Issues identified as having a high likelihood of causing a significant change in ecological condition (either positive or negative), trigger intensive, targeted investigations to appropriately characterise the extent of the issue.
    3. The outputs stimulate discussion regarding what an acceptable level of risk is, and how it should best be managed.

The indicators and risk ratings relevant to the Whareama Estuary sedimentation monitoring programme are presented in Table 1 below:

Table 1. Risk indicator ratings for sedimentation rate, sediment mud content, and RPD depth.

RISK INDICATOR RATING	SEDIMENTATION RATE[1]	MUD CONTENT[2]	RPD DEPTH[3]
Very Low	<1mm/yr	<2%	>10cm
Low	>1-2mm/yr	2-5%	3-10cm
Moderate	>2-5mm/yr	>5-15%	1-<3cm
High	>5-10mm/yr	>15-25%	0-<1cm
Very High	>10mm/yr	>25%	Anoxic at surface

NOTES:

Detailed background notes explaining the use and justifications for each indicator are presented in the NZ ETI (Robertson et al. 2016a, 2016b).

[1]**Sedimentation Rate:** Elevated sedimentation rates are likely to lead to major and detrimental ecological changes within estuary areas that could be very difficult to reverse, and indicate where changes in land use management may be needed. Note the very low risk category is based on a typical NZ pre-European average rate of <1mm/year, which may underestimate sedimentation rates on the Wairarapa coast.

[2]**Sediment Mud Content:** In their natural state, most NZ estuaries would have been dominated by sandy or shelly substrates. Fine sediment is likely to cause detrimental and difficult to reverse changes in community composition (Robertson 2013), can facilitate the establishment of invasive species, increase turbidity (from re-suspension), and reduce amenity values. High or increasing mud content can indicate where changes in land use management may be needed.

[3]**Redox Potential Discontinuity (RPD):** RPD depth, the transition between oxygenated sediments near the surface and deeper anoxic sediments, is a primary estuary condition indicator as it is a direct measure of whether nutrient and organic enrichment exceeds levels causing nuisance (anoxic) conditions. Knowing if the RPD close to the surface is important for two main reasons:

1. As the RPD layer gets close to the surface, a "tipping point" is reached where the pool of sediment nutrients (which can be large), suddenly becomes available to fuel algal blooms and to worsen sediment conditions.
2. Anoxic sediments contain toxic sulphides and support very little aquatic life.

In sandy porous sediments, the RPD layer is usually relatively deep (>3cm) and is maintained primarily by current or wave action that pumps oxygenated water into the sediments. In finer silt/clay sediments, physical diffusion limits oxygen penetration to <1cm (Jørgensen and Revsbech 1985) unless bioturbation by infauna oxygenates the sediments. The tendency for sediments to become anoxic is much greater if the sediments are muddy.

2. RESULTS, RATING AND MANAGEMENT

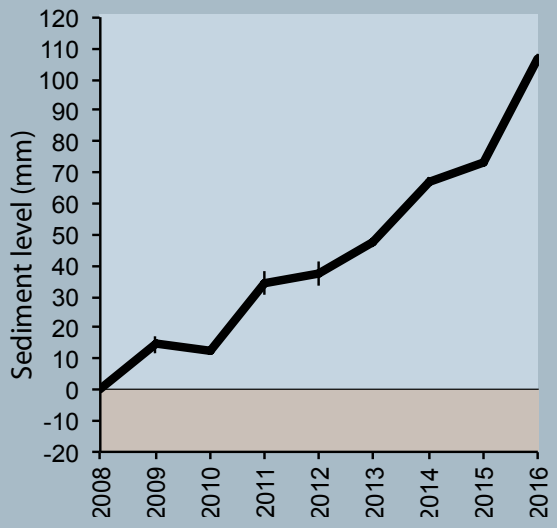

Figure 2. Change in mean sediment level (+/- SE, n=4), Whareama Estuary, 2008 to 2016.

The three risk indicators used to assess sediment condition in 2015 were sedimentation rate, sediment mud content, and RPD depth.

Sedimentation Rate

The depths to four plates buried in Whareama Estuary (see Robertson and Stevens 2008) were measured in January 2016 as part of annual long term sedimentation rate monitoring in the estuary (Figure 2, Table 2).

Mean annual sedimentation rates for the site since 2008 range from -2 to +33.3mm/yr. The variance between years is almost certainly due to river related deposition and erosion of sediment. The highest rate of net sediment deposition measured was recorded in 2016, covering the period Jan 2015 to Jan 2016.

Since 2008 site overall has shown a mean increase of 13.3mm/yr, and a total increase of 107mm. This mean sedimentation rate is in the "very high" risk category and indicates that the intertidal flats in the lower Whareama Estuary are currently infilling at a rapid rate.

Figure 3. Example of intertidal soft mud deposits at Whareama Estuary, Site WhaB, Jan. 2016.

2. Results, Rating and Management (Continued)

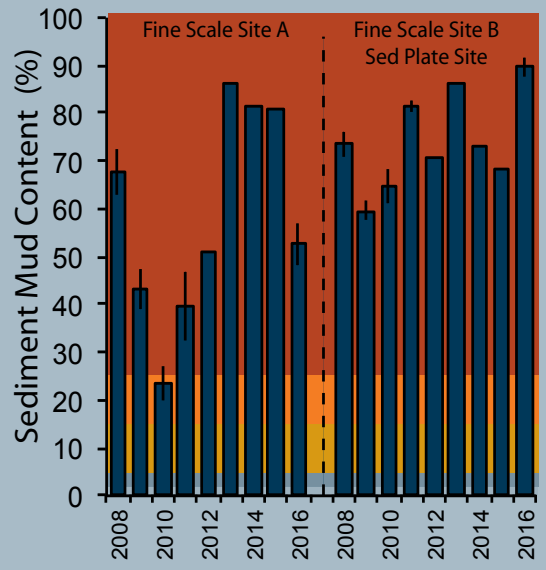

Figure 4. Sediment mud content (mean +/-SE, n=3*), Whareama Estuary, 2008-2016.
*2012, 2013, 2014 , 2015 = single composite sample

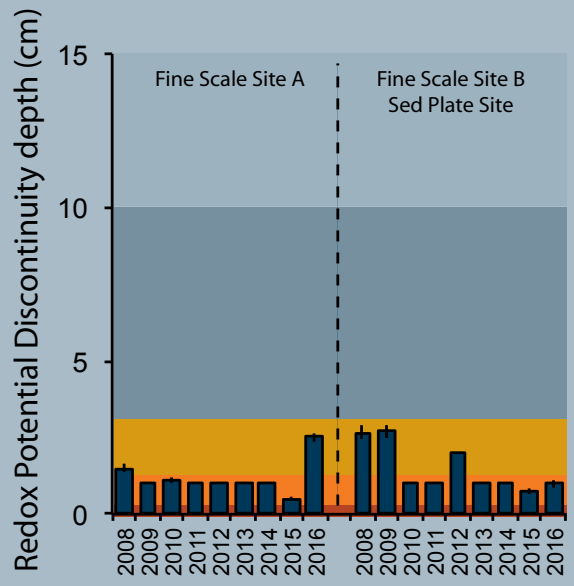

Figure 5. aRPD depth (mean +/-SE, n=10), Whareama Estuary, 2008-2016.

Sediment Mud Content

Grain size (% mud, sand, gravel) is a key indicator of both eutrophication and sediment changes. In tidal river estuaries that lack large intertidal flats, like Whareama, elevated levels of mud are often present along the narrow channel banks in the lower estuary. A high or increasing mud content signals a deterioration in estuary condition.

Results show both Whareama fine scale sites were very muddy in 2016 (53% at Site A and 90% at Site B, a risk indicator rating of "very high") and have been consistently muddy since monitoring started in 2008 (Figure 4, Table 3). As noted in previous reports, the relatively low mud content recorded at WhaA in 2010 was due to marine sands being overlain on mudflats in this part of the estuary, which was again evident in 2016. Both sites are subjected to regular flood deposition erosion with the high mud content attributed to ongoing effects of flood deposition in the lower estuary. Pulsed inputs of mud smothering the surface of the estuary are usually highly detrimental to the animals living on and in the sediments, while the very high mud content means the sediment dwelling community will be dominated by the relatively few species able to tolerate such muddy conditions.

Redox Potential Discontinuity (RPD)

The depth to the RPD boundary is a key primary estuary condition indicator in that it provides a direct measure of sediment oxygenation. This commonly shows whether nutrient enrichment in the estuary exceeds levels causing nuisance anoxic conditions in the surface sediments, and also reflects the capacity of tidal flows to maintain and replenish sediment oxygen levels. In well flushed sandy intertidal sediments, tidal flows typically oxygenate the top 5-10cm of sediment. However, when fine muds fill the interstitial pore spaces, less re-oxygenation occurs and the RPD moves closer to the surface.

In response to the presence of fine muds and, to a lesser extent, nutrient enrichment, the RPD depth at both Whareama sites is relatively close (1-3cm) to the surface (Figure 5, Table 3) indicating sediments are relatively poorly oxygenated and within the "moderate" risk indicator rating.

Table 2. Sediment plate data, Whareama Estuary (2008-2016).

SITE	Measured Mean Depth to Sediment Plate (mm)									Change in Sediment Level Over Plate (mm)								SEDIMENTATION RATE
	18/1/08	18/1/09	22/1/10	16/1/11	22/2/12	14/1/13	23/1/14	22/1/15	26/1/16	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2008-2016 Site mean (mm/yr)
Plate 1	182	188	185	202	216	230	254	257	295	6	-3	17	14	14	24	3	38	13.3
Plate 2	156	170	170	201	199	205	221	229	262	14	0	31	-2	6	16	8	33	(SE=0.4)
Plate 3	215	234	232	256	252	262	282	291	325	19	-2	24	-4	10	20	9	34	RISK INDICATOR RATING
Plate 4	216	235	232	247	251	261	281	285	313	19	-3	15	4	10	20	4	28	VERY HIGH
Mean Change in Sediment Level (mm/yr)										+14.5	-2.0	+21.8	+3.0	+10.0	+20.0	+6.0	+33.3	

2. Results, Rating and Management (Continued)

Table 3. aRPD depth and grain size results, Whareama Estuary, (26 Jan. 2016).

Fine Scale Site	aRPD mean depth (cm)	% Mud	% Sand	% Gravel
Whareama A	2.5 (Range=2.0-3.0)	48.3	51.5	0.3
		61.3	38.7	< 0.1
		48.2	51.5	0.3
Whareama B	1 (Range=0.5-1.5)	86.3	13.7	< 0.1
		89.5	10.5	< 0.1
		93.0	7.0	< 0.1

Note grain size results are based on three samples (two a composite from four plots and one a composite from two plots) of the top 20mm of sediment collected from each fine scale site. aRPD depth is based on 10 replicate measures at each site.

CONCLUSION

The very high rate of sedimentation, very high percentage mud content, and relatively shallow aRPD depth, indicate there is a high to very high risk of elevated muddiness and rapid infilling adversely affecting estuary condition.

RECOMMENDED MONITORING AND INTENSIVE INVESTIGATIONS

It is recommended that long term monitoring continue as outlined below:

Sediment Monitoring. As a robust baseline has now been established, monitor sedimentation rate, RPD depth and grain size in conjunction with 5 yearly fine scale monitoring (see below).

Fine Scale Monitoring. It is recommended that "complete" fine scale monitoring assessment (including sedimentation rate measures and macroalgal mapping) be undertaken at 5 yearly intervals (next due to be repeated in 2021).

Broad Scale Habitat Mapping. It is recommended that broad scale habitat mapping be undertaken at 10 yearly intervals. Although next scheduled for Jan-Feb 2017, any decision regarding ongoing monitoring should be linked to a review of catchment land management and reflect region-wide priorities.

If initiated, it is recommended that broad scale mapping be expanded to include subtidal areas, considering the predominantly subtidal nature of Whareama River Estuary (see following recommendation).

Intensive Investigation.

In order to defensibly support effective management decisions, further intensive investigations are recommended as follows:

- Assess the full extent of current sedimentation within this 10-11km long estuary (broad scale subtidal mapping is recommended as the first step to identifying fine sediment deposition areas).
- Subsequently develop a defensible monitoring programme to assess whole estuary sedimentation rates and the success of catchment erosion control initiatives.
- Identify ecological consequences (in particular, to macroinvertebrates, fish and birds) of current sedimentation rates and develop sedimentation rating thresholds for differing categories of ecosystem protection for this tidal river estuary situated in a very erosion-prone catchment.
- Establish both "natural state" sedimentation rates and "recommended" target sedimentation rates that will ensure that the estuary is maintained in at least a moderate ecological state.

RECOMMENDED MANAGEMENT

The fine scale monitoring results reinforce the need for management of fine sediment and, to a lesser extent, nutrient sources entering the estuary. However, further investigations are recommended before defensible targets for fine sediment loads can be identified (see above).

Such investigations will provide a foundation to further guide the type and extent of sediment control initiatives already being undertaken in the catchment. Currently ~50% of the catchment is included under farm erosion plans as part of the Wellington Regional Erosion Control Initiative (WRECI) established in 2009.

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Figure 6. Oxic brown surface sediments overlying anoxic muds at Site WhaB, 26 January 2016.