Bay of Plenty Marine Sediment Contaminants Survey 2008

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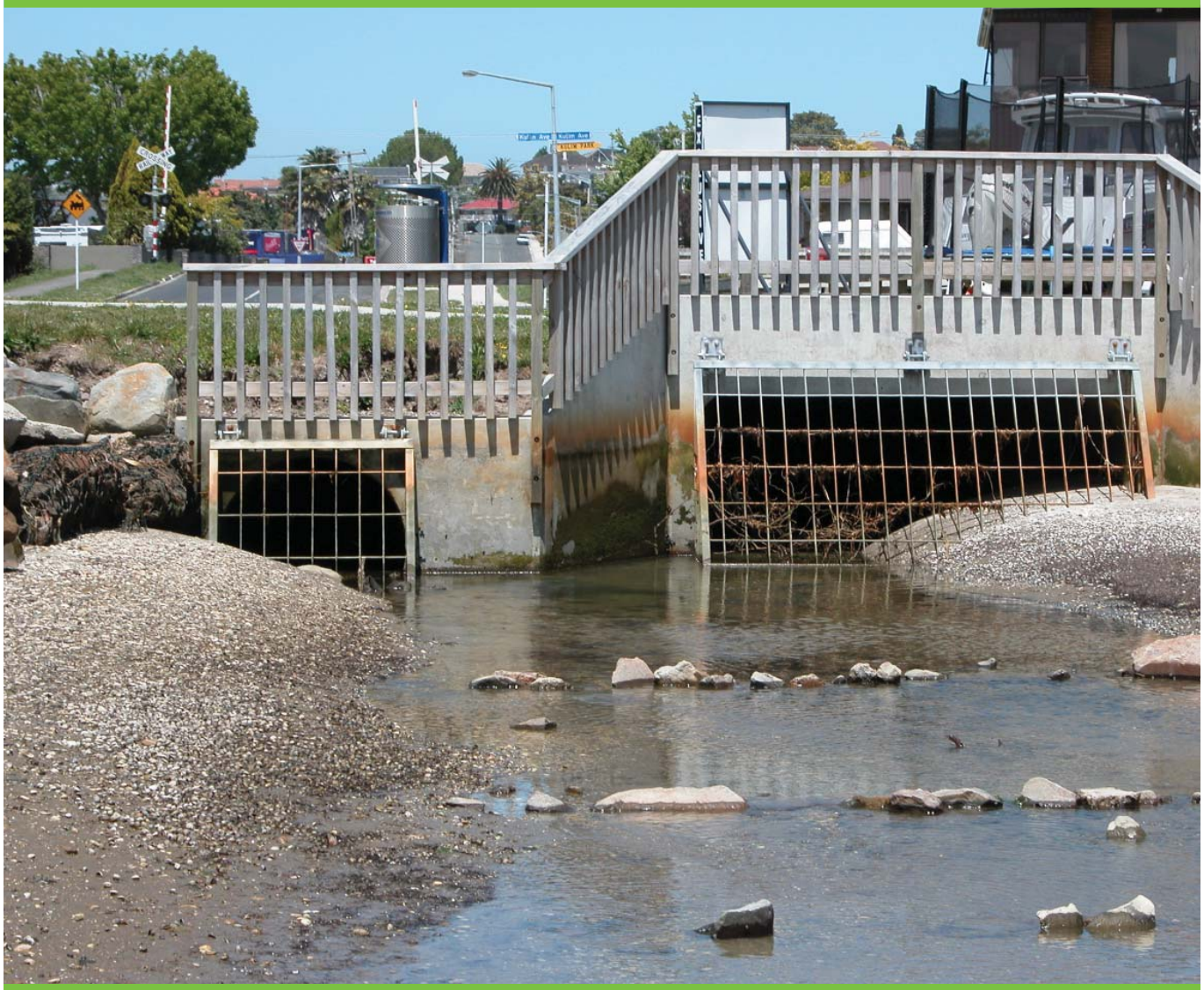

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Cover Photo: Stormwater outfall sampled for sediment contaminants at Otumoetai, Tauranga.

Executive Summary

This report presents sediment contaminant results (metals and organics) from the following surveys:

- Tauranga Harbour and Ohiwa Harbour baseline monitoring (2006) – this is undertaken every three years.

- Coastal and estuarine ecology survey (2006 to 2008) – sediment sampling of harbours and estuaries for metals is undertaken annually in conjunction with the benthic macrofauna sampling.

- Stormwater outlet survey (2008) - a one-off survey of sediment contaminants associated with stormwater outfalls and industrial areas around Tauranga City.

In 2006 the concentrations of organic contaminants and metals at 31 sites in Tauranga Harbour were very similar to those found in 2003. The highest metal concentrations were found in areas with the highest level of urban and commercial development. The concentrations of contaminants in Ohiwa Harbour (7 sites) were generally within the range found in Tauranga Harbour. None of the sites sampled exceeded the ANZECC (2000) Interim Sediment Quality Guidelines (ISQG Low) for the protection of aquatic life.

The metals data from the coastal and estuarine ecology surveys was included in this report to provide more information on background concentrations. The concentrations recorded show the same general pattern as for the Tauranga and Ohiwa harbour baseline monitoring. The results of these two surveys show that there are some geographic variations in the background concentrations of metals. For example, in Ohiwa Harbour nickel concentrations are consistently higher than other areas.

The results from the Tauranga stormwater outfalls (on a whole sediment basis) show elevated concentrations of Polycyclic Aromatic Hydrocarbons (PAH's) and metals although these are generally below the ANZECC guidelines. However when results are standardised to the mud fraction, which may occur naturally in some sheltered areas of the harbour, copper, lead, zinc and PAH's have the potential to reach concentrations above the guidelines. Zinc in particular is elevated compared to the guidelines when standardised to the mud fraction.

A small number of sediment samples taken from drains and streams around Tauranga show that the industrial areas (e.g. Mount Maunganui) contribute high levels of contaminants. However, sampling of the Maleme Street industrial area showed lower levels of contaminants than that recorded in 1998/99.

The emerging pattern appears very similar to that found around Auckland where stormwater discharges of zinc and copper are still accumulating in the settlement zone of estuaries. Close attention and ongoing improvements in stormwater management will be needed to prevent sensitive areas of Tauranga Harbour becoming ecologically degraded.

Given that results generally show potential for the ANZECC guidelines to be exceeded for PAH's, zinc and lead, further investigation to determine environmental levels and the toxicity risk should be undertaken.

Contents

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Scope

This report presents the results of sediment contamination surveys in harbours and estuaries throughout the Bay of Plenty. The surveys were undertaken to provide:

- Sediment contamination trends over time.
- Assessment of contaminant concentrations against environmental guidelines.
- Provision of contaminant data for interpreting benthic macrofauna health trends.
- Assessment of localised stormwater discharge impacts.

The information is also expected to inform applications for Comprehensive Stormwater Consents (CSC's) by the regions Territorial Authorities. The need for these consents was identified in the Bay of Plenty Stormwater Strategy which was finalised in 2005 (Environment Bay of Plenty 2005).

1.2 Background

Accumulation of contaminants in sediments is a global problem. Rivers and streams carry a range of pollutants from developed catchments and because of chemical and physical processes these pollutants tend to accumulate in harbours and estuaries. Contaminants vary according to land use and come from both point and diffuse sources. Nutrients, pesticides and herbicides are common contaminants from agricultural use while urban areas often result in problems with the metals zinc, lead and copper or organic polycyclic aromatic hydrocarbons (PAH's) that are sourced from combustion processes. When these compounds or metals accumulate to high levels they can have a wide range of effects on different species. The effects need not be lethal and if certain key species are affected there may also be marked flow on effects to the ecosystem as a whole.

Within New Zealand, monitoring by Auckland Regional Council around Auckland provides a good example of impacts from developed catchments with zinc and copper concentrations steadily increasing over time (Timperley & Mathieson 2002). Lead levels are also high in sediment around Auckland's estuaries but have tended to decline since lead was reduced in petrol in 1996. Up to 2001, probability plots of Auckland zinc, lead and copper show that the ANZECC (2000) low guideline is exceeded for 20%, 30% and 8% of the data respectively (Williamson & Mills 2002).

Previous surveys in the Bay of Plenty (McIntosh 1994, Park 2003) have shown that contaminant concentrations in Tauranga Harbour reflect the degree of catchment development, but levels are below ANZECC guidelines. Other studies have looked at the impact of the historic sewage outfall at Otumoetai (Roper 1990) and organic contaminants (Wilkins et al. 1992, Burgraaf et al. 1994) but there are few records from investigations showing the general impact of stormwater outfalls around Tauranga.

This report covers the results of three monitoring surveys. The first arises from a recommendation of the earlier Tauranga Harbour sediment study (Park 2003) for regular monitoring of baseline sediment contaminant sites in Ohiwa and Tauranga harbours. Sites have now been monitored twice with sampling scheduled to occur every three years. The second relates to analysis of metals in sediments collected during the annual benthic macrofauna monitoring around the Bay of Plenty. The third is a study of the more localised impacts of stormwater discharges in Tauranga Harbour which also arose from Park (2003) and as an action from the Tauranga Harbour Integrated Management Strategy (Lawrie 2006).

Chapter 2: Location and Methods

2.1 Location

The Bay of Plenty region is located on the northeast coast of the North Island, New Zealand. It has similar oceanographic characteristics to the coast extending further north as this part of New Zealand's coast is strongly influenced by the East Auckland current. The Bay of Plenty has 259 km of open coast of which 74% is sandy shores and 26% is rocky. Harbours and estuaries in the Bay of Plenty have a total length of 369 km of which the majority is sandy shoreline.

2.1.1 Tauranga Harbour

Tauranga Harbour is the largest estuarine inlet in the region being impounded by a barrier island (Matakana Island) and two barrier tombolos, Mount Maunganui at the southern entrance and Bowentown to the north (Healy and Kirk 1981). The harbour is shallow and covers an area of 201 km^2 with 66% of its total area being intertidal.

The harbour catchment covers an area of approximately 1,300 km^2 and is well developed with extensive horticultural and agricultural use. At the southern end of the harbour, the city of Tauranga and surrounding area supports a large residential population (around 103,000). Near the southern entrance, the Mount Maunganui – Sulphur Point region of the harbour has been progressively developed for port facilities.

There are three main harbour basins with the northern basin having a total catchment area of 270 km^2 and a mean freshwater inflow of 4.1 m^3/s. The southern catchment has a total area of 1,030 km^2 and a mean freshwater inflow of 30.5 m^3/s. There are many small sub-estuaries around the harbour. At mean high water the northern basin has a volume of approximately 178 million m^3 and the southern basin a volume of 278 million m^3. In the northern harbour the freshwater inflow represents only 0.1% of the harbour volume per tidal cycle while the southern input represents 0.48%. A more detailed breakdown of catchments and sub estuaries is presented in Park (2003).

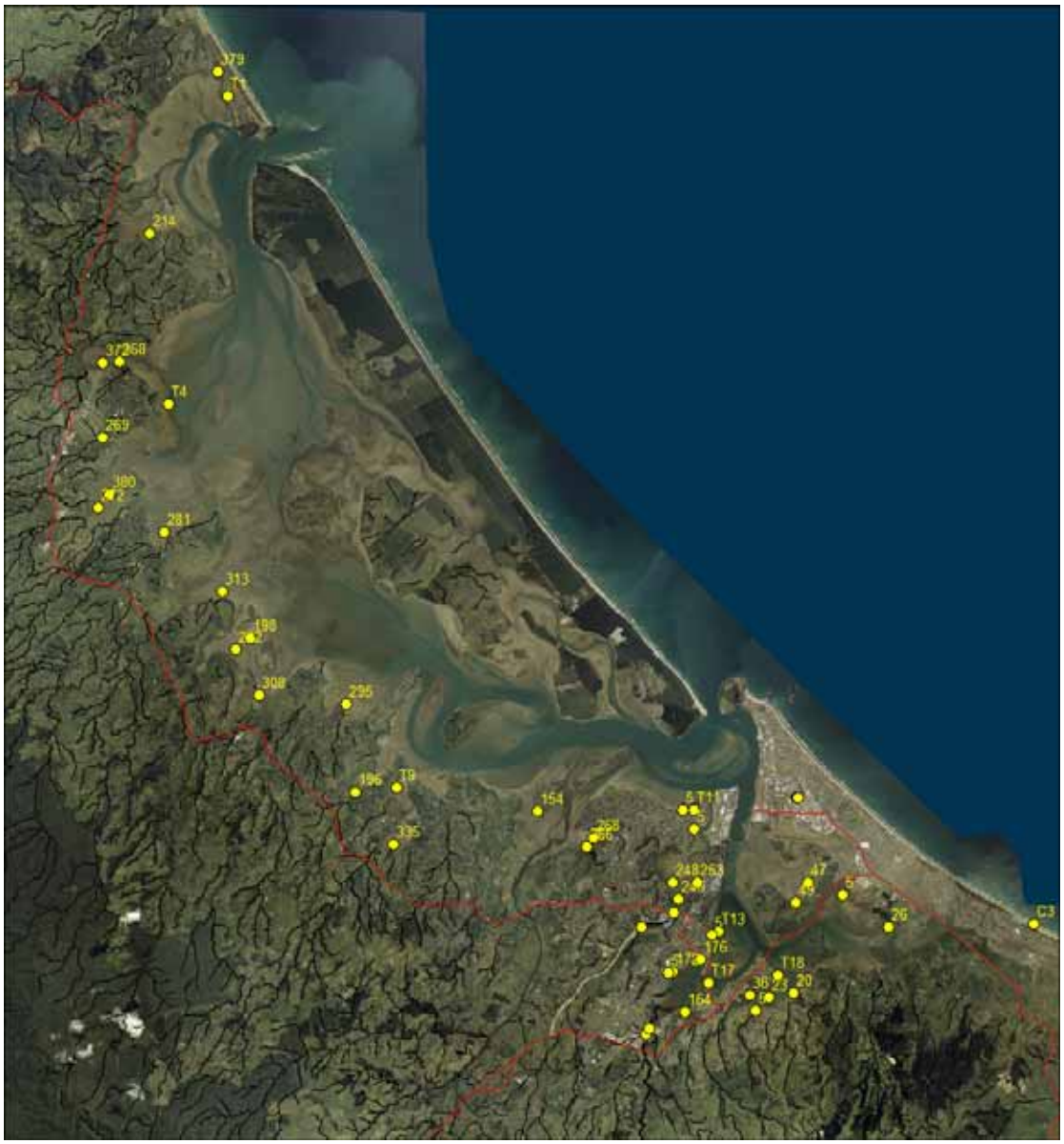

Figure 1 Location of the sites in and around Tauranga Harbour sampled for contaminants between 2003 and 2008.

2.1.2 Ohiwa Harbour

Ohiwa Harbour is a 26.4 km^2 estuarine lagoon enclosed by the Ohope and Ohiwa barrier spits. It is shallow with 83% of its area being exposed sand and mudflats at low tide. The harbour has a very low volume compared to the spring tidal compartment and is dominated by tidal currents. Residence time of water in the harbour is low and estimated to be 1-2 tidal cycles. The Nukuhou River with a median flow of 0.98 m^3/s is the main freshwater inflow to the harbour.

The harbour is a valley system drowned by the post-glacial rise in sea level between 6,500 and 18,000 years ago to form an open embayment. From 6,500 to 2,000 years ago the bay was enclosed by the Ohope and Ohiwa spits. The largest changes occurred over the last 2,000 years with the drift of sand around Whakatane Heads to the east. Over this period the Ohope spit accreted laterally eastwards at an average rate of about 3 m/year. Ohiwa spit at the same time has eroded, and there has been an accelerated infilling of Ohiwa Harbour. The tidal compartment being reduced by 36% between 1878 and 1976 (Gibb 1977).

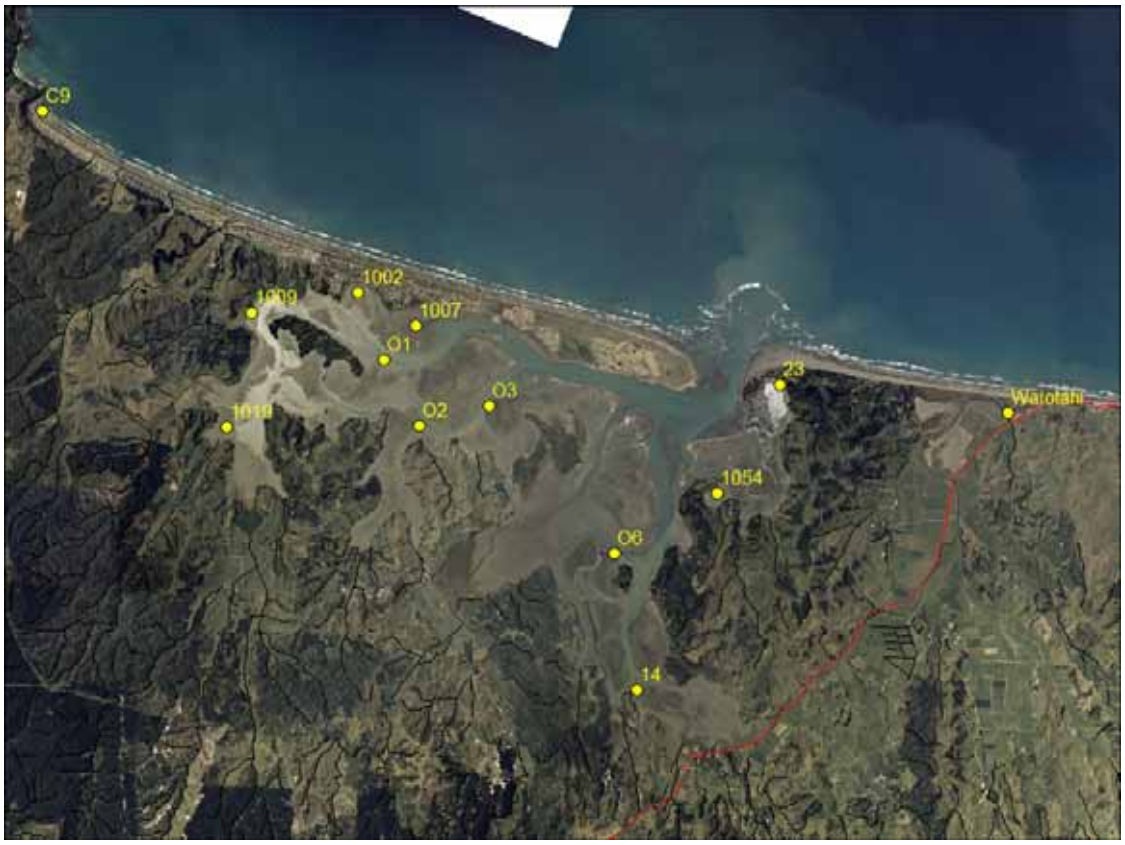

Figure 2 Sites in and around Ohiwa Harbour sampled for contaminants between 2003 and 2008.

2.1.3 Maketu, Waihi and Waiotahi Estuaries

Maketu Estuary is the former outlet for the Kaituna River which was diverted directly to the sea at Te Tumu in 1956. It covers an area of approximately 2.3 km^2 and is very shallow with extensive tidal flats. The estuary is very dynamic with channels continually shifting and since the removal of the river it has been infilling with sand. Since 1996 flows from the river of around 100,000 m^3 per tidal cycle have been re-diverted back into the estuary.

Waihi Estuary covers an area of approximately 2.4 km^2 most of which dries at low tide. The estuary is impounded by a spit with extensive housing development. The main freshwater inflow is the Pongakawa Stream with a median flow of 4.6 m^3/s.

Waiotahi Estuary is very small (0.95 km^2) and the main freshwater flow comes from the Waiotahi River. The catchment of this estuary is predominantly comprised of agricultural and forest land use with no urban development.

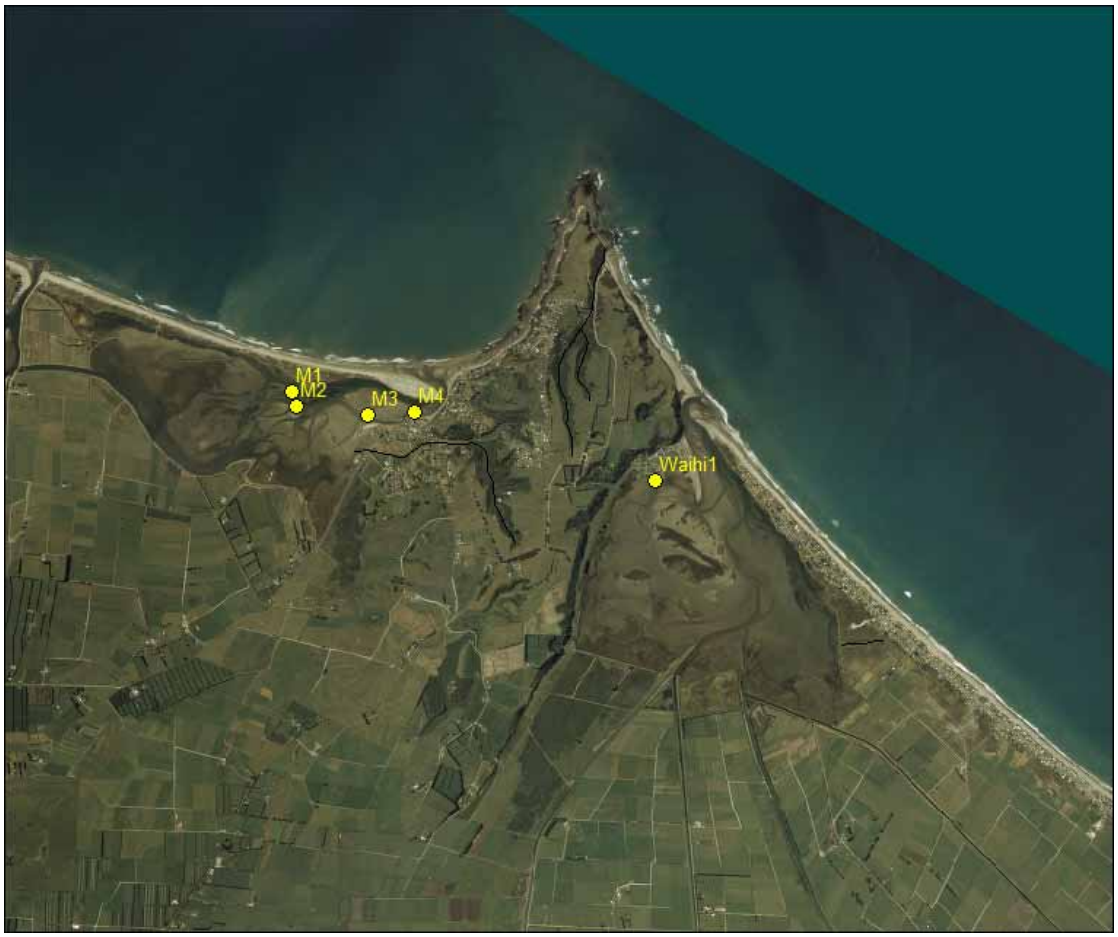

Figure 3 *Sites in Maketu and Waihi Estuaries that have been sampled for contaminants between 2003 and 2008.*

2.2 Methods

2.2.1 Sediment samples

(a) Tauranga Harbour and Ohiwa Harbour baseline monitoring

The 31 sites sampled in Tauranga Harbour as part of the three yearly contaminant survey programme correspond with sites previously sampled in June 2003 (reported in Park 2003). The latest survey of Tauranga sites took place on 23 May 2006. The seven sites in Ohiwa Harbour have only been sampled once on 24 May 2006.

Each survey involves locating and marking sites using GPS units. The protocol for collecting sediment consists of randomly taking 15 small replicate samples from the top 2 cm of sediment using a stainless steel trowel from within a 10 m radius from the marked site location. Replicate samples from each site are combined into a single sample and stored in labelled plastic bags. Analysis for contaminants and TOC (2006 survey) is based on the whole sediment sample size fractions as collected.

Sediment particle size analysis for samples from the three yearly survey was done using a "Malvern" laser particle size analyser at the University of Waikato to provide detail of the particle size range from 0.05 – 880 microns. This allowed the proportions of gravel, sand and mud (silt and clay) to be determined and presented as an indicator of particle size fractions.

(b) **Coastal and Estuarine Ecology survey**

Sediment samples collected as part of the Coastal and Estuarine Ecology annual ecological survey occur over summer between November and February covering Tauranga, Ohiwa, Maketu, Waihi and Waiotahi estuaries. Each site is located by GPS and runs as a transect for 45 m along the shore (Park 2000). The protocol for collecting sediment consists of randomly taking 15 small replicate samples from the top 2 cm of sediment with a stainless steel trowel along the transect for the estuarine sites. Replicate samples from each site were combined into a single composite sample and stored in labelled plastic bags. At open coastal sites a single core sample to 25 cm depth is collected. Analysis for contaminants and TOC is based on the sediment sample size fractions <500 microns.

Sediment particle size analysis is undertaken by use of dry sieving. All procedures follow standard methods except that carbonate (shell fragments) is not removed from the samples. Particle size is analysed using the Wentworth scale and graphical determination of mean, sorting and skewness.

(c) **Stormwater outlet survey**

A survey of the impact of stormwater on sediment contaminants was conducted at freshwater and marine sites in January 2008. Freshwater sediment samples were collected around Tauranga's developed catchments. The Maleme Street and Te Maire Street sites drain industrial areas while those in the Kopurererua Stream have urban and industrial stormwater impacts. A number of the freshwater sites have been sampled in the past (McIntosh and Deely 2001).

Only a small number of representative marine stormwater outfalls were sampled from around Tauranga (see list in Appendix I). These were selected to provide a range of environmental conditions. At each freshwater site a minimum of 15 small replicate samples of fine sediment from the top 2 cm were collected and combined into a single composite sample. At marine outfalls the same sampling protocol was used to collect samples from an arc around 10 and 50 m from the outfall. Analysis for contaminants and TOC (2006 survey) is based on the whole sediment sample size fractions as collected.

2.2.2 Contaminant analysis

Methods for contaminant analysis follows standard methods conducted by IANZ accredited laboratories.

Total recoverable metals used nitric/hydrochloric acid digestion, ICP-MS (low level), USEPA 200.2. Total hydrocarbons by ASE or Sonication extraction, GC-FID Quantification USEPA 8015B/NZ OIEWG. PAH's by sonication extraction, silica gel cleanup, GC-MS selected ion monitoring quantification. USEPA 3540 and 3630. PCB's by sonication extraction, GPC/Florisil cleanup and GC-MS SIM USEPA 3540, 3611 and GC-MS SIM.

2.2.3 Use of ANZECC environmental guidelines

Results from the surveys are compared to the Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 guidelines. These guidelines are referred to as the interim sediment quality guidelines (ISQG). There are two guidelines values (low and high) which are not intended to be absolute guidelines to aim for but rather used to guide decision making and actions. The low value is a level at which sub-lethal effects may occur for sensitive species. Used correctly it provides a trigger level for further investigation to determine whether there may be toxicity issues and a need for remedial action. The high ISQG is a trigger level indicating that there is a need for further investigation and action to remediate the contaminant(s) due to potential toxicity. If environments have very high biological values then ideally there should be no increase in contaminant levels above background values.

Comparison of contaminant values against the guidelines is often made with a range of methodologies for analysis of sediment samples. Ideally metals results should be standardised to the <63 micron sediment particle size fraction. Also results are normally gained in terms of total metals which utilises a high strength acid digestion of the sample. The ANZECC guidelines point out that a milder digestion of samples would provide a more biologically relevant results which would normally mean lower detected metal levels.

Chapter 3: Results

3.1 Sediment contaminants

3.1.1 Tauranga Harbour and Ohiwa Harbour baseline monitoring

The concentration of contaminants in sediments collected in May 2006 are presented in Table 1. The sediment quality guidelines for the protection of sediment dwelling fauna (bottom of the table) show that no results based on whole sediment analysis exceed these guidelines.

Sites 253 in Waikareao Estuary and 176 in Waimapu Estuary have the highest contaminant levels of all the sites in this survey (i.e. PAH's and lead (Pb)). Site 253 in Waikareao Estuary is the only site with metals (As, Pb, Zn) concentrations that would exceed guidelines if standardised to 100% mud (<63 micron particle size).

Overall, the results for the 2006 survey are very similar to those recorded in 2003 (Park 2003). With only two survey results for each of the Tauranga Harbour sites it is not yet possible to indicate trends with any reliability.

Table 1 *Concentration of total PAH's and metals (mg/kg dry wt) collected from sediment monitoring sites in Tauranga and Ohiwa Harbours in May 2006 based on whole sediment samples.*

Tauranga H.	Site	Mud %	TOC g/100g	PAH	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
Rangataua Bay	5	14.6	0.36		2.0	0.04	2.3	1.6	2.5	0.03	1.0	14.2
Welcome Bay	20	18.2	0.54		2.3	0.06	2.5	2.4	3.3	0.05	1.0	23.8
Welcome Bay	23	19	0.49	0.001	3.1	0.06	2.1	1.9	3.0	0.04	0.9	25.3
Rangataua Bay	26	15.4	0.41	0.001	2.0	0.03	2.3	1.6	2.7	0.02	0.8	20.0
Welcome Bay	36	25.2	0.48		2.9	0.07	3.8	2.3	4.0	0.03	1.4	33.0
Waipu Bay	47	26.5	0.28		1.8	0.21	1.8	1.5	1.7	0.05	0.7	18.4
Waipu Bay	49	14.5	0.27	0.001	1.2	0.03	1.4	1.0	1.5	0.02	0.5	9.8
Wairoa	154	21.3	0.38		2.0	0.16	2.7	0.9	2.1	0.03	1.0	15.8
Waimapu	164	40	0.82	0.004	3.5	0.04	2.8	2.0	4.9	0.04	1.0	42.6
Waimapu	172	54	0.84	0.076	3.1	0.09	3.6	3.9	7.0	0.04	1.4	41.5
Waimapu	176	18.9	0.52	0.141	1.9	0.06	2.9	3.9	8.9	0.02	1.4	32.3
Mangawhai	196	38.4	0.45	0.001	3.1	0.03	2.8	1.4	3.3	0.02	1.0	17.2
Wainui Estuary	198	36.9	0.44		3.3	0.06	4.7	1.5	3.1	0.03	1.8	12.8
Wainui Estuary	202	73.2	1.2		6.0	0.12	7.0	3.2	6.6	0.04	2.7	30.3
Tuapiro Estuary	214	44	0.62	0.001	4.2	0.10	5.4	2.0	3.1	0.04	1.9	18.5
Waikareao	246	51.9	0.59	0.005	3.7	0.08	3.5	1.8	6.3	0.03	1.1	78.1
Waikareao	248	22.9	0.35		2.7	0.04	3.4	1.3	3.7	0.02	1.0	40.0
Waikareao	253	17.9	0.49	0.378	3.6	0.11	4.4	2.1	8.6	0.02	1.1	76.0
Wairoa	266	15.1	0.42		1.3	0.05	2.1	0.8	2.0	0.01	0.9	10.4
Wairoa	268	20.6	0.64	0.001	2.4	0.06	2.3	1.1	2.9	0.02	0.8	16.0
Rereatukahia	269	54.7	0.85	0.001	5.0	0.06	5.4	3.9	5.3	0.06	2.3	25.2
Rereatukahia	272	48.1	1.09		6.5	0.06	12.2	4.3	7.1	0.08	5.1	28.9
Matahui	281	45.6	0.65		5.6	0.10	8.7	2.9	4.6	0.11	4.0	32.8
Waipapa	295	17.1	0.29		1.5	0.06	2.1	0.9	1.7	0.01	0.8	9.1
Apata Estuary	308	68.3	0.59		3.7	0.07	4.7	2.2	4.3	0.03	1.9	20.0
Aongatete	313	32.9	0.4	0.001	3.6	0.05	4.2	1.4	3.3	0.03	1.6	15.7
Te Puna	335	47.7	0.87	0.001	4.3	0.08	4.0	5.0	4.8	0.03	1.5	23.0
Katikati	368	66.4	1.42	0.001	7.3	0.13	9.2	3.7	6.7	0.06	3.6	36.5
Katikati	372	61.8	1.04		5.8	0.08	6.9	2.6	4.7	0.04	2.7	28.4
Waiau Estuary	379	28.2	0.64		3.7	0.10	4.2	2.2	3.6	0.04	1.4	16.5
Rereatukahia	380	42.8	0.81		5.7	0.08	10.9	3.2	5.0	0.05	3.9	28.7
Ohiwa H.												
Kuterere	14	50.6	0.64	0.033	5.5	0.04	7.3	6.3	6.3	0.07	5.4	37.3
Ohiwa camp	23	61.6	0.57	0.023	5.6	0.04	7.6	6.7	6.2	0.06	5.4	34.6
Water ways	1002	24.3	0.3	0.006	4.0	0.01	4.2	3.4	3.7	0.03	3.2	21.9
North	1007	36.8	0.44	0.037	5.1	0.02	7.2	5.4	5.6	0.05	5.3	33.9
Oyster farm	1009	43.3	0.53	0.014	3.9	0.02	5.4	4.8	5.0	0.03	3.9	28.9
West	1019	23.7	0.37	0.003	2.7	0.02	4.2	4.2	3.9	0.03	3.4	22.9
East	1054	44.3	0.28	0.007	4.5	0.01	5.6	3.9	4.7	0.04	3.9	25.4
ISQG Low				4	20	1.5	80	65	50	0.15	21	200
ISQG high				45	70	10	370	270	220	1	52	410

3.1.2 Coastal and Estuarine Ecology survey

The metal concentrations measured at the Coastal and Estuarine Ecology monitoring sites are presented in Table 2. These are all low tide sites located in generally more open sandy areas of the harbour. Results are presented as mean values for the three years of data obtained to date. No sites exceed the ISQG low values despite analysis being based on only the particle size fraction less than 500 micron (coarse sand and gravel removed).

In Table 1 and 2 results show some geographical trends. Arsenic concentrations appear to be higher in the central and eastern Bay of Plenty sites. In Ohiwa Harbour chromium, copper and nickel concentrations appear to be marginally higher.

Table 2 *Mean metal concentrations (mg/kg dry wt – 500 micron sediment fraction) from the annual Coastal and Estuarine Ecology monitoring sites for the period 2006 – 2008.*

	TOC g/100g	Mud %	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
Tau1	0.22	1	1.1	0.037	3.17	0.80	1.33	0.035	0.87	7.6
Tau4	0.29	2	2.6	0.04	4.63	0.90	1.81	0.037	1.60	9
Tau9	0.36	7.9	2.9	0.09	3.23	0.97	2.64	0.04	0.97	17.5
Tau11	0.34	0.8	2.3	0.043	4.30	0.80	1.95	0.035	1.40	12.5
Tau13	0.34	5.8	2.3	0.07	3.90	1.87	3.63	0.037	1.67	40.3
Tau17	0.81	13.3	3.3	0.093	6.53	3.63	6.93	0.05	2.63	40.3
Tau18	0.52	9.5	3.2	0.107	6.30	2.80	4.83	0.04	2.43	32.7
Mak1	0.16	0.9	3.7	0.04	5.05	0.90	2.17	0.035	2.30	20.1
Mak2	0.19	0.7	3.7	0.035	3.67	0.93	2.02	0.04	1.10	19.4
Mak3	0.18	0.9	4.1	0.035	3.20	0.87	1.98	0.035	1.53	15.8
Mak4	0.19	0.2	4.8	0.028	2.10	0.80	1.76	0.04	1.05	11.7
Waihi	0.3	7.9	2.7	0.037	5.67	1.40	2.72	0.057	2.37	17.8
Ohiwa1	0.4	15.1	5.9	0.05	13.00	5.30	6.00	0.05	8.00	36
Ohiwa2	0.38	14	5.4	0.04	10.10	4.53	5.44	0.047	6.50	32.4
Ohiwa3	0.38	14.2	6	0.04	12.40	4.45	4.93	0.045	7.70	29.6
Ohiwa6	0.23	5.3	6.6	0.04	9.27	4.57	5.11	0.047	6.17	34.7
Waiotahi	0.15	1.1	6.3	0.035	7.53	5.43	5.78	0.05	5.80	36.5
Papamoa	0.05	0.1	7.7	0.05	3.30	1.00	1.70	0.05	1.00	9
Matata	0.04	0.1	5	0.035	2.13	0.87	2.16	0.04	1.07	11
Ohope	0.11	0.1	10.1	0.04	8.23	4.70	5.66	0.043	6.23	35.4
Opape	0.08	0.1	8.2	0.035	6.37	5.00	6.06	0.04	5.47	30.7
ISQG Low			20	1.5	80	65	50	0.15	21	200
ISQG high			70	10	370	270	220	1	52	410

3.1.3 Stormwater outlet survey

Contaminant levels from the freshwater and stormwater impacted sites are presented in Table 3. The contaminant concentrations on a whole sample basis are low to moderate for most sites. Te Maire Street samples (industrial site including two scrap metal yards) contained the highest level of metals. Zinc (Zn) concentrations at this site exceed the ANZECC interim sediment quality guidelines low level (ISQG see bottom of Table 3). Marine samples from Welcome Bay just exceeded the ISQG low value for lead (Pb) and was the only marine site to do so for any parameter measured.

Table 3 *Concentration of PCB's, PAH's and heavy metals (mg/kg dry wt) sampled on 18 and 23 January 2008 at stormwater impacted sites in and around Tauranga Harbour based on whole sediment samples.*

Freshwater sites	Mud %	TOC g/100g	PCB	PAH	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
Waimapu River	10.1	2.1	<0.02	0.031	2.4	<0.1	2.6	4.6	7.5	<0.1	1	38
Maleme St drain	18.3	2.0	<0.02	0.049	2.6	<0.1	2.1	3.7	8.6	<0.1	1	45
Kopurererua Tamatea Dr	20.6	2.3	<0.02	0.000	3.1	0.2	2.3	4.3	11	<0.1	1	60
Kopurererua Waihi Rd	26.5	1.4	<0.02	0.044	3.5	0.11	4.4	5.9	14	<0.1	1	65
Te Maire below Manu	5.4	1.1	<0.02	0.244	2.9	0.49	20	28	32	<0.1	7.1	260
Te Maire above Manu	8.4	2.5	<0.02	0.347	6.8	0.27	13	31	22	<0.1	3.6	280
Marine sites												
Grace Rd 0 -10m	3.0	0.4	<0.02	0.114	1	<0.1	1	1	3.3	<0.1	1	19
Grace Rd 50m	5.5	0.4	<0.02	0.016	1	<0.1	1	1	3.3	0.12	1	22
Maxwell Rd 0 -10m	13.2	1.0	<0.02	2.244	4.8	<0.1	5	9.5	20	<0.1	1	85
Maxwell Rd 50m	8.3	0.4	<0.02	0.338	3.2	<0.1	2.6	1	3.6	<0.1	1	18
Harbour Dr 0 -10m	10.2	0.7	<0.02	0.474	4.9	<0.1	3.6	3.5	5.9	<0.1	1	32
Harbour Dr 50m	2.3	0.2	<0.02	0.013	1	<0.1	2.3	1	3	<0.1	1	17
Fraser Rd 0 -10m	20.1	1.9	<0.02	0.581	4.8	0.11	9.2	15	24	<0.1	3.6	110
Fraser Rd 50m	24.8	2.3	<0.02	0.772	6.2	0.13	8.6	53	32	<0.1	5	130
Welcome Bay 0 -10m	7.8	2.0	<0.02	0.642	5.7	0.11	10	10	24	<0.1	3.1	92
Welcome Bay 50m	47.7	2.8	<0.02	0.121	7.5	0.14	10	12	52	0.14	2.7	71
ISQG Low			23	4	20	1.5	80	65	50	0.15	21	200
ISQG high				45	70	10	370	270	220	1	52	410

PAH concentrations in Table 3 are totals (not including half level of detection) for this group of compounds. The highest concentrations were recorded at the Maxwell Rd stormwater outfall in Waikareao Estuary (2.2 mg/kg). The individual PAH compounds found at highest concentrations included fluoranthene, pyrene, fluorene, phenanthrene and benzo-fluoranthene. Both fluorene and phenanthrene concentrations (0.037 and 0.28 mg/kg dry weight) exceed the sediment quality guidelines (low level - 0.019 and 0.24). No sites recorded PCB's above the detection limit of 0.02 mg/kg dry weight.

Sediment contaminant results standardised to the mud fraction (less than 63 microns) are presented in Table 4. This allows better comparison between sites using the assumption that most of the contaminants will be adhering to the smaller sediment particles. It also provides an indication of what the sediment concentrations would be in areas where sorting might occur such as the accumulation of just the finer mud particles in low energy environments. Blank cells in the table are where the initial results were below the analytical detection limits.

Table 4 *Concentration of PAH's and heavy metals (mg/kg dry wt) sampled on 18 and 23 January 2008 at stormwater impacted sites in and around Tauranga Harbour standardised to the 63 micron (mud) sediment fraction*

Freshwater sites	**PAH**	**As**	**Cd**	**Cr**	**Cu**	**Pb**	**Hg**	**Ni**	**Zn**
Waimapu River	0.305	24		26	46	75			377
Maleme St drain	0.266	14		12	20	47			245
Kopurererua Tamatea Dr	0.000	15	0.97	11	21	54			292
Kopurererua Waihi Rd	0.167	13	0.42	17	22	53			245
Te Maire Rd below Manu	4.545	54	9.14	**373**	**522**	**597**		**133**	**4851**
Te Maire Rd above Manu	4.119	**81**	3.20	154	**368**	**261**		43	**3321**
Marine sites									
Grace Rd 0 - 10m	3.803					110			**635**
Grace Rd 50m	0.291					60	**2.2**		400
Maxwell Rd 0 - 10m	17.065	37		38	72	152			**646**
Maxwell Rd 50m	4.090	39		32		44			218
Harbour Dr 0 - 10m	4.660	48		35	34	58			315
Harbour Dr 50m	0.581			100		131			**742**
Fraser Rd 0 - 10m	2.891	24	0.55	46	74	119		18	**547**
Fraser Rd 50m	3.116	25	0.52	35	214	129		20	**525**
Welcome Bay 0 - 10m	8.227	**73**	1.41	128	128	**308**		40	**1179**
Welcome Bay 50m	0.253	16	0.29	21	25	109	**2.6**	6	148
ISQG Low	**4**	**20**	**1.5**	**80**	**65**	**50**	**0.15**	**21**	**200**
ISQG high	45	70	10	370	270	220	1	52	410

A number of contaminant concentrations exceed sediment quality guidelines when standardised to the mud fraction. Zinc and lead (Zn and Pb) exceed the low level sediment guideline at nearly all sites. At the marine stormwater outfall sites zinc exceeds the high sediment guideline. The Te Maire Road site draining the industrial area in Mt Maunganui exceeds at least the ISQG low for every metal measured except mercury (Hg). Standardised total PAH's also exceed the ISQG low for a number of sites. At the Maxwell road site every individual standardised compound concentration exceeds the ISQG low and phenanthrene and pyrene exceed the ISQG high.

Chapter 4: Discussion and Summary

4.1 Stormwater impacts

Previous harbour wide surveys of Tauranga Harbour have shown that the highest metal concentrations occur near urban and industrialised areas (McIntosh 1994, Park 2003). This trend is also found in the Auckland region and is attributed mainly to stormwater discharges (Williamson et al. 1999). Table 5 below provides comparison of the mean concentration of metals from the various surveys. Copper, lead and zinc are the metals which are clearly elevated above background levels.

Table 5 Mean sediment concentration of metals (mg/kg dry wt) from the various surveys around the Bay of Plenty.

Study	As	Cd	Cr	Hg	Ni	Cu	Pb	Zn
Stormwater outfalls 0-10m	4.2	0.07	5.8	<0.1	1.9	7.8	15.4	68
Stormwater outfalls 50m	3.8	0.08	4.9	0.08	2.1	13.6	18.8	52
Tauranga - 2006	3.5	0.08	4.4	0.04	1.7	2.3	4.3	27
Ohiwa - 2006	4.5	0.02	5.9	0.04	4.4	5.0	5.1	29
CEE 2006-2008*	4.7	0.05	5.9	0.04	3.2	2.5	3.7	24
Tauranga -1991	3		3	.03		2	6	21

*Results on sediment fraction <500microns – all others on whole sample

A study of stormwater sediments in drains/streams around Tauranga (McIntosh & Deely 2001) showed that high levels of copper, lead and zinc had the potential to impact harbour sediment ecology. The sample taken in this study from the previously reported industrial site at Maleme Street now has lower metal concentrations suggesting that improvements have occurred over time. Mean values for zinc, copper and lead in 1998/99 were 241, 17 and 30 mg/kg compared to the 2008 result of 45, 4 and 9 mg/kg. Results show contamination impacts at Te Maire street in Mt Maunganui where runoff from scrap metal yards and other industrial activities have the potential to adversely impact harbour ecology.

The results of the marine stormwater outfall survey around Tauranga Harbour show intertidal flats have been exposed to elevated levels of contaminants. Based on the range of sites surveyed it appears that most sediments still meet the ANZECC ISQG low value for the protection of infauna. However, if results are standardised to the mud (<63 micron particle size) fraction, which may occur naturally in sheltered areas with low currents and wave energy, then guidelines would be exceeded.

Even though only a small amount of stream/drain data was collected in this investigation, it reflects the pattern of results obtained for the harbour. Concentrations of lead and zinc in the sediment of the Kopurererua Stream standardised to the mud fraction exceed the ISQG low value. These two metals also exceed the guideline values at nearly all the stormwater outfall sites on a standardised basis. Copper and PAH's also show elevated concentrations and exceed the ISQG low at around half the sites sampled.

Concentrations of total PAH's at stormwater outfalls in this study (0.013–2.24 mg/kg dry wt) are within guidelines and similar to the ARC's sediment monitoring programme (27 sites) which has recorded average values ranging from 0.012– 9.48 mg/kg dry weight (Mathieson et al. 2002). As shown in Table 4, there is a potential for environmental effects as standardising results to the mud fraction produces results that exceed guidelines. In general PAH's are commonly derived from incomplete combustion of organic material, or petroleum and coal products. The two individual compounds in this study potentially exceeding the ISQG (fluorene and phenanthrene) are commonly sourced from coal tar, asphalt and engine exhaust.

All results, including previous studies, show that stormwater discharges are having a localised impact on contaminant levels in Tauranga Harbour. Concentrations of contaminants in some areas are close to levels at which environmental effects may be occurring. Results indicate that further investigations around more sheltered outfalls could reveal additional marginal habitat.

This study highlights the need to closely address control of stormwater contaminants discharged to Tauranga Harbour. In the Auckland region zinc in particular is continuing to increase at most sites and already exceeds guidelines at some (Mathieson et al. 2002). The source of much of the zinc is being traced back to roofing materials. Currently Environment Bay of Plenty is working with the regions territorial authorities to improve stormwater management practises and consent requirements. In addition to the regular background monitoring programme that is now in place, a selection of the more sensitive receiving environments around marine stormwater outfalls should also be undertaken. This could be a monitoring requirement of resource consents.

4.2 Summary

The results from the Tauranga stormwater outfalls (on a whole sediment basis) show elevated concentrations of Polycyclic Aromatic Hydrocarbons (PAH's) and metals although these are generally below the ANZECC guidelines. However when results are standardised to the mud fraction, which may occur naturally in some sheltered areas of the harbour, copper, lead, zinc and PAH's have the potential to reach concentrations above the guidelines. Zinc in particular is elevated compared to the guidelines when standardised to the mud fraction.

A small number of sediment samples taken from drains and streams around Tauranga show that the industrial areas (e.g. Mount Maunganui) contribute high levels of contaminants. However, sampling of the Maleme Street industrial area showed lower levels of contaminants than that recorded in 1998/99.

The emerging pattern appears very similar to that found around Auckland where stormwater discharges of zinc and copper are still accumulating in the settlement zone of estuaries. Close attention and ongoing improvements in stormwater management will be needed to prevent sensitive areas of Tauranga Harbour becoming ecologically degraded.

Given that results generally show potential for the ANZECC guidelines to be exceeded for PAH's, zinc and lead, further investigation to determine environmental levels and the toxicity risk should be undertaken.

Chapter 5: References

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Appendices

Appendix I Sediment sampling sites

Appendix I – Sediment Sampling Sites

location	Survey	Site number	Hydro class	easting	northing
Tauranga	Contaminants 3 yearly	5	marine	2793758	6385236
Tauranga	Contaminants 3 yearly	20	marine	2792143	6381932
Tauranga	Contaminants 3 yearly	23	marine	2791291	6381766
Tauranga	Contaminants 3 yearly	26	marine	2795310	6384123
Tauranga	Contaminants 3 yearly	36	marine	2790689	6381862
Tauranga	Contaminants 3 yearly	47	marine	2792619	6385620
Tauranga	Contaminants 3 yearly	49	marine	2792218	6384956
Tauranga	Contaminants 3 yearly	154	marine	2783548	6388043
Tauranga	Contaminants 3 yearly	164	marine	2788494	6381283
Tauranga	Contaminants 3 yearly	172	marine	2788105	6382634
Tauranga	Contaminants 3 yearly	176	marine	2789038	6383039
Tauranga	Contaminants 3 yearly	196	marine	2777478	6388665
Tauranga	Contaminants 3 yearly	198	marine	2773932	6393818
Tauranga	Contaminants 3 yearly	202	marine	2773476	6393464
Tauranga	Contaminants 3 yearly	214	marine	2770594	6407417
Tauranga	Contaminants 3 yearly	246	marine	2788261	6385074
Tauranga	Contaminants 3 yearly	248	marine	2788108	6385614
Tauranga	Contaminants 3 yearly	253	marine	2788899	6385632
Tauranga	Contaminants 3 yearly	266	marine	2785206	6386841
Tauranga	Contaminants 3 yearly	268	marine	2785446	6387115
Tauranga	Contaminants 3 yearly	269	marine	2768998	6400568
Tauranga	Contaminants 3 yearly	272	marine	2768851	6398206
Tauranga	Contaminants 3 yearly	281	marine	2771072	6397370
Tauranga	Contaminants 3 yearly	295	marine	2777179	6391631
Tauranga	Contaminants 3 yearly	308	marine	2774242	6391903
Tauranga	Contaminants 3 yearly	313	marine	2773014	6395407
Tauranga	Contaminants 3 yearly	335	marine	2778731	6386896
Tauranga	Contaminants 3 yearly	368	marine	2769565	6403114
Tauranga	Contaminants 3 yearly	372	marine	2769003	6403058
Tauranga	Contaminants 3 yearly	379	marine	2772874	6412828
Tauranga	Contaminants 3 yearly	380	marine	2769224	6398654
Ohiwa	Contaminants 3 yearly	14	marine	2873172	6343590
Ohiwa	Contaminants 3 yearly	23	marine	2875432	6348425
Ohiwa	Contaminants 3 yearly	1002	marine	2868756	6349893
Ohiwa	Contaminants 3 yearly	1007	marine	2869676	6349365
Ohiwa	Contaminants 3 yearly	1009	marine	2867074	6349563
Ohiwa	Contaminants 3 yearly	1019	marine	2866684	6347754
Ohiwa	Contaminants 3 yearly	1054	marine	2874447	6346712
Papamoa Beach	Coastal & Estuarine Ecology - annual	C3	marine	2800170	6384240
Matata Beach	Coastal & Estuarine Ecology - annual	C6	marine	2840986	6361625
Ohope Beach	Coastal & Estuarine Ecology - annual	C9	marine	2863753	6352765
Opape Beach	Coastal & Estuarine Ecology - annual	C12	marine	2898339	6348995
Tauranga	Coastal & Estuarine Ecology - annual	T1	marine	2773186	6411993
Tauranga	Coastal & Estuarine Ecology - annual	T4	marine	2771215	6401692
Tauranga	Coastal & Estuarine Ecology - annual	T9	marine	2778845	6388800

Tauranga	Coastal & Estuarine Ecology - annual	T11	marine	2788794	6388056
Tauranga	Coastal & Estuarine Ecology - annual	T13	marine	2789639	6383981
Tauranga	Coastal & Estuarine Ecology - annual	T17	marine	2789290	6382265
Tauranga	Coastal & Estuarine Ecology - annual	T18	marine	2791615	6382522
Maketu	Coastal & Estuarine Ecology - annual	M1	marine	2813286	6377150
Maketu	Coastal & Estuarine Ecology - annual	M2	marine	2813324	6377025
Maketu	Coastal & Estuarine Ecology - annual	M3	marine	2813942	6376942
Maketu	Coastal & Estuarine Ecology - annual	M4	marine	2814331	6376969
Waihi	Coastal & Estuarine Ecology - annual	Waihi1	marine	2816376	6376389
Ohiwa	Coastal & Estuarine Ecology - annual	O1	marine	2869163	6348822
Ohiwa	Coastal & Estuarine Ecology - annual	O2	marine	2869724	6347779
Ohiwa	Coastal & Estuarine Ecology - annual	O3	marine	2870838	6348092
Ohiwa	Coastal & Estuarine Ecology - annual	O6	marine	2872817	6345752
Waiotahi	Coastal & Estuarine Ecology - annual	Waiotahi	marine	2879038	6347974
Maleme drain	Stormwater contaminants survey		fresh water	2787177	6380546
Waimapu River below Maleme	Stormwater contaminants survey		fresh water	2787300	6380750
Kopureruru Stream below Tamatea Dr	Stormwater contaminants survey		fresh water	2787042	6384122
Kopureruru Stream below Waihi Rd	Stormwater contaminants survey		fresh water	2788113	6384635
Te Maire below Manu Rd	Stormwater contaminants survey		fresh water	2792238	6388467
Te Maire above Manu Rd	Stormwater contaminants survey		fresh water	2792270	6388465
Grace Rd 0 -10m	Stormwater contaminants survey	0-10	marine	2789409	6383871
Grace Rd 50m	Stormwater contaminants survey	50	marine	2789409	6383871
Maxwell Rd 0 -10m	Stormwater contaminants survey	0-10	marine	2788807	6387434
Maxwell Rd 50m	Stormwater contaminants survey	50	marine	2788807	6387434
Harbour Dr 0 -10m	Stormwater contaminants survey	0-10	marine	2788423	6388068
Harbour Dr 50m	Stormwater contaminants survey	50	marine	2788423	6388068
Fraser Rd 0 -10m	Stormwater contaminants survey	0-10	marine	2787933	6382593
Fraser Rd 50m	Stormwater contaminants survey	50	marine	2787933	6382593
Welcome Bay Rd 0 -10m	Stormwater contaminants survey	0-10	marine	2790843	6381335
Welcome Bay Rd 50m	Stormwater contaminants survey	50	marine	2790843	6381335