greater WELLINGTON
REGIONAL COUNCIL
Te Pane Matua Taiao

Coastal State of the Environment monitoring programme

Annual data report, 2014/15

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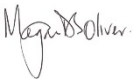
Report prepared by:	MD Oliver	Senior Environmental Scientist – Coast	
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Contents

1. Introduction

This report summarises the key results of microbiological water quality, sediment quality, ecological health and habitat monitoring undertaken in the Wellington Region's near-shore coastal environment for the period 1 July 2014 to 30 June 2015. Note that the suitability of coastal waters for contact recreation purposes is assessed separately under Greater Wellington Regional Council's (GWRC) recreational water quality monitoring programme (see Keenan et al. 2015 for the 2014/15 results).

2. Overview of Coastal SoE monitoring programme

Coastal monitoring in the Wellington Region began around 25 years ago, with a focus on microbiological water quality – a reflection of the high usage of much of the region's coastline for contact recreation such as swimming and surfing. Periodic assessments of contaminants in shellfish flesh commenced around 1997, with the most recent assessment undertaken at 20 sites in 2006 (see Milne 2006). In 2004 monitoring expanded into coastal ecology and sediment quality, with a key focus being the effects of urban stormwater on our coastal harbour environments. In addition, between 2004 and 2008 broad scale surveys of the region's coastal habitats were carried out, with fine scale sediment and ecological assessments undertaken at representative intertidal locations of selected estuaries and sandy beaches. The information gained from these surveys was combined with ecological vulnerability assessments to identify priorities for a long-term monitoring programme that would enable GWRC to fulfil State of the Environment (SoE) monitoring obligations with respect to coastal ecosystems.

2.1 Monitoring objectives

The aims of GWRC's Coastal SoE monitoring programme are to:

1. Assist in the detection of spatial and temporal changes in near-shore coastal waters;

2. Contribute to our understanding of coastal biodiversity in the Wellington Region;

3. Determine the suitability of coastal waters for designated uses;

4. Provide information to assist in targeted investigations where remediation or mitigation of poor water quality or ecosystem health is desired; and

5. Provide information required to determine the effectiveness of regional plans and policies.

2.2 Monitoring sites and frequency

Details on microbiological water quality monitoring are outlined in Keenan et al. (2015), with the location of the 63 monitoring sites shown in Figure 2.1 and listed in Appendix 1. In terms of coastal ecological monitoring, the core monitoring sites are located in Porirua and Wellington harbours, Waikanae, Hutt and Whareama estuaries, and Castlepoint and Peka Peka beaches (Figure 2.2, Appendix 1).

In addition, habitat mapping of key substrate and habitat types is carried out at selected sites approximately every five years. In the past, habitat mapping has been limited to the intertidal areas of estuaries but in early 2014, habitat mapping was extended to the subtidal areas of Te Awarua-o-Porirua Harbour (Porirua Harbour).

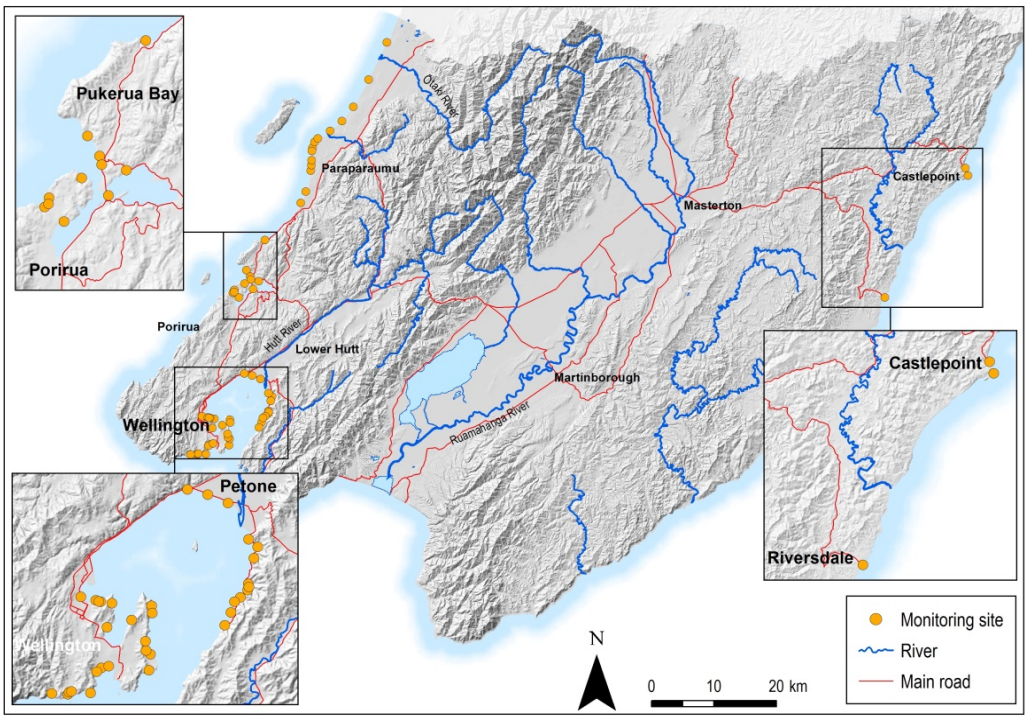


Figure 2.1: Coastal microbiological water quality monitoring sites sampled during 2014/15

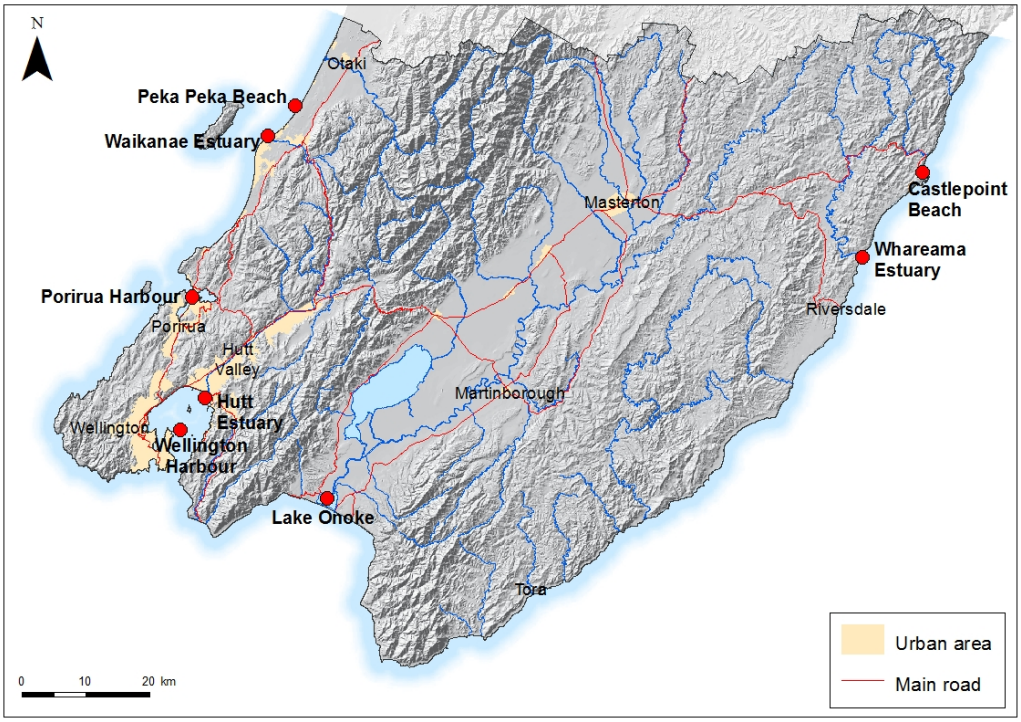


Figure 2.2: Map of the current core estuary, harbour and sandy beach ecological monitoring sites in the Wellington region as at 30 June 2015

Monitoring frequency varies across the sites, depending on the nature of the receiving environment, the purpose of monitoring and what the results indicate. The general approach is to monitor beach and estuary sites annually for three years to establish a baseline, with monitoring then reducing to five-yearly intervals unless specific issues have been identified that warrant more frequent monitoring (eg, sedimentation in Whareama Estuary). In contrast, subtidal monitoring in Porirua Harbour and Wellington Harbour is undertaken approximately every five years. See Oliver and Milne (2012) for more information.

2.2.1 Sites monitored during 2014/15

Coastal monitoring undertaken over the period 1 July 2014 to 30 June 2015 included:

- Microbiological water quality monitoring at 63 sites across the region (Section 3);
- Selected fine scale ecological monitoring in Porirua Harbour and the Hutt, Whareama and Waikanae estuaries, and broad scale habitat mapping of the Waikanae Estuary (Section 4); and
- Fine scale ecological monitoring at Peka Peka Beach (Section 5).

2.3 Monitoring variables

The basic approach to monitoring coastal microbiological water quality, ecological condition of the region's estuaries and sandy beaches, and subtidal harbour sediment quality and ecology is outlined in detail in Oliver and Milne (2012) and summarised in Appendix 2.

3. Microbiological water quality

This section presents a tabulated summary of microbiological water quality at 63 marine recreational sites monitored weekly for 20 weeks between mid-November 2014 and March 2015 and monthly outside of this period during 2014/15. See Keenan et al. (2015) for a detailed analysis of microbiological water quality sampling results during the official summer bathing season.

Table 3.1 summarises the median, 95th percentile and maximum enterococci counts recorded from all water sampling conducted during the period 1 July 2014 to 30 June 2015 for each of the 63 marine sites (ie, these statistics include the results of additional follow-up sampling conducted in response to an exceedance of the Ministry for the Environment/Ministry of Health (2003) microbiological water quality guidelines). Table 3.2 summarises the median, 95th percentile and maximum faecal coliform counts recorded from all water sampling conducted during the same period for each of the seven marine sites classed as recreational shellfish gathering sites.

Table 3.1: Summary of enterococci counts recorded at 61 marine recreation sites monitored between 1 July 2014 and 30 June 2015 inclusive

Site	Total no. of samples	Enterococci (cfu/100 mL)		
		Median	95th percentile	Max
Kapiti Coast				
Otaki Beach at Surf Club	29	5	137	445
Te Horo Beach at Sea Rd	28	24	113	420
Peka Peka Beach at Road End	28	3	66	240
Waikanae Beach at William St	27	9	56	90
Waikanae Beach at Ara Kuaka Carpark	27	5	98	130
Paraparaumu Beach at Ngapotiki St	29	15	221	790
Paraparaumu Beach at Nathan Ave	27	15	59	60
Paraparaumu Beach at Maclean Park	29	15	135	246
Paraparaumu Beach at Toru Rd	28	10	62	325
Raumati Beach at Tainui St	28	17	121	200
Raumati Beach at Marine Gardens	28	10	126	290
Raumati Beach at Aotea Rd	29	10	189	230
Paekakariki Beach at Whareroa Rd	27	6	80	93
Paekakariki Beach at Surf Club	27	5	39	47
Porirua				
Pukerua Bay	28	4	88	330
Karehana Bay at Cluny Road	27	4	91	110
Plimmerton Beach at Bath Street	29	12	210	520
South Beach at Plimmerton	33	28	1,072	3,500
Pauatahanui Inlet at Water Ski Club	28	4	73	260
Pauatahanui Inlet at Paremata Bridge	27	<4	51	100
Porirua Harbour at Rowing Club	32	8	264	370
Titahi Bay at Bay Drive	29	16	152	220
Titahi Bay at Toms Road	30	12	146	200
Titahi Bay at South Beach Access Road	30	20	403	680
Wellington City				
Aotea Lagoon	29	12	158	480
Wgtn Harbour at Taranaki St Dive Platform	26	26	293	1,400

Site	Total no. of samples	Enterococci (cfu/100 mL)		
		Median	95th percentile	Max
Oriental Bay at Freyberg Beach	27	4	83	130
Oriental Bay at Wishing Well	28	6	110	140
Oriental Bay at Band Rotunda	30	4	246	310
Balaena Bay	30	4	935	2,300
Hataitai Beach	28	4	41	510
Shark Bay	28	6	63	920
Mahanga Bay	28	<4	31	250
Scorching Bay	30	4	236	600
Worser Bay	29	4	180	270
Seatoun Beach at Wharf	28	4	113	200
Seatoun Beach at Inglis Street	29	<4	117	220
Breaker Bay	27	2	19	160
Lyall Bay at Tirangi Road	29	8	174	560
Lyall Bay at Onepu Road	28	<4	110	640
Lyall Bay at Queens Drive	29	<4	168	570
Princess Bay	30	<4	147	500
Island Bay at Reef St Recreation Ground	32	12	254	2,300
Island Bay at Surf Club	32	10	446	1,700
Island Bay at Derwent Street	29	4	172	690
Owhiro Bay	36	16	1,033	6,000
Hutt				
Petone Beach at Water Ski Club	35	16	827	1,100
Petone Beach at Sydney Street	47	56	553	1,200
Petone Beach at Kiosk	34	12	455	560
Sorrento Bay	30	8	180	460
Lowry Bay at Cheviot Road	31	16	275	550
York Bay	27	8	83	120
Days Bay at Wellesley College	28	6	92	600
Days Bay at Wharf	31	4	195	1,700
Days Bay at Moana Road	28	4	127	150
Rona Bay at N end of Cliff Bishop Park	43	28	789	4,500
Rona Bay at Wharf	33	4	320	920
Robinson Bay at HW Shortt Recreation Ground	29	8	143	220
Robinson Bay at Nikau Street	30	4	161	860
Wairarapa				
Castlepoint Beach at Castlepoint Stream	27	<4	38	48
Castlepoint Beach at Smelly Creek	27	<4	15	16
Riversdale Beach Between the Flags	27	<4	12	120
Riversdale Lagoon	27	8	513	680

Table 3.2: Summary of faecal coliform counts recorded at seven marine shellfish gathering sites monitored between 1 July 2014 and 30 June 2015 inclusive

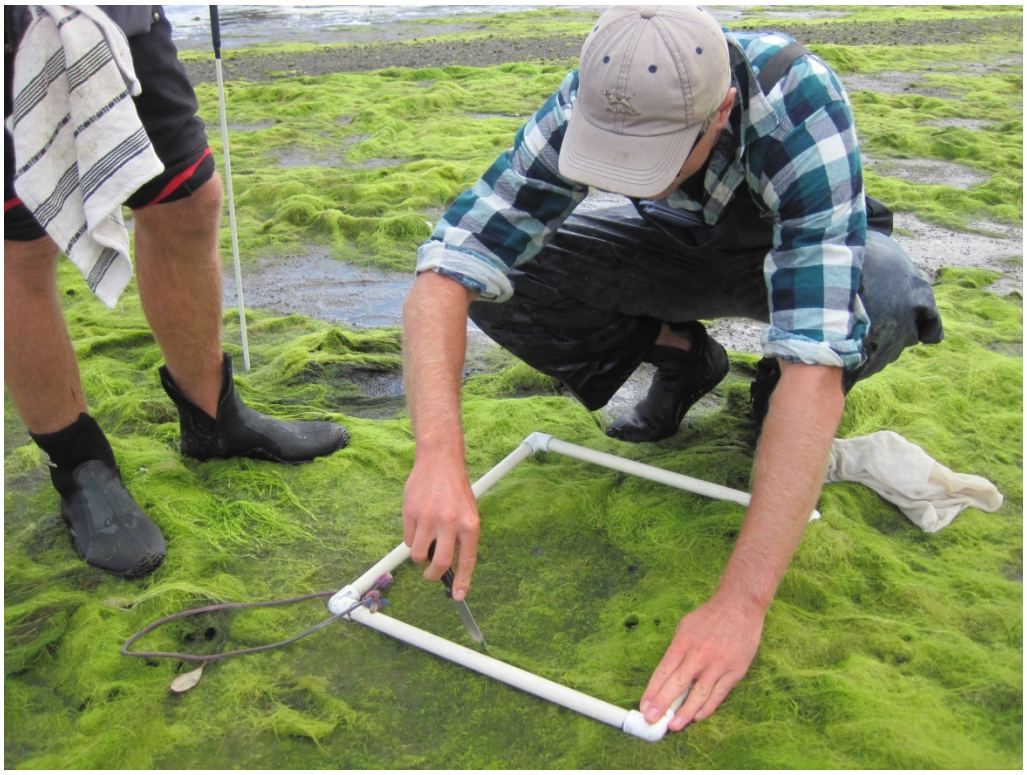
Site	Total no. of samples	Faecal coliforms (cfu/100 mL)		
		Median	95th percentile	Max
Kapiti Coast				
Otaki Beach at Surf Club	29	25	622	1,260
Peka Peka Beach at Road End	28	17	158	360
Raumati Beach at Tainui Street	28	23	300	3,850
Porirua				
Porirua Harbour at Rowing Club	27	20	359	740
Wellington City				
Shark Bay	28	4	252	770
Mahanga Bay	28	4	96	250
Hutt				
Sorrento Bay	30	6	247	420

4. Estuary condition

In January 2015, Wriggle Coastal Management carried out surveys of the Waikanae, Hutt and Whareama estuaries and Porirua Harbour (Onepoto and Pauatahanui Arms). The surveys are documented in full in Robertson and Stevens (2015a-b) and Stevens and Robertson (2015a-g) and the key findings are summarised in Table 4.1.

4.1 Annual monitoring indicators

In broad terms the surveys of the Waikanae, Hutt and Whareama estuaries included measurements of sedimentation over buried plates, Redox Potential Discontinuity (RPD)[1] depth, and mud content. With the exception of Whareama Estuary, measures of macroalgal biomass and cover were also carried out at these locations. These are the fine and broad scale indicators selected for ongoing annual monitoring, following detailed baseline surveys between 2008 and 2012. Table 4.1 presents the results of these assessments for the period January 2014 to January 2015. Further details of the monitoring variables and assessment methods are summarised in Appendix 2.



(Source: Stevens & Robertson 2015a)

Figure 4.1: Sampling macroalgae in the Hutt Estuary, January 2015

[1] The RPD provides a measure of the depth of oxygenated sediment.

Table 4.1: Sedimentation and eutrophication indicator results for estuaries monitored in early 2015. Porirua Harbour cells shaded in light blue and dark blue equate to intertidal and subtidal sites, respectively

		Sedimentation					Eutrophication	
		Sedimentation rate (2014/15)	Mean sedimentation rate (mm/yr)	No. of years measured	RPD (cm)	Mud content (%)	Ecological Quality Rating (EQR) for macroalgae	Quality status
Waikanae Estuary		22.0	25.6	5	1.5	18.7	0.72	Good
Hutt Estuary		-1.5	-3.7	5	1.5	12.3	0.39	Poor
Whareama Estuary		6.0	10.5	7	<1	74.5	Not assessed	
Porirua Harbour								
Onepoto Arm	1	1.5	1.4	7	1	8.3	0.58	Moderate
	2	2.3	4.8	3	2	4.3		
	3	2.3	2.3	7	1	3.8		
	S6	5.0	-1.5	2	2	42.2		
	S7	-92.0	-49.0	2	2	8.0		
	S8	-93.0	-46.5	2	2	11.7		
	S9	4.0	-1.7	7	3	8.4		
Pauatahanui Arm	6	-3.0	-0.3	6	1	10.0		
	7	-2.0	1.1	3	1	11.1		
	8	1.3	0.3	3	1	7.6		
	9	-2.5	0.3	7	1	3.7		
	10	-5.5	2.1	3	3	1.7		
	11	4.0	-13.0[1]	2	3	7.2		
	S1	2.0	4.3	2	1	77.8		
	S2	18.0	22.2	2	1	60.8		
	S3	-12.0	-2.0	2	1	63.4		
	S4	-4.0	3.5	2	1	16.8		
	S5	-10.0	-0.4	2	1	74.4		

[1]Change attributed to local movement of intertidal sands and does not reflect a change in sedimentation. This value was excluded from the calculation of the mean.

It is important to note that the method for assessing the macroalgae condition changed in 2014/15 from simple percentage cover (density) estimates used in previous years, to an Ecological Quality Rating (EQR) for macroalgae. This rating incorporates a more comprehensive assessment of parameters such as macroalgae biomass, the degree to which the algae are found growing deep in the sediment (entrainment) and the area of available habitat (see Stevens & Robertson 2015e for more detail). This rating is intended to provide an early warning of increasing or excessive algal growth and triggers annual macroalgal monitoring when the EQR is <0.4 (a 'Poor' or 'Bad' rating, as reported for the Hutt Estuary, Table 4.1).

4.2 Five-yearly monitoring indicators

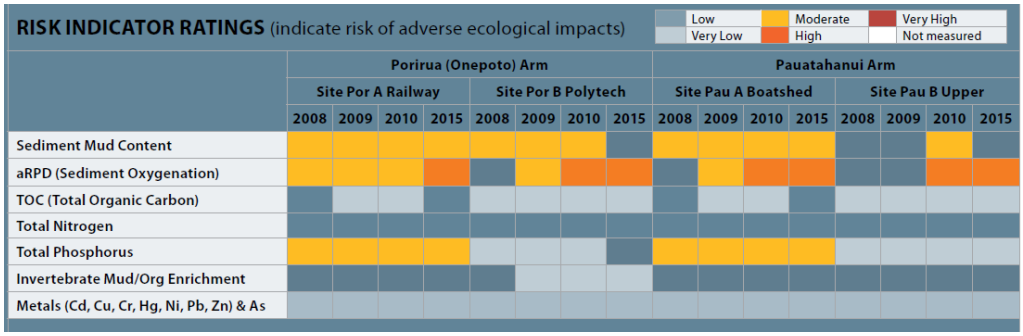
Detailed monitoring of Porirua Harbour intertidal sediment quality and benthic community health was carried out in January 2015 at four long-term sites (Robertson & Stevens 2015b). This is the first detailed fine scale survey since the three-year baseline was established in 2010 (Robertson & Stevens 2010). In

addition to the annual fine scale indicators outlined in Table 4.1 (eg, RPD, mud content), this more detailed five-yearly monitoring considers indicators such as nutrient and heavy metal concentrations, total organic carbon content and abundance and type of invertebrates living in the sediment.

To provide a defensible, cost-effective means of quickly identifying the key issues affecting an estuary, Wriggle Coastal Management developed risk indicator ratings for each of these indicators (Robertson & Stevens 2015b). A summary of the indicators and interim risk ratings for each are given in Table 4.2, for the three baseline monitoring years (2008–2010) and the 2015 survey.

Table 4.2: Summary of risk indicator ratings from the baseline fine scale surveys (2008–2010) and post-baseline (2015) survey of Porirua Harbour

(Source: Robertson & Stevens 2015b)

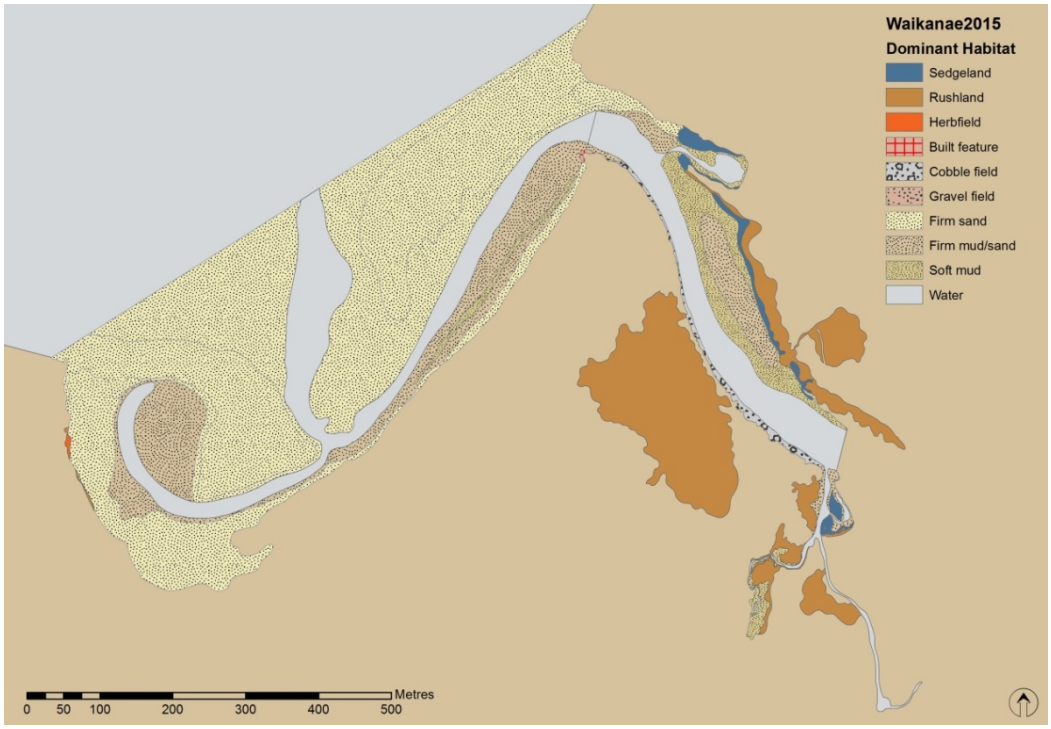


Detailed habitat and substrate mapping was also carried out in Waikanae Estuary in January 2015 (Stevens & Robertson 2015e). This provided an opportunity to compare changes in key habitat and substrate types with the results of the first habitat mapping exercise carried out in 2006 as part of a region-wide assessment of the coastal environment (Stevens & Robertson 2006). A summary of the dominant substrate categories and area of macroalgae is presented in Table 4.3. Figure 4.1 provides an example of the habitat maps produced from the field data. A more detailed explanation of the methods used to map subtidal substrates and habitats can be found in Appendix 2.

Table 4.3: Summary of dominant substrate categories and area of macroalgae and saltmarsh determined from broad scale habitat mapping of Waikanae Estuary in January 2015

(Source: Robertson & Stevens 2015e)

Habitat/substrate category	Area (ha)	Percentage
Substrate		
Cobble field	0.3	1.2
Firm sand	18.0	73.7
Firm mud/sand	4.5	18.2
Very soft mud	1.7	6.9
TOTAL	*24.5*	*100*
Habitat		
Macroalgae	0.3	0.1
Saltmarsh	5.7	15



(Source: Stevens & Robertson 2015e)

Figure 4.2: Habitat map showing the dominant habitat features recorded during the January 2015 broad scale survey of Waikanae Estuary

5. Sandy beach condition

In January 2015, Wriggle Coastal Management carried out the second detailed survey of Peka Peka Beach. This beach was selected for annual baseline assessments over two to three years as an example of a dissipative[2] beach on the region's west coast. The survey is documented in full in Robertson and Stevens (2015a) and the key findings are summarised in Table 5.1.

The key measurements carried out at Peka Peka Beach included beach morphometry (shape and size), Redox Potential Discontinuity Depth (RPD) as a proxy for sediment oxygenation, sediment grain size, and identification and enumeration of invertebrate taxa. Table 5.1 presents a summary of these results. Other fine scale indicators relating to eutrophication and sediment contamination are not monitored at Peka Peka Beach because there are no major nutrient or toxic contaminant inputs to this beach.

Table 5.1: Summary of beach condition risk indicator results from the January 2014 and 2015 beach surveys

Site and year	RPD depth (cm)	% mud	Macroinvertebrate enrichment index
Peka Peka Beach 2014	>15	<1.5	1.2–3.3 (Low)
Peka Peka Beach 2015	>15	<1.5	<3.3 (Low)

(Source: Robertson & Stevens 2015a)

Figure 5.1: Sediment sampling at Peka Peka Beach, January 2015

[2] Dissipative beaches are characterised as being high energy beaches with a wide surf zone and a low-sloping and wide beach face consisting of fine sand.

Acknowledgements

Coastal microbiological water quality monitoring in the western half of the Wellington Region is a joint effort involving Kapiti Coast District Council, Porirua City Council, Wellington City Council and Hutt City Council.

Laura Keenan compiled the microbiological water quality summary statistics.

Dr Barry Robertson, Leigh Stevens and Ben Robertson of Wriggle Coastal Management Ltd undertake the estuarine, beach and habitat mapping fieldwork and reporting. Benthic invertebrate sample identification is carried out by Gary Stephenson of Coastal Marine Ecology Consultants.

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Appendix 1: Monitoring sites

Table A1.1: Microbiological water quality sampling locations

Site	NZTM co-ordinates Easting	Northing	Type
Kapiti Coast			
Otaki Beach at Surf Club	1778622	5488330	Recreation
Paekakariki Beach at Surf Club	1764791	5462273	Recreation & shellfish gathering
Paekakariki Beach at Whareroa Road	1765598	5464128	Recreation
Paraparaumu Beach at Maclean Park	1766694	5471267	Recreation
Paraparaumu Beach at Nathan Avenue	1767033	5472174	Recreation
Paraparaumu Beach at Ngapotiki Street	1767543	5472762	Recreation
Paraparaumu Beach at Toru Road	1766577	5470715	Recreation
Peka Peka Beach at Road End	1773215	5477905	Recreation & shellfish gathering
Raumati Beach at Aotea Road	1766414	5467529	Recreation
Raumati Beach at Marine Gardens	1766516	5468441	Recreation
Raumati Beach at Tainui Street	1766531	5469229	Recreation & shellfish gathering
Te Horo Beach at Sea Road	1775692	5482324	Recreation
Waikanae Beach at Ara Kuaka Carpark	1769514	5473978	Recreation
Waikanae Beach at William Street	1771388	5475584	Recreation
Porirua			
Karehana Bay at Cluny Road	1756093	5451360	Recreation
Pauatahanui Inlet at Paremata Bridge	1757153	5448284	Recreation
Pauatahanui Inlet at Water Ski Club	1758074	5449593	Recreation
Plimmerton Beach at Bath Street	1756706	5450316	Recreation
Porirua Harbour at Rowing Club	1754891	5446947	Recreation & shellfish gathering
Pukerua Bay	1759058	5456278	Recreation
South Beach at Plimmerton	1756810	5449874	Recreation
Titahi Bay at Bay Drive	1754132	5448169	Recreation
Titahi Bay at South Beach Access Road	1753906	5447682	Recreation
Titahi Bay at Toms Road	1754110	5447857	Recreation
Wellington City			
Aotea Lagoon	1748985	5427683	Recreation
Wellington Harbour at Taranaki St Dive Platform	1749092	5427538	Recreation
Balaena Bay	1750958	5427267	Recreation
Breaker Bay	1753312	5422970	Recreation
Hataitai Beach	1750632	5425730	Recreation
Island Bay at Derwent Street	1748155	5421415	Recreation
Island Bay at Reef St Recreation Ground	1748229	5421542	Recreation
Island Bay at Surf Club	1748377	5421590	Recreation
Lyall Bay at Onepu Road	1750286	5423116	Recreation
Lyall Bay at Queens Drive	1749990	5422868	Recreation
Lyall Bay at Tirangi Road	1750747	5423230	Recreation
Mahanga Bay	1753468	5427115	Recreation & shellfish gathering
Oriental Bay at Band Rotunda	1750243	5427375	Recreation
Oriental Bay at Freyberg Beach	1749920	5427464	Recreation
Oriental Bay at Wishing Well	1750118	5427386	Recreation
Owhiro Bay	1747122	5421463	Recreation
Princess Bay	1749586	5421504	Recreation
Scorching Bay	1753517	5426647	Recreation

Site	NZTM co-ordinates		Type
	Easting	Northing	
Seatoun Beach at Inglis Street	1753405	5423994	Recreation
Seatoun Beach at Wharf	1753129	5424234	Recreation
Shark Bay	1752211	5426197	Recreation & shellfish gathering
Worser Bay	1753074	5424823	Recreation
Hutt			
Days Bay at Moana Road	1759582	5428120	Recreation
Days Bay at Wellesley College	1759616	5428529	Recreation
Days Bay at Wharf	1759654	5428313	Recreation
Lowry Bay at Cheviot Road	1760206	5430891	Recreation
Petone Beach at Kiosk	1758326	5433711	Recreation
Petone Beach at Sydney Street	1757045	5434248	Recreation
Petone Beach at Water Ski Club	1755744	5434591	Recreation
Robinson Bay at HW Shortt Rec Ground	1758519	5426674	Recreation
Robinson Bay at Nikau Street	1758131	5425856	Recreation
Rona Bay at N end of Cliff Bishop Park	1759109	5427654	Recreation
Rona Bay at Wharf	1758730	5427371	Recreation
Sorrento Bay	1759632	5431384	Recreation & shellfish gathering
York Bay	1759977	5430160	Recreation
Wairarapa			
Castlepoint Beach at Castlepoint Stream	1871366	5467559	Recreation
Castlepoint Beach at Smelly Creek	1871670	5467202	Recreation
Riversdale Beach Between the Flags	1858435	5446948	Recreation
Riversdale Lagoon	1858304	5447128	Recreation

Table A1.2: Waikanae Estuary intertidal sampling locations

Sampling site	NZTM co-ordinates	
	Easting	Northing
Waikanae A	1769248 (Plot 01) 1769261 (Plot 10)	5473364 (Plot 01) 5473355 (Plot 10)

Table A1.3: Hutt Estuary sampling locations

Sampling site	NZTM co-ordinates	
	Easting	Northing
Hutt A (South)	1759174 (Peg 1) 1759174 (Peg 2)	5433638 (Peg 1) 5433618 (Peg 2)
Hutt B (North)	1759369 (Peg 1) 1759369 (Peg 2)	5434135 (Peg 1) 5434116 (Peg 2)

Table A1.4: Whareama Estuary intertidal sampling locations

Sampling site	NZTM co-ordinates	
	Easting	Northing
Whareama A (North)	1860703 (Plot 01) 1860684 (Plot 10)	5455343 (Plot 01) 5455338 (Plot 10)
Whareama B (South)	1860084 (Plot 01) 1860067 (Plot 10)	5455318 (Plot 01) 5455294 (Plot 10)

Table A1.5: Porirua Harbour sediment plate locations

Sampling site	Location	NZTM co-ordinates	
		Easting	Northing
1	Porirua A Railway	1756505	5447788
2	Aotea	1754771	5445520
3	Por B Polytech	1754561	5445430
S6	Titahi (subtidal)	1755704	5446797
S7	Onepoto (subtidal)	1754811	5446762
S8	Papkowhai (subtidal)	1754580	5445864
S9	Te Onepoto (subtidal)	1755551	5447105
6	Boatsheds	1757267	5448785
7	Kakaho	1758885	5449747
8	Horokiri	1760040	5448827
9	Paua B	1760333	5448378
10	Duck Creek	1759829	5447944
11	Browns Bay	1757971	5447956
S1	Kakaho (subtidal)	1758810	5449470
S2	Horokiri (subtidal)	1759325	5448867
S3	Duck Creek (subtidal)	1759529	5447896
S4	Bradeys Bay (subtidal)	1758763	5447865
S5	Browns Bay (subtidal)	1758040	5448015

Table A1.6: Peka Peka Beach sampling locations

Sampling site	NZTM co-ordinates	
	Easting	Northing
Peka Peka Beach A	1772686 (High shore) 1772620 (Low shore)	5477096 (High shore) 5477156 (Low shore)
Peka Peka Beach B	1772657 (High shore) 1772585 (Low shore)	5477060 (High shore) 5477120 (Low shore)

Appendix 2: Monitoring variables and methods

Microbiological water quality

Microbiological water quality monitoring is undertaken in accordance with the 2003[3] Ministry for the Environment (MfE) and the Ministry of Health (MoH) microbiological water quality guidelines for marine and freshwater recreational areas. In coastal waters, which are generally sampled weekly during the summer bathing season (November to March inclusive) and monthly during the remainder of the year, the recommended indicator is enterococci (with faecal coliforms the preferred indicator for shellfish gathering waters). Refer to Keenan et al. (2015) for full details of GWRC's microbiological water quality monitoring methods.

Estuary condition

The broad and fine scale surveys undertaken in the region's estuaries to date have been based on the National Estuary Monitoring Protocol (Robertson et al. 2002) and recent extensions to these developed by Wriggle Coastal Management (eg, Robertson & Stevens 2008, 2015b; Stevens & Robertson 2008, 2015e). The fine scale surveys target the dominant intertidal habitat and three of the five core indicators of estuarine ecosystem health: sedimentation, eutrophication (nutrient enrichment) and toxic contamination (Table A2.1). The remaining two indicators are habitat loss and disease risk, which are assessed through periodic broad scale surveys and GWRC's recreational water quality programme, respectively. As outlined below, broad scale surveys also provide information relevant to assessing sedimentation and nutrient enrichment.

Fine scale monitoring generally takes place at one or two locations (sites) within an estuary that are selected to be representative of the dominant (generally intertidal) habitat present. Each site is assessed for a suite of environmental characteristics that are indicative of estuary condition and will provide a means for detecting future change (Table A2.1) (Robertson et al. 2002; Robertson & Stevens 2015b).

Broad scale monitoring involves defining the dominant habitats and features of an area and developing baseline maps with a combination of photography, ground-truthing and digital mapping using GIS technology. The area boundaries are first defined at a scale appropriate for baseline monitoring before vegetation (eg, saltmarsh, seagrass, macroalgae) and substrate types (eg, gravel, coarse sand, mud) are mapped (Robertson et al. 2002; Stevens & Robertson 2015e).

In 2014/15, the annual broad scale assessment of macroalgal density was updated to an Ecological Quality Rating (EQR) for macroalgae. The EQR approach replaces the previous Low Density Macroalgal Coefficient developed by Wriggle because it incorporates a more comprehensive assessment of key parameters, particularly macroalgal biomass and entrainment. It is intended to provide an early warning of increasing or widespread low density growth, as well as warning of excessive dense growth within those parts of an estuary when macroalgae can potentially establish (Stevens & Robertson 2015e).

Along with annual estuary-scale mapping of macroalgae cover and condition to complement the fine scale assessments of estuary condition, sedimentation monitoring

[3] The guidelines were published in June 2002 and updated in June 2003.

plates are used to measure sedimentation rates at specific locations within each estuary. Such plates have been deployed at several locations across five of the region's estuaries to date.

Table A2.1: Key broad scale (BS) and fine scale (FS) indicators used to assess estuarine condition in the Wellington Region. Many of the indicators in the table are also applicable to assessing beach condition

(Source: Adapted from Robertson & Stevens 2015b)

Issue	Indicator	Indicator type	Rationale
Sedimentation	Soft mud area	BS	Estuaries are a natural sink for catchment-derived sediment but if sediment inputs are excessive, estuaries infill quickly with muds, reducing biodiversity and human values and uses. In particular: - muddy sediments have a higher tendency to become anoxic and anoxic sediments contain toxic sulphides and very little aquatic life. - elevated sedimentation rates are likely to lead to major and detrimental ecological changes within estuary areas that could be very difficult to reverse.
	Sediment composition (% mud)	FS	
	Sedimentation rate	FS	
	Diversity of benthic fauna	FS	Soft sediment macrofauna can be used to represent benthic community health in relation to the extent of mud tolerant organisms compared with those that prefer sands.
Eutrophication (nutrient enrichment)	Ecological Quality Rating (EQR) for Macroalgae	BS	Mass blooms of green and red macroalgae, mainly of the genera *Enteromorpha, Cladophora, Ulva,* and *Gracilaria,* can present a significant nuisance problem, especially when loose mats accumulate and decompose. Algal blooms also have major ecological impacts on water and sediment quality, such as reduced clarity, physical smothering and lack of oxygen, and can displace estuarine animals.
	Organic content	FS	High sediment organic content can result in anoxic sediments and bottom water, release of excessive nutrients, and adverse impacts on biota.
	Sediment nutrient concentrations: • Nitrogen • Phosphorus	FS	In shallow estuaries the sediment compartment is often the largest nutrient pool in the system, and nutrient exchange between the water column and sediments can play a large role in determining trophic status and stimulating the production and abundance of fast-growing algae, such as phytoplankton and short-lived macroalgae (eg, sea lettuce).
	Sediment oxygenation (RPD depth)	FS	Surface sediments need to be well oxygenated to support healthy invertebrate communities (anoxic sediments contain toxic sulphides and very little aquatic life).
	Diversity of benthic fauna	FS	Soft sediment macrofauna can be used to represent benthic community health and classify estuary condition.
Toxic contamination	Sediment contamination – eg, concentrations of: • heavy metals • PAHs • pesticides	FS	Many chemicals discharged to estuaries via urban and rural runoff are toxic, even at very low concentrations. These chemicals can accumulate in sediments and bioaccumulate in fish and shellfish, causing health risks to people and marine life.
	Diversity of benthic fauna	FS	Soft sediment macrofauna can be used to represent benthic community health and classify estuary condition.
Habitat loss	Saltmarsh area	BS	Estuaries function best with a large area of rooted vegetation (ie, saltmarsh and seagrass), as well as a healthy vegetated terrestrial margin. Loss of this habitat reduces ecological, fishery and aesthetic values, and adversely impacts on an estuary's role in flood and erosion protection, contaminant mitigation, sediment stabilisation and nutrient cycling.
	Seagrass area	BS	
	Vegetated terrestrial buffer	BS	

A series of interim fine and broad scale estuary 'condition ratings' (reproduced as Tables A2.2–A2.4 from reports prepared for GWRC by Wriggle Coastal Management) are proposed for Porirua Harbour, and Waikanae, Hutt and Whareama estuaries. These ratings are based on data collected within the Wellington Region over the last 8 years and the observed correlation between each indicator and the presence of degraded estuary conditions from a range of tidal lagoon estuaries throughout New Zealand. They are designed to be used in combination with each other (usually involving expert input) when evaluating overall estuary condition and deciding on appropriate management. The ratings will continue to be refined and updated as data become available.

Table A2.2: Summary of fine scale estuary condition ratings used in the Wellington Region

(Source: Robertson & Stevens 2015b)

INDICATOR	RISK RATING				
	Very Low	Low	Moderate	High	Very High
Apparent Redox Potential Discontinuity (aRPD)	>10cm depth below surface	3-10cm depth below sediment surface	1-<3cm depth below sediment surface	0-<1cm depth below sediment surface	Anoxic conditions at surface
Sediment Mud Content (%mud)	<2%	2-5%	>5-15%	>15-25%	>25%
Macroinvertebrate Enrichment Index (WEBI)	0-1.0 None to minor stress on benthic fauna.	>1.0-2.5 Minor to moderate stress on fauna.	>2.5-4.0 Moderate to high stress on fauna.	>4.0 Persistent, high stress on benthic fauna.	
Total Organic Carbon (TOC)	<0.5%	0.5-<1%	1-<2%	2-<3.5%	>3.5%
Total Nitrogen (TN)	<250mg/kg	250-1000mg/kg	>1000-2000mg/kg	>2000-4000mg/kg	>4000mg/kg
Total Phosphorus (TP)	<100mg/kg	100-300mg/kg	>300-500mg/kg	>500-1000mg/kg	>1000mg/kg
Metals	<0.2 x ISQG Low	0.2 x ISQG Low to 0.5 x ISQG Low	>0.5 x ISQG Low to ISQG Low	>ISQG Low to ISQG High	>ISQG High

Table A2.3: Risk indicator ratings for sedimentation rate in estuaries in the Wellington Region

(Source: Stevens & Robertson 2015d)

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:

[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 in soft rock catchments.

[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.

Table A2.4: Summary of broad scale estuary condition ratings used in the Wellington Region

(Source: Stevens & Robertson 2015e)

INDICATOR	RISK RATING				
	Very Low	Low	Moderate	High	Very High
Soft mud (% cover)	<2%	2-5%	>5-15%	>15-25%	>25%
Gross Eutrophic Conditions (ha)	<0.5ha	0.5-5ha	6-20ha	20-30ha	>30ha
Macroalgal Ecological Quality Rating	≥0.8 - 1.0	≥0.6 - <0.8	≥0.4 - <0.6	≥0.2 - <0.4	0.0 - <0.2
Seagrass Coefficient (SC)	>7.0	>4.5-7.0	>1.5-4.5	>0.2 - 1.5	0.0 - 0.2
Saltmarsh (% remaining from estimated natural state)	>80-100%	>60-80%	>40-60%	>20-40%	<20%
Saltmarsh Extent (vegetated % of available saltmarsh habitat)	>80-100%	>60-80%	>40-60%	>20-40%	<20%
Vegetated 200m Terrestrial Margin	>80-100%	>50-80%	>25-50%	>5-25%	<5%

Sandy beach condition

There is currently no nationally recognised protocol for ecological monitoring of sandy beaches. The monitoring methods employed at Peka Peka Beach were devised by Robertson and Stevenson (2008a) based on an approach taken by Aerts et al. (2004) for monitoring a sandy beach in Ecuador. Six stations are sampled along two transects that span from high to low tide, with the following fine scale variables measured at each station: sediment particle size, sediment oxygenation, and benthic fauna abundance and diversity. Other fine scale indicators relating to eutrophication and sediment contamination are not monitored at Peka Peka Beach because there are no major nutrient or toxic contaminant inputs.

A series of interim fine scale beach condition risk ratings (reproduced as Table A2.5) from reports prepared for GWRC by Wriggle Coastal Management) are proposed for Peka Peka Beach. The ratings have been established to provide a defensible, cost-effective way to help identify environmental pressures and to assess changes in the long-term condition of beach ecosystems. The design is based on the use of primary indicators that have a documented strong relationship with water or sediment quality. Each rating is designed to be used in combination with other ratings and under expert guidance to assess overall beach condition and to make appropriate monitoring and management recommendations.

Table A2.5: Summary of beach condition risk indicator ratings

(Source: Robertson & Stevens 2015a)

INDICATOR	RISK RATING				
	Very Low	Low	Moderate	High	Very High
Redox Potential Discontinuity (aRPD, cm)	>10cm depth below surface	3-10cm depth below sediment surface	1-<3cm depth below sediment surface	0-<1cm depth below sediment surface	Anoxic conditions at surface
Sediment Mud Content (% mud)	<2%	2-5%	5-15%	15-25%	>25%
Macroinvertebrate Enrichment Index (AMBI)	0-1.2 Intolerant of enriched conditions	1.2-3.3 Tolerant of slight enrichment	3.3-5.0 Tolerant of moderate enrichment	5.0-6.0 Tolerant of high enrichment	>6.0 Azoic (devoid of invertebrate life)