

Healthy Estuary and Rivers of the City

*Water quality and ecosystem health
monitoring programme of Ihutai*

**Water quality of the Avon-Heathcote
Estuary/Ihutai**

Summary report on data collected in 2010

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Report No. R11/70

ISBN 978-1-927146-47-7 (print copy)

ISBN 978-1-927146-48-4 (electronic)

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May 2011





Report R11/70

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ISBN 978-1-927146-48-4 (electronic)

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1 Introduction

In order to assess the state of the water quality in the Avon-Heathcote Estuary/Ihutai a water quality monitoring¹ programme started in 2007. This programme is one of the four monitoring programmes described in *The Healthy Estuary and Rivers of the City: Water quality and ecosystem health monitoring programme of Ihutai document (2009)*².

Good water quality is required for the plants and animals that live in the water, and on and in the sea bed, to function normally. For the water to be of good quality it should not contain unnaturally high concentrations of nutrients or sediment and must contain sufficient oxygen for living things. High concentrations of nutrients and sediment and low concentrations of oxygen can be detrimental to the plants and animals that live in the water, and on and in the sea bed.

Prior to 4 March 2010, the water within the Avon-Heathcote Estuary/Ihutai was a mix of the fresh water flowing out of the Avon and Heathcote rivers, the sea water from Pegasus Bay flowing into the estuary as the tide rises and the tertiary treated wastewater discharged from the oxidation ponds. On 4 March 2010 the discharge of tertiary treated wastewater into the estuary ceased. This wastewater consisted of nutrient enriched freshwater that was discharged into the estuary twice a day around high tide.

Water quality is monitored monthly at sites within and just outside the estuary. This is a summary report of the water quality data collected at these sites in 2010. The information provided in this report only gives the state of the water quality in 2010. This is the fourth summary report to be produced. The reader can refer to the annual summary reports (access via www.estuary.org.nz and www.ecan.govt.nz search: Ihutai) to evaluate differences over time. There will be considerable interest in the difference in water quality in 2010 to that in previous years given the removal of the wastewater discharge. Given this interest, the calculated decreases in ammonia nitrogen and dissolved reactive phosphorus concentrations following removal of the wastewater are presented in this report. A report including more detailed analysis, such as analysis of trends over time, will be produced following five years of data collection.

¹ Monitoring is the routine collection of data over time in order to assess the state of the environment and identify changes over time.

² Batcheler, L., Bolton-Ritchie, L., Bond, J., Dagg, D., Dickson, P., Drysdale, A., Handforth, D and Hayward, S. 2009. *Healthy Estuary and Rivers of the City: Water quality and ecosystem health monitoring programme of Ihutai*. Environment Canterbury Report No RO9/8. 60pp.

2 Sampling

2.1 Sampling sites

The sites sampled are shown in Figure 1.

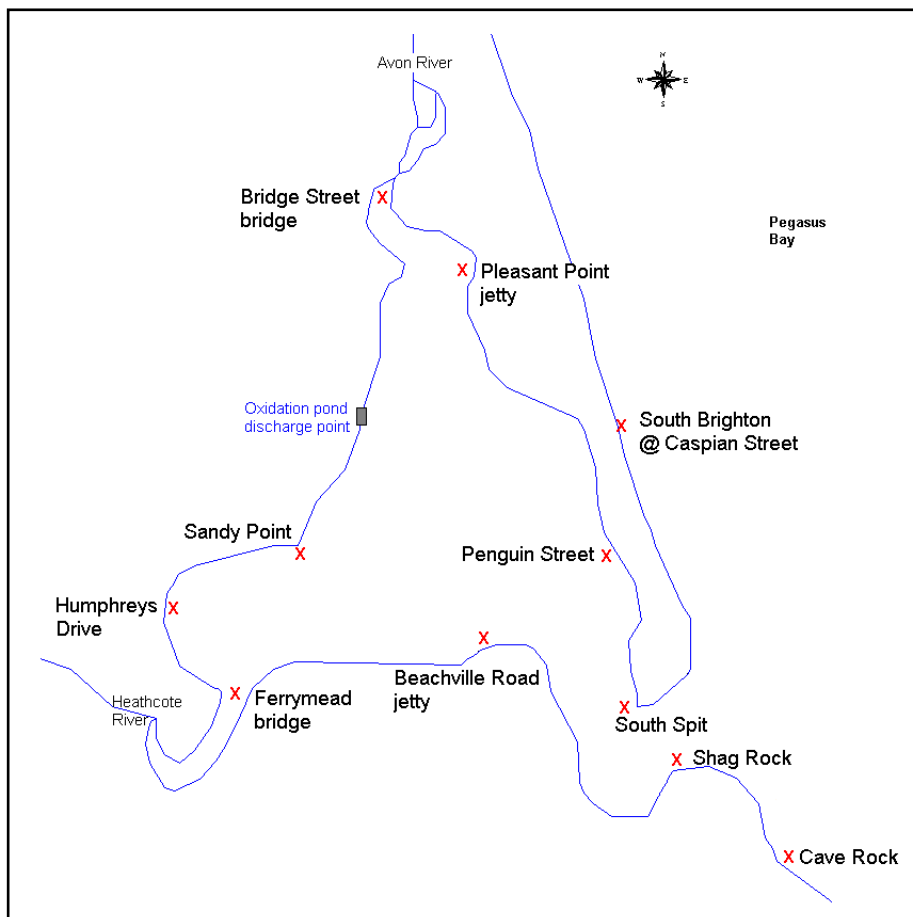


Figure 1: Location of the water quality sampling sites

2.2 Collection of water samples

Water samples were collected around the time of high tide at South Brighton @ Caspian Street, South Spit, Penguin Street, Pleasant Point jetty, Sandy Point, Humphreys Drive, Beachville Road jetty, Shag Rock (estuary mouth) and Cave Rock. Water samples were collected around the time of low tide at Bridge Street bridge (Avon River), Ferrymead bridge (Heathcote River) and Shag Rock (estuary mouth).

Water samples were collected monthly by Environment Canterbury staff. Note, three months of data were collected prior to cessation of the wastewater discharge and nine months of data were collected when there was no wastewater discharge.

2.3 Water quality parameters

The water samples were analysed for a range of water quality parameters including:

- Water temperature
- Ammonia nitrogen
- Dissolved reactive phosphorus
- Dissolved oxygen saturation
- Salinity
- Nitrate-nitrite nitrogen
- Chlorophyll-a
- Total suspended solids

3 Results

The results are presented on the following pages. The data are typically presented as bar graphs. The height of the bar depicts the median³ value. The bars have been positioned on a map and below each bar are the minimum and maximum values recorded at a site. This form of presentation makes it is easy to see the similarities and differences between sites.

Guideline trigger values

Guidelines are established to protect different waterway values, such as ecosystem health and suitability for contact recreation. Comparison of water quality results with relevant guidelines is useful to determine whether the water quality state may be impacting on the values that a community considers are important for a waterway.

The ANZECC (2000)⁴ guidelines specify trigger values for nutrients and other water quality parameters in Australian estuarine waters. However, there are no specific ANZECC (2000) guideline trigger values for the nutrients ammonia nitrogen, nitrate-nitrite nitrogen and dissolved reactive phosphorus and for chlorophyll-a and dissolved oxygen saturation in New Zealand marine and estuarine waters. The guidelines suggest that New Zealand uses the south-east Australia trigger values but these are for low-nutrient waters and have been found to be unsuitable for the concentrations of nutrients in the estuarine and coastal waters of Canterbury and elsewhere in New Zealand. Hence the nutrient results from this study have not been compared to ANZECC (2000) trigger values.

Within the ANZECC (2000) guidelines there are also trigger values for known toxic chemicals such as ammonia and metals in sea water. The recorded ammonia nitrogen and metal concentrations have been compared to the toxicity trigger value that provides protection for 95% of marine species.

³ The median is the middle number when all numbers are ordered from lowest to highest. When there is an even number of numbers it is the average of the middle two numbers.

⁴ ANZECC 2000. Australia and New Zealand guidelines for fresh and marine water quality, Volume 1, The guidelines. Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

3.1 Water temperature

The water temperatures at each site are shown in Figure 2.

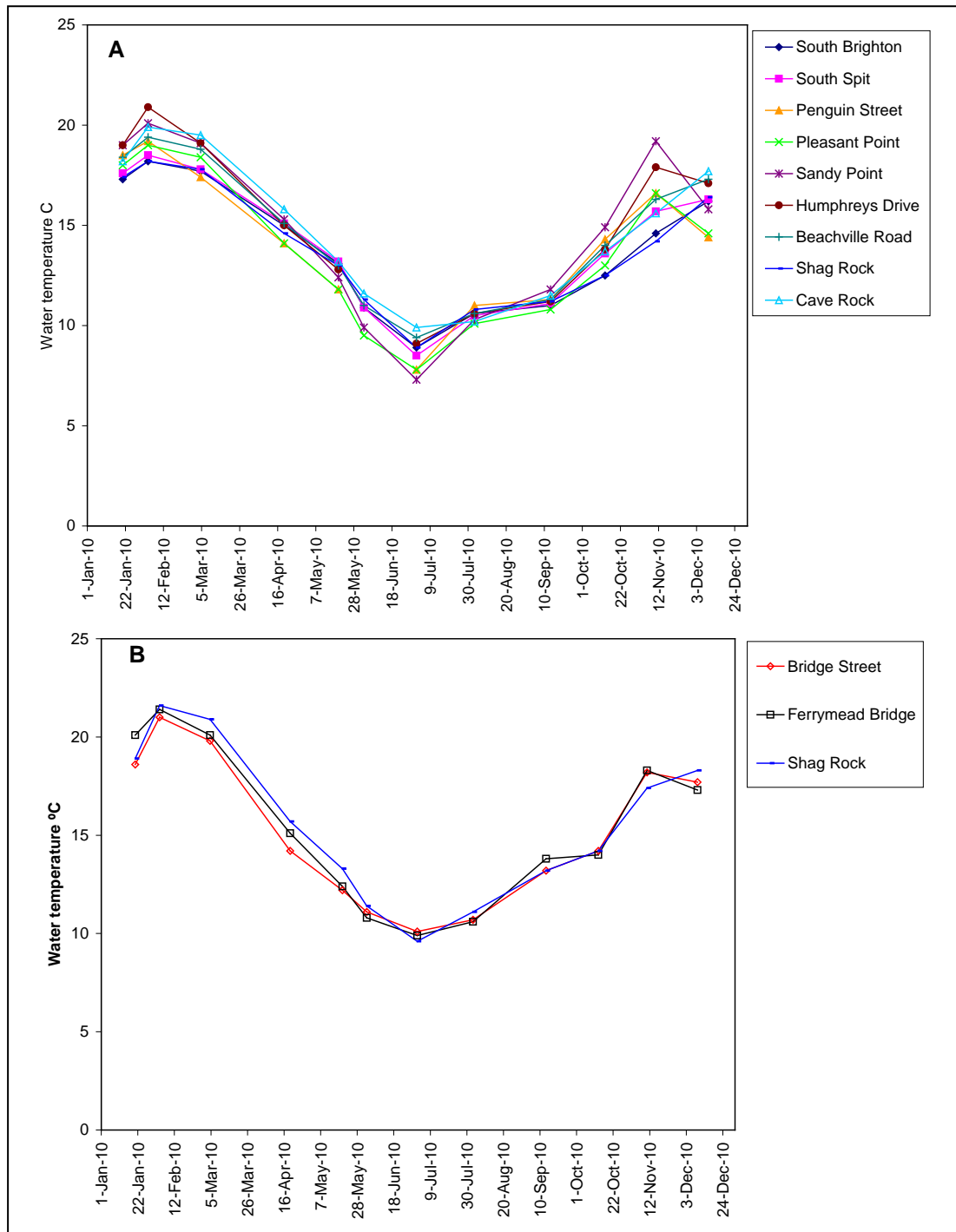


Figure 2: Water temperatures (°C) A – High tide B – Low tide

Water temperature is affected by air temperature, sunlight and water depth.

There were bigger differences in water temperature between high tide sites in November than in any other month. In July water temperatures at many of the high tide sites were lower

than those at low tide sites. The time of day of sampling and water depth may explain the results, high tide sites were typically sampled mid morning while low tide sites were typically sampled mid afternoon of the same day.

3.2 Salinity

This is a measure of how salty the water is. The sea water 2.5 to 10 kilometres from shore in Pegasus Bay typically has a salinity of 33 - 34.5 ppt (parts per thousand). Fresh water has a salinity of 0 ppt.

The minimum and maximum salinity at each site are shown on Figure 3.

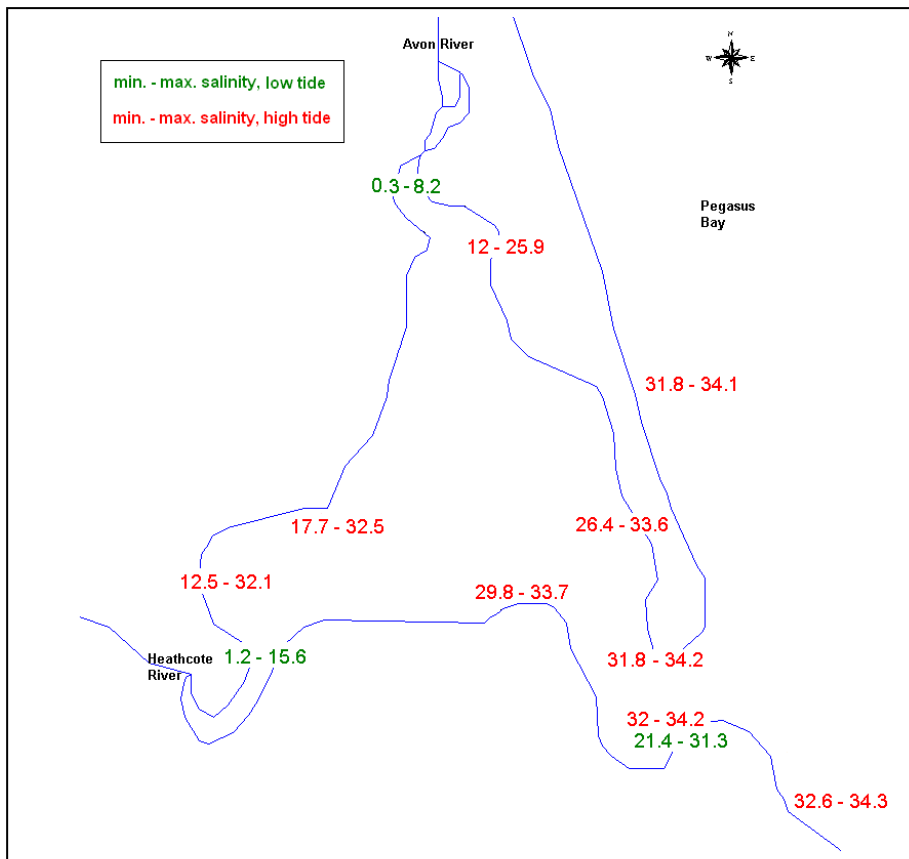


Figure 3: Range in salinity (ppt) at the high and low tide sites

At high tide the salinity within the estuary results from the mixing of the fresh water from the Avon and Heathcote rivers and the discharged wastewater (prior to 4 March) with the incoming sea water. The mixing of the fresh water with the sea water is influenced by wind and weather conditions as well as the volumes of fresh water flowing into the estuary. The salinity at sites within the estuary was very variable with the salinity at the mouth of the estuary and at sites in Pegasus Bay less variable. The less salty water flowing out of the estuary does influence salinity at the sites in Pegasus Bay.

At low tide the water flowing out of the Heathcote River contains some of the sea water that moved up the river with the rising tide. The water flowing out of the Avon River also contains some sea water, but less than the Heathcote River. At low tide the water at the mouth of the estuary is a mix of fresh water and sea water with the salinity depending on wind, weather and sea conditions.

3.3 Ammonia nitrogen (NH₃N)

The ammonia nitrogen (NH₃N) that occurs naturally in water is from the breakdown of once living and non-living nitrogenous matter and from gas exchange with the atmosphere. Ammonia nitrogen is formed during the breakdown of human and other animal excreta and the discharged wastewater was a contributor of this nutrient to estuary water.

The ammonia nitrogen concentrations at high tide are shown in Figure 4 while those at low tide are shown in Figure 5.

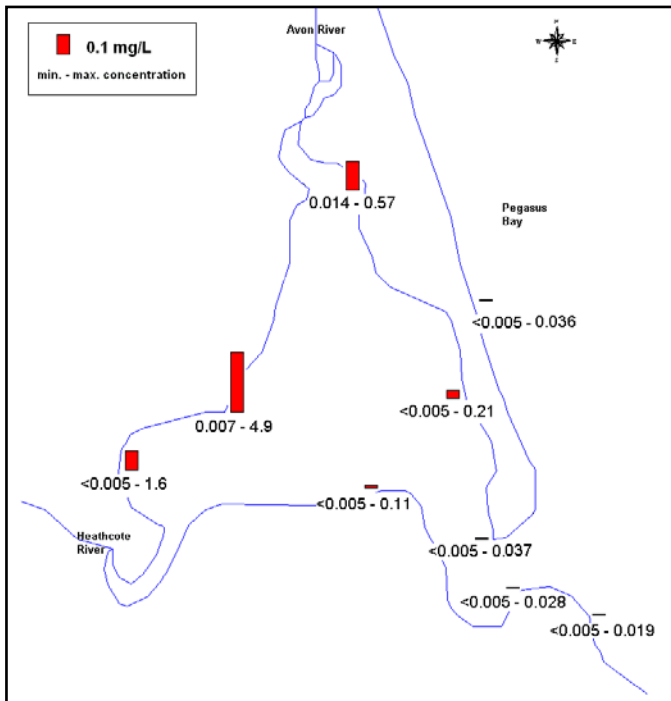


Figure 4: High tide ammonia nitrogen concentrations (mg/L)

When wastewater was discharged to the estuary the highest high tide concentrations of NH₃N occurred at sites close to the wastewater discharge point. The further away the site was from the discharge point, the lower the NH₃N concentrations.

The maximum NH₃N concentrations shown occurred when wastewater was still being discharged. With cessation of the wastewater discharge, concentrations at all sites dropped (Figure 6). There has been up to a 90% reduction in ammonia nitrogen concentrations.

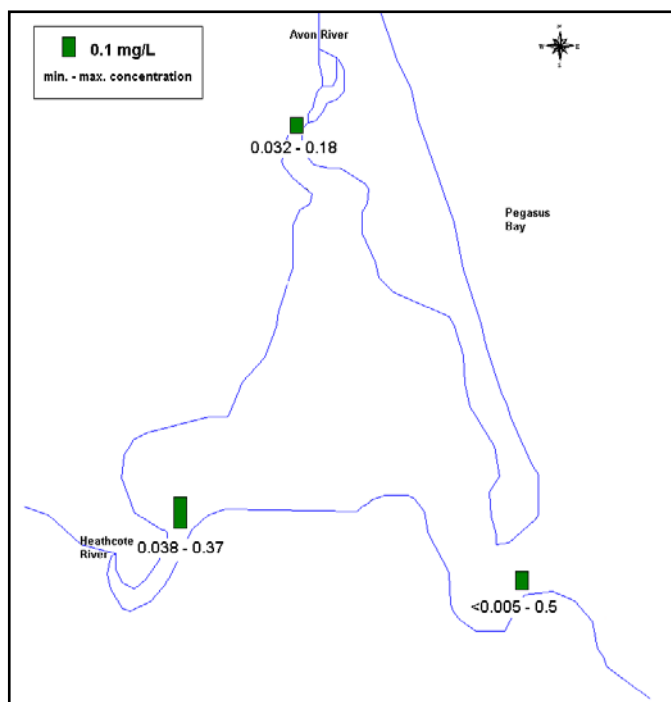


Figure 5: Low tide ammonia nitrogen concentrations (mg/L)

When wastewater was discharged to the estuary the highest low tide concentrations of NH₃N occurred at the mouth of the estuary. That is, as the tide went out it carried the NH₃N that was discharged into the estuary around high tide out of the estuary.

With cessation of the wastewater discharge concentrations at Ferrymead Bridge and Shag Rock dropped (Figure 7). There has been up to a 90% reduction in low tide NH₃N concentrations at the mouth of the estuary.

Healthy Estuary and Rivers of the City
Water quality of the Avon-Heathcote Estuary/Ihutai

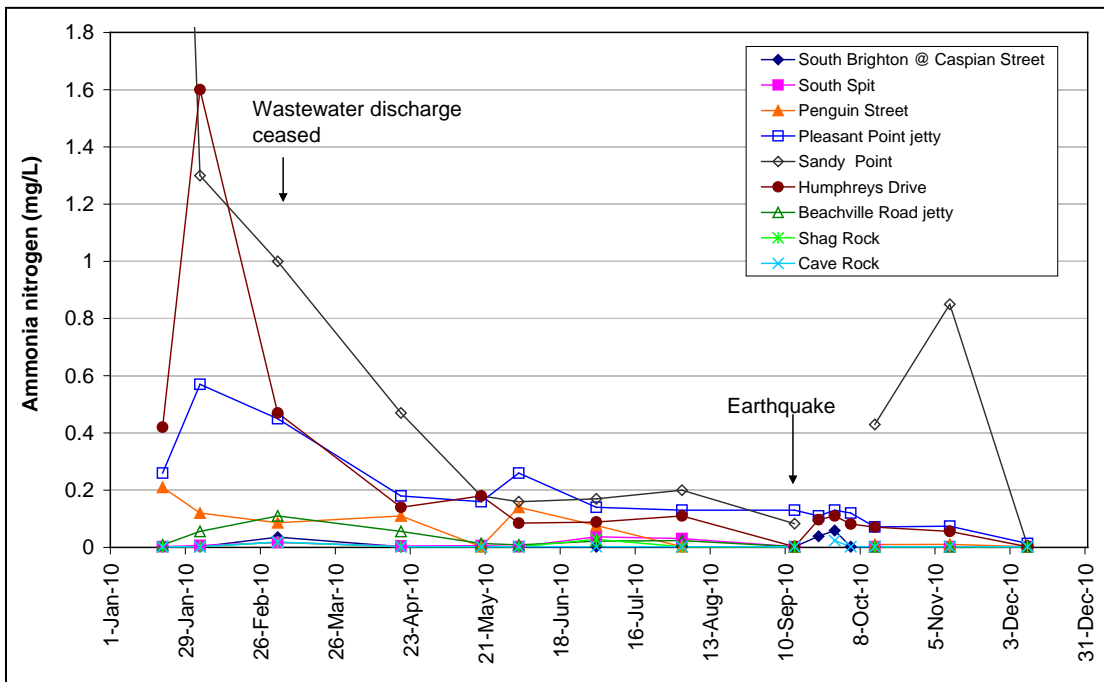


Figure 6: High tide ammonia nitrogen concentrations (mg/L) at each site during 2010

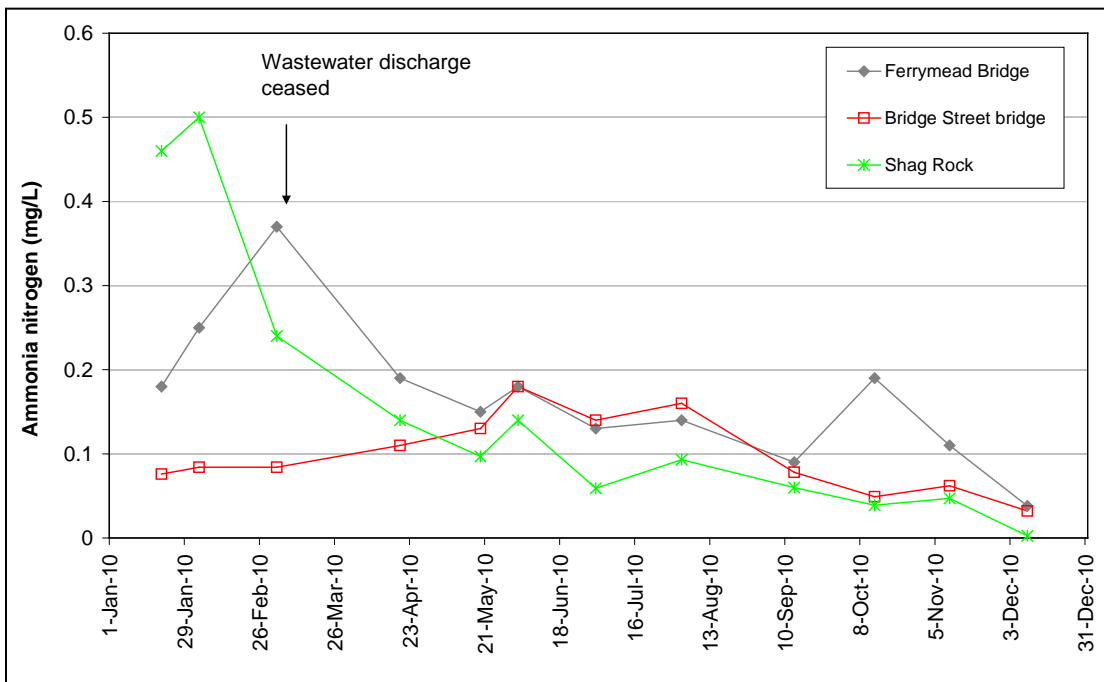


Figure 7: Low tide ammonia nitrogen concentrations (mg/L) at each site during 2010

Ammonia is a non-persistent and non-cumulative toxin to aquatic life. Its toxicity is affected by pH and water temperature and to a lesser degree the salinity.

To assess the potential for the concentrations in the estuary to be toxic to estuarine life, the results have been compared to the ANZECC (2000) trigger values for toxic chemicals in marine water. The trigger concentration providing protection for 95% of species was used. The results of the comparison are presented in Table 1.

Table 1: Percentage of samples exceeding the ammonia nitrogen trigger concentration providing protection for 95% of species

	Percentage of samples
High tide sites	
South Brighton@Caspian Street	0
South Spit	0
Penguin Street	0
Pleasant Point jetty	0
Sandy Point	25
Humphreys Drive	8
Beachville Road jetty	0
Shag Rock	0
Cave Rock	0
Low tide sites	
Bridge Street bridge	0
Ferrymead bridge	0
Shag Rock	0

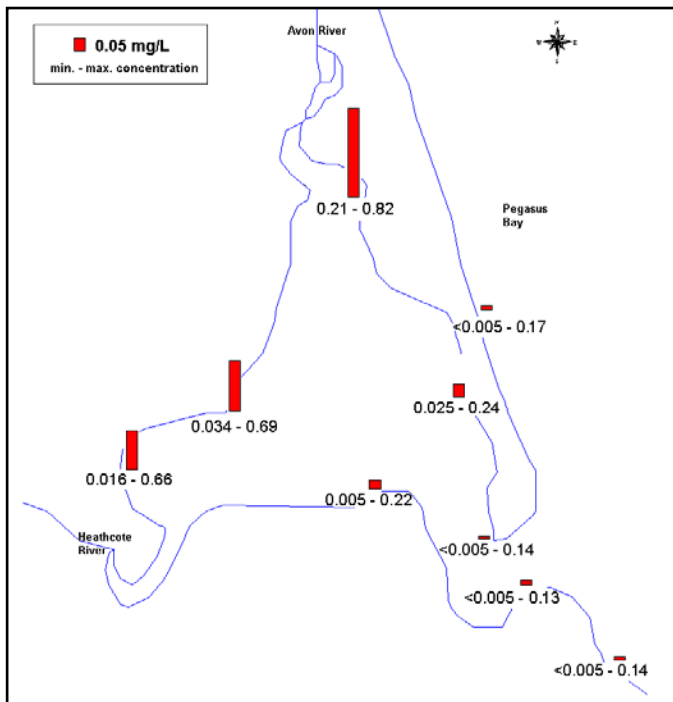
Prior to the cessation of the wastewater discharge the 2010 ammonia nitrogen concentrations at two sites in the estuary were potentially toxic to life in the estuary. Since the cessation of the discharge all ammonia nitrogen concentrations have been below ANZECC (2000) trigger values.

NOTE: On 4 September 2010 Christchurch was struck by a 7.1 earthquake. This caused damage to city infrastructure including the sewerage network. For a period of around two months untreated human sewage was discharged into the Avon River. Environment Canterbury undertook additional weekly water quality sampling through September, at Pleasant Point jetty and Humphreys Drive in the estuary, to assess the impact of the discharge on nutrient concentrations. The results indicate that ammonia nitrogen and other nutrient concentrations at these two estuary sites did not increase as a consequence of the discharge of untreated human sewage into the Avon River. However, the routine monthly sampling detected notably high ammonia nitrogen and dissolved reactive phosphorus concentrations at Sandy Point in October and November 2010. It is possible that these notably high concentrations were caused by discharges of untreated human sewage into the drain which flows into the estuary near Sandy Point.

3.4 Nitrite-nitrate nitrogen (NNN)

Nitrate is the common form of nitrogen found in natural waters. Nitrate is changed by biochemical processes to nitrite when there is no oxygen; when oxygen is present the nitrite quickly forms nitrate. Nitrate and nitrite are formed during the biochemical breakdown of ammonia nitrogen. Nitrate and nitrite occur in fertilisers applied to land to enhance plant growth, but fertiliser can dissolve in rain and flow off the land and into the nearest waterway.

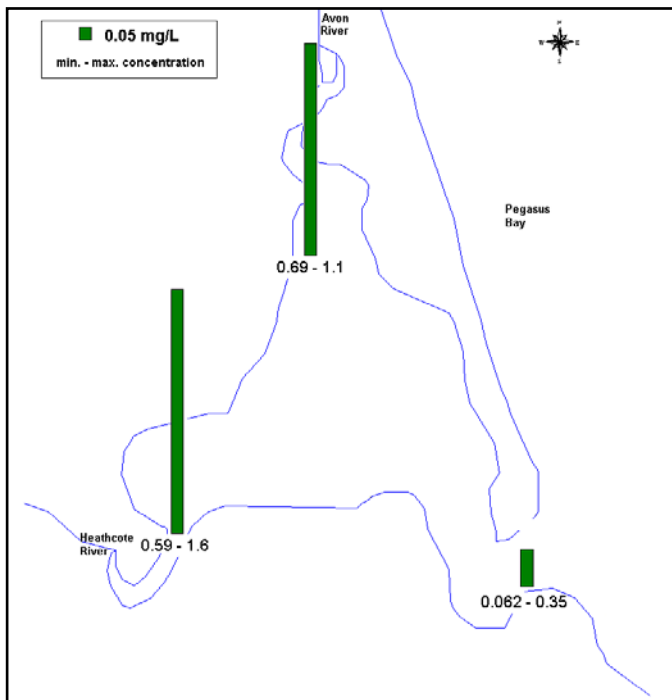
The nitrite-nitrate nitrogen (NNN) concentrations at high tide are shown in Figure 8 while those at low tide are shown in Figure 9.



Around high tide the highest concentrations of NNN occurred at the site closest to the Avon River mouth, i.e. Pleasant Point jetty. NNN concentrations at Humphreys Drive and Sandy Point, which are near to a river and/or drains, were higher than those at estuary sites further from a freshwater source.

These results indicate that the rivers and drains are the major source of NNN to the estuary.

Figure 8: High tide nitrite-nitrate nitrogen concentrations (mg/L)



Around low tide NNN concentrations were higher in the Avon and Heathcote rivers than at the mouth of the estuary.

These results indicate that the rivers are the major source of NNN to the estuary. The springs that feed the Avon and Heathcote rivers contain high NNN concentrations.

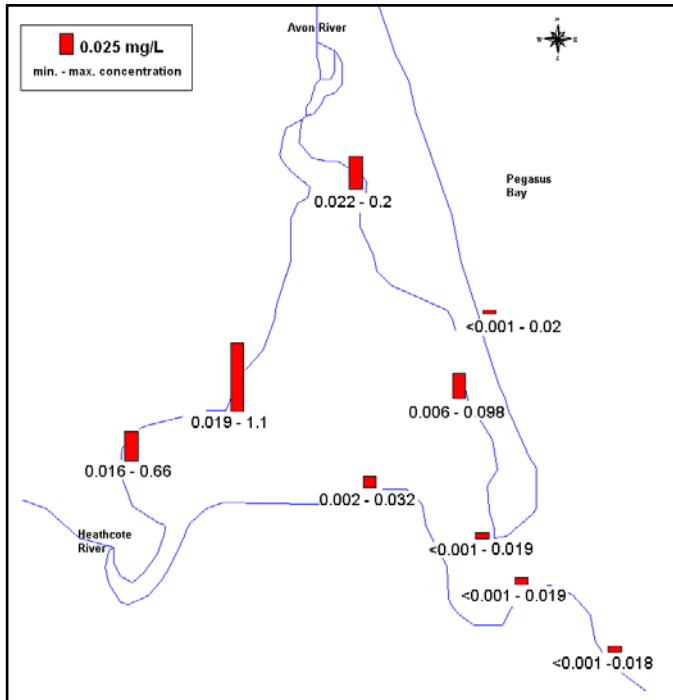
Figure 9: Low tide nitrite-nitrate nitrogen concentrations (mg/L)

3.5 Dissolved reactive phosphorus (DRP)

Phosphorus naturally occurs in water with the concentrations typically reflecting the concentrations in the surrounding soil and rock. Phosphorus occurs in fertilisers applied to land to enhance plant growth, but fertiliser can dissolve in rain and flow into the nearest

waterway. Phosphorus is also a constituent of dishwashing liquid and washing powders and hence is present in wastewater.

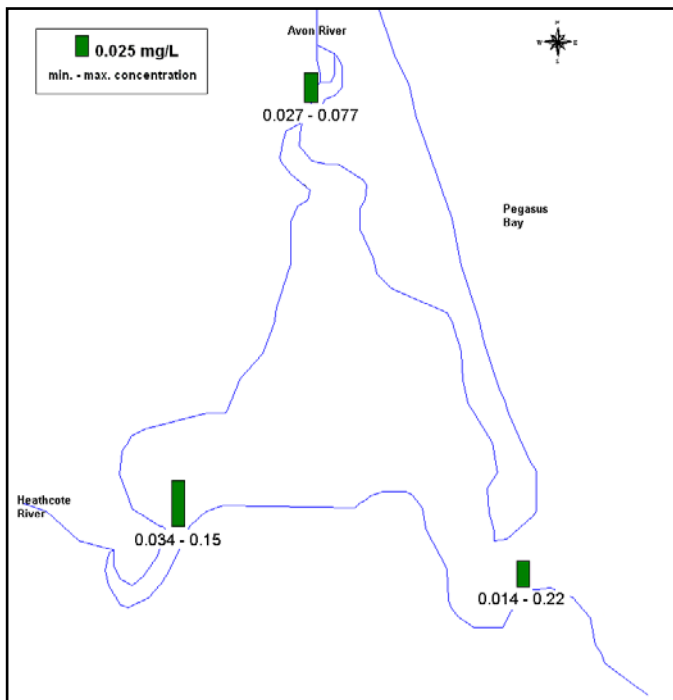
Dissolved reactive phosphorus (DRP) is the dissolved form of phosphorus that is available for plant growth. The DRP concentrations at high tide are shown in Figure 10 while those at low tide are shown in Figure 11.



When wastewater was discharged to the estuary the highest high tide concentrations of DRP occurred at sites close to the wastewater discharge point. The further away the site was from the discharge point, the lower the DRP concentrations.

The maximum DRP concentrations shown occurred when wastewater was still being discharged. With cessation of the wastewater discharge, concentrations at all sites dropped. There has been up to a 90% reduction in DRP concentrations.

Figure 10: High tide dissolved reactive phosphorus concentrations (mg/L)



When wastewater was discharged to the estuary the highest low tide concentrations of DRP occurred at the mouth of the estuary. That is, as the tide went out it carried the DRP, discharged into the estuary around high tide, out of the estuary.

With cessation of the wastewater discharge concentrations at low tide sites dropped. There has been up to 50% reduction in low tide DRP concentrations at the mouth of the estuary.

The Avon and Heathcote rivers contribute some DRP to the estuary. DRP concentrations in the Heathcote River were higher than those in the Avon River.

Figure 11: Low tide dissolved reactive phosphorus concentrations (mg/L)

3.6 Chlorophyll-a

Chlorophyll-a concentration is used as a measure of the amount of plant plankton (phytoplankton) in the water, i.e. the higher the chlorophyll-a concentration the more plant plankton in the water. Chlorophyll-a concentrations of 5 µg/L can result in discolouration of the water.

Chlorophyll-a concentrations at high tide are shown in Figure 12 while those at low tide are shown in Figure 13.

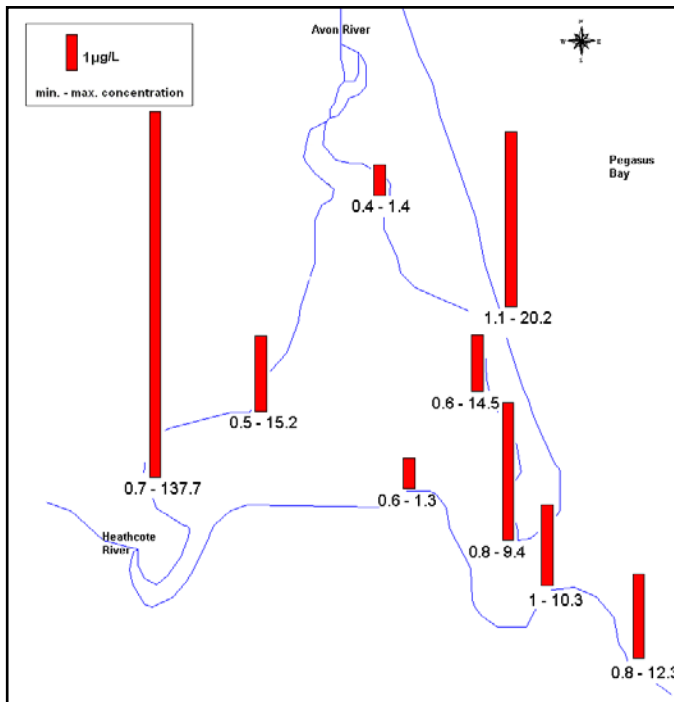


Figure 12: High tide chlorophyll-a concentrations (µg/L)

Around high tide chlorophyll-a concentrations at Beachville Road and Pleasant Point jetties were considerably lower than those at the other sites.

The highest concentration recorded was at Humphreys Drive on 20 January 2010. No discolouration of the water was noted. On this day chlorophyll-a concentrations at other estuary sites were low, which indicates the high concentration was localised. In February a high concentration (93.3 µg/L) also occurred at Humphreys Drive. The highest concentration at Penguin Street, South Spit, Shag Rock and Cave Rock occurred on 2 August. This indicates a proliferation of phytoplankton near the mouth of the estuary and into Pegasus Bay at this time.

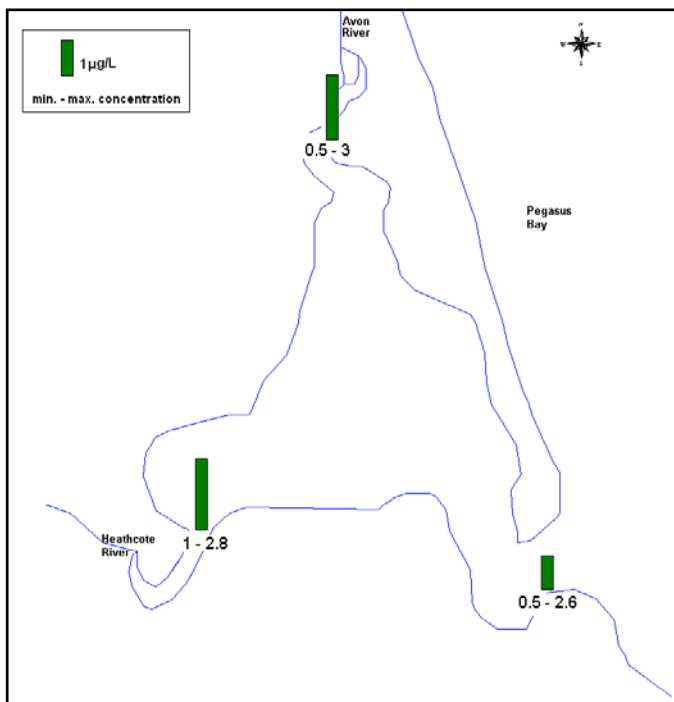


Figure 13: Low tide chlorophyll-a concentrations (µg/L)

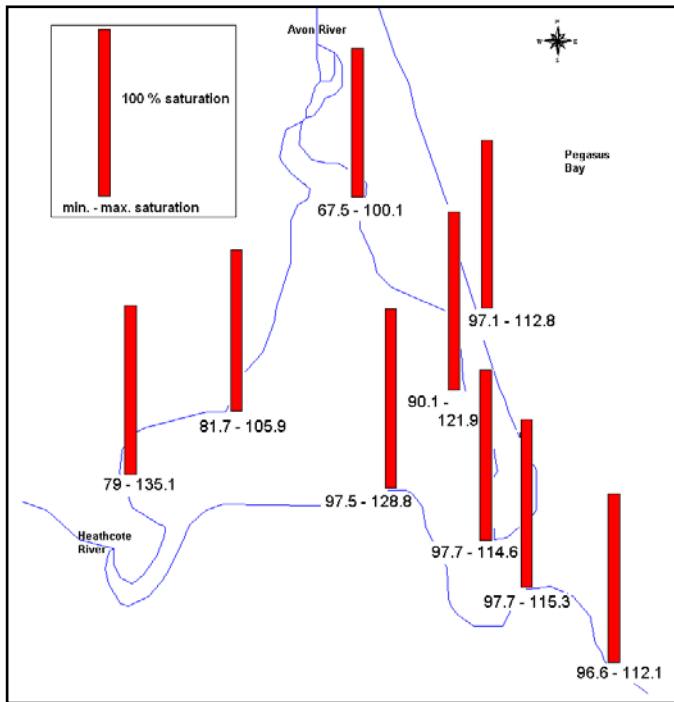
The median chlorophyll-a concentration was similar at both low tide river sites.

The highest low tide concentration at each site was similar. The highest concentrations at the three sites did not occur on the same day.

3.7 Dissolved oxygen saturation

Dissolved oxygen (DO) is essential for aquatic animals, including fish and invertebrates, to survive. The percent saturation affects the ease with which aquatic animals respire. DO saturation can exceed 100% when oxygen gas is dissolved in the water.

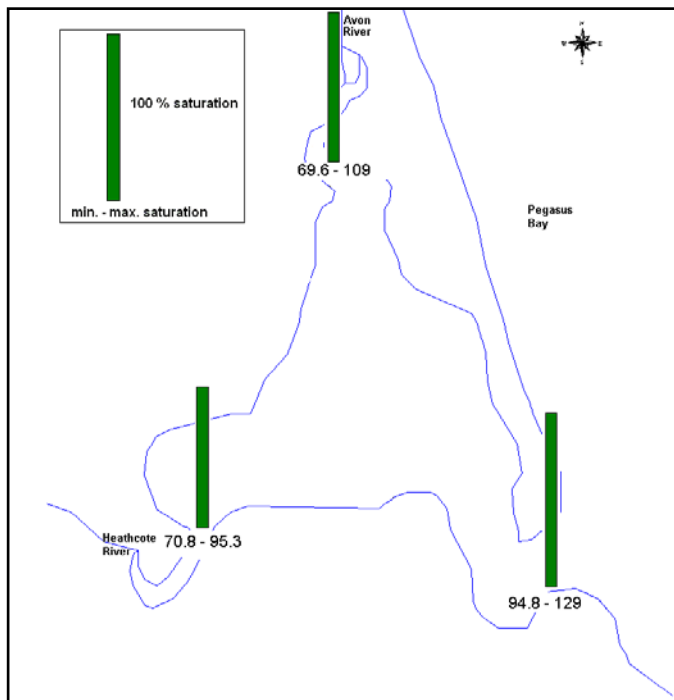
Dissolved oxygen saturations at high tide are shown in Figure 14 while those at the low tide are shown in Figure 15.



Around high tide the median dissolved oxygen saturation was lowest at Pleasant Point jetty and highest at Beachville Road.

There were differences in the minimum and maximum values between sites. Minimum concentrations were lower at sites close to the river mouths and at Sandy Point than at sites closer to the mouth.

Figure 14: High tide dissolved oxygen saturation (%)



Around low tide the median dissolved oxygen saturation at the mouth of the estuary was higher than in the Avon and Heathcote rivers.

The median and maximum dissolved oxygen saturations in Heathcote River water were lower than in Avon River water.

Figure 15: Low tide dissolved oxygen saturation (%)

The dissolved oxygen saturations were compared to the ANZECC (2000) South-east Australia trigger values. For DO saturation there are lower limit values. If the recorded DO saturation is below this lower limit there is the potential for fish and other marine life to be affected. The lower limit for South-east Australia is 80% saturation.

The percentage of samples in which the DO saturation was below a saturation of 80% is given in Table 2.

Table 2: Percentage of samples with a dissolved oxygen saturation of less than 80%

	Percentage of samples
High tide sites	
South Brighton@Caspian Street	0
South Spit	0
Penguin Street	0
Pleasant Point jetty	42
Sandy Point	0
Humphreys Drive	17
Beachville Road jetty	0
Shag Rock	0
Cave Rock	0
Low tide sites	
Bridge Street bridge	25
Ferrymead bridge	33
Shag Rock	0

These results indicate that DO saturation at two sites within the estuary and at the mouth of the Avon and Heathcote rivers, has the potential at times to have an impact on fish and invertebrates. The mobile fish and invertebrates would probably avoid or move away from areas of low oxygen saturation. The non-mobile animals that live in an estuary are exposed to air when the tide recedes and have strategies such as retracting into the shell or tube when environmental conditions are unsuitable. For these animals it is likely that there would be an impact if low DO saturation persists for a considerable period of time.

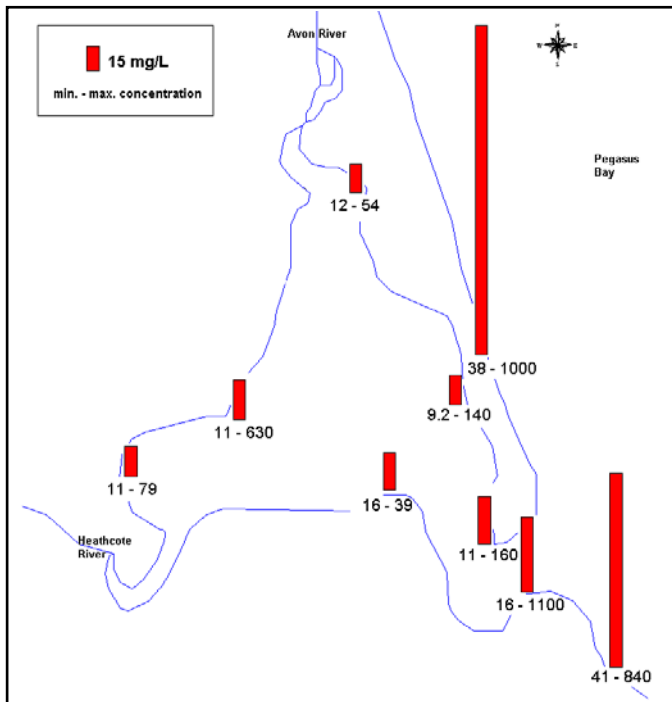
NOTE: The lowest DO saturation values at Humphreys Drive occurred in late summer and early autumn while those at Pleasant Point jetty occurred in summer, early autumn and winter. The lowest values at the river sites occurred in late autumn/ winter. That is, the below trigger value DO concentrations at the sites were not as a result of the September Earthquake.

3.8 Total suspended solids (TSS)

Total suspended solids (TSS) concentration is a measure of the amount of particles within the water column. It includes inorganic (non living) particles such as the sand and mud stirred up from the seabed and soil washed off the land and organic (from living things) particles like detritus (dead plant or animal material) and live organisms. The particles within

the water affect the amount of light that penetrates into the water and hence the growth of plant plankton and seaweeds. It also affects the feeding and other behaviours of the animals.

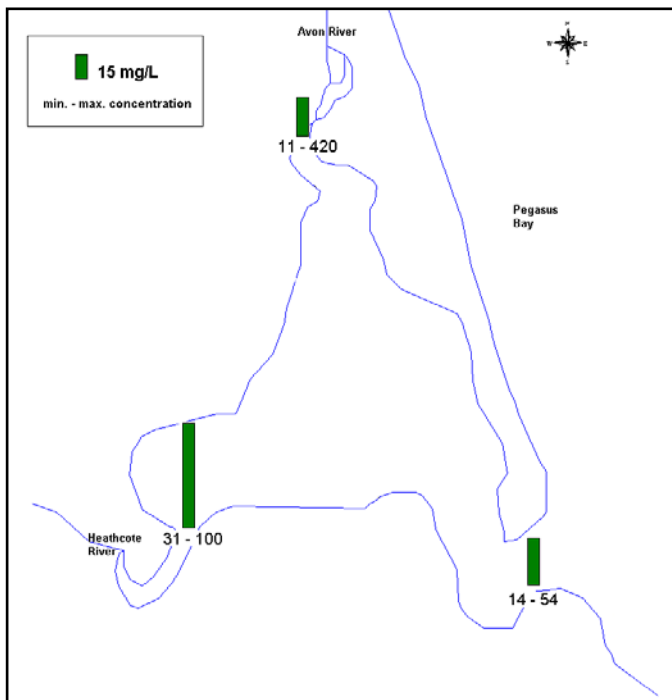
The total suspended solids concentrations at high tide are shown in Figure 16 while those at low tide are shown in Figure 17.



Around high tide high TSS concentrations occurred at South Brighton @ Caspian Street, Cave Rock and Shag Rock. The TSS at these sites typically consisted of sand stirred up by wave action.

Within the estuary the highest TSS concentration at Sandy Point and Humphreys Drive occurred on 13 October. It is possible that these concentrations were as a result of the earthquake in September. The earthquake caused liquefaction around Christchurch which likely resulted in sediment laden water flowing into this part of the estuary via the drains and stormwater.

Figure 16: High tide total suspended solids concentrations (mg/L)



Around low tide there were more total suspended solids in the water flowing out of the Heathcote River than the Avon River. Of note is the maximum concentration in the Avon River was higher than that in the Heathcote River.

Figure 17: Low tide total suspended solids concentrations (mg/L)

3.9 Metals

Industry and cars are significant sources of metals, with wastewater and stormwater the conduit of the metals to the aquatic environment. Many of the metals are potentially toxic to aquatic life at low concentration.

The total cadmium, chromium, copper, lead, nickel and zinc concentrations were measured at high and low tide on one occasion (2 August 2010). The cadmium, lead and nickel concentrations in all samples were below the level of detection. At some sites chromium, copper and zinc concentrations were above the level of detection. The results for chromium, copper and zinc are presented in Figures 18-20.

3.9.1 Chromium

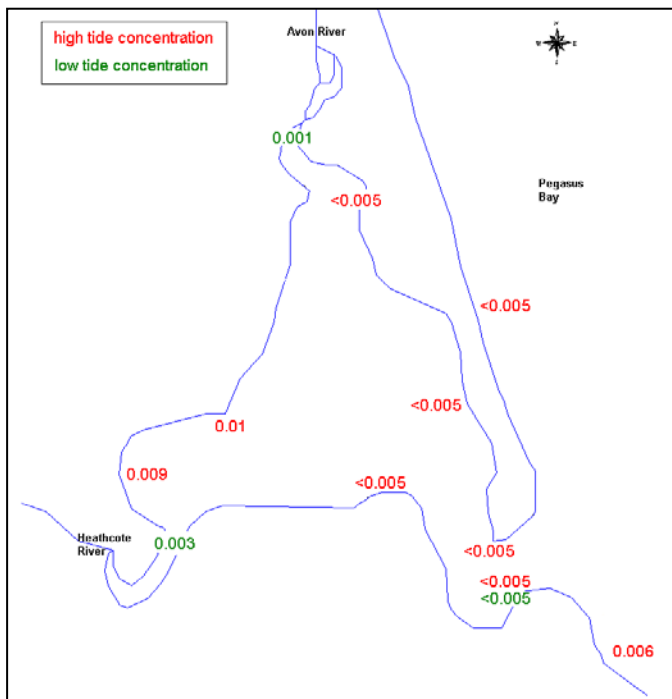


Figure 18: Chromium concentrations (mg/L)

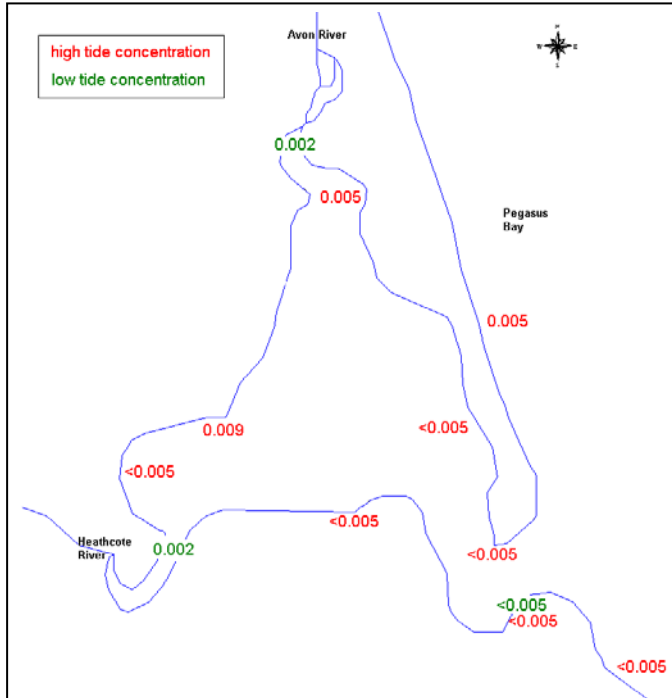
Within the estuary above detection limit concentrations occurred at Sandy Point and Humphreys Drive. The concentrations at these sites are similar.

These results indicate that Heathcote River water contains more chromium than Avon River water.

All concentrations were below the ANZECC (2000) trigger concentration providing protection for 95 % of species. The trigger concentration is 0.0274 mg/L.

3.9.2 Copper

Within the estuary above detection limit concentrations occurred at Sandy Point and Pleasant Point jetty.

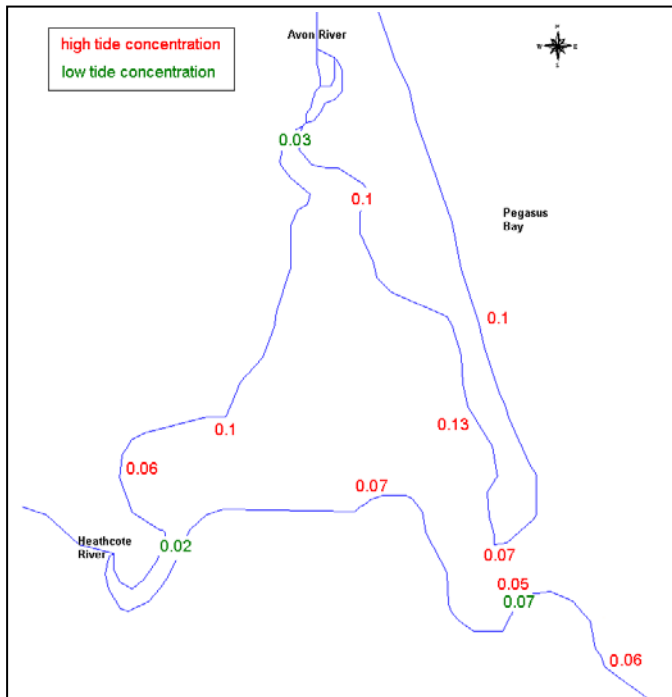


The copper concentration in Heathcote River water was the same as that in Avon River water.

All above detection limit concentrations of copper were also above the ANZECC (2000) trigger concentration providing protection for 95 % of species. The trigger concentration is 0.0013 mg/L.

Figure 19: Copper concentrations (mg/L)

3.9.3 Zinc



The highest high tide concentration was at Penguin Street. The highest low tide concentration was at the mouth of the estuary.

The zinc concentration at all sites was above the ANZECC (2000) trigger concentration providing protection for 95 % of species. The trigger concentration is 0.015 mg/L.

Figure 20: Zinc concentrations (mg/L)

4 Conclusion

In 2010 the quality of the water within the Avon-Heathcote Estuary/Ihutai changed. Prior to 4 March 2010 tertiary treated wastewater was discharged into the estuary twice a day around high tide. This discharge ceased on 4 March. With the cessation of the wastewater discharge, freshwater inputs via the rivers in particular but also via the large drains and direct stormwater flows now have the greatest influence on estuary water quality.

The results presented in this report include three months of data collected when wastewater was discharged and nine months when there was no discharge. The wastewater was a significant contributor of the nutrients ammonia nitrogen and dissolved reactive phosphorus to estuary water. Hence for both nutrients the maximum concentrations for 2010 were similar to those in previous years. However, the median concentrations of both ammonia nitrogen and dissolved reactive phosphorus are lower than in previous years and at many sites the minimum concentration was below the level of detection. Prior to the cessation of the wastewater discharge ammonia nitrogen concentrations above the ANZECC (2000) trigger value occurred at two sites in the estuary. These concentrations were potentially toxic to life. Since the cessation of the discharge all ammonia nitrogen concentrations within and at the mouth of the estuary have been below the ANZECC (2000) trigger value.

The rivers are a significant contributor of nitrate-nitrite nitrogen to the estuary. Dissolved inorganic nitrogen, i.e. nitrate-nitrite nitrogen and ammonia nitrogen, and dissolved reactive phosphorus are used by plants (plant plankton and seaweeds) for growth. That is, the dissolved nitrogen and phosphorus enriched waters of the estuary more than likely provide conditions that enhance the growth of plant plankton and seaweed. Weather and sea conditions, temperature, sunlight and the availability of other chemicals such as silica and iron also influence such growth. The high chlorophyll-a concentrations at Humphreys Drive in January and February and the abundance of seaweed in the Humphreys Drive area in March 2010 (refer to the 2010 sediments and biota report) are attributed to favourable environmental conditions in combination with the concentrations of dissolved nitrogen and phosphorus present.

It is likely that the discharged wastewater directly or indirectly caused the low dissolved oxygen saturations at Humphreys Drive in late summer/early autumn. Decaying seaweeds, plant plankton and other organic matter within the water gets broken down by bacteria. Such a plentiful supply of food will encourage the growth of millions of bacteria. Bacteria need oxygen so when there are millions of them they will be consuming the oxygen in the water which results in a decrease in the dissolved oxygen saturation. The discharged wastewater and bacteria laden Avon River water may have caused the low dissolved oxygen saturations at Pleasant Point jetty. The low dissolved oxygen saturations in both Avon River and Heathcote River water in late autumn/winter suggest high bacteria populations in the river water over this time.

On 4 September 2010 Christchurch was struck by a 7.1 earthquake. Some additional sampling at Pleasant Point jetty and Humphreys Drive determined that ammonia nitrogen and other nutrient concentrations at these two estuary sites did not increase as a consequence of the discharge of untreated human sewage into the Avon River. However, routine monthly sampling detected notably high ammonia nitrogen and dissolved reactive phosphorus concentrations at Sandy Point in October and November 2010. It is possible that these notably high concentrations were caused by discharges of untreated human sewage into the drain which flows into the estuary near Sandy Point. The elevated TSS concentrations at both Humphreys Drive and Sandy Point in October 2010 were likely as a result of the earthquake.

Now wastewater is no longer discharged into the estuary, any consequent changes in the presence and abundance of fish, seaweed and other life in the estuary is being assessed. This will provide information on the impact that the discharged wastewater had on life in the estuary. This assessment has been and will continue to be complicated by direct and indirect effects of the 7.1 earthquake in September 2010, the 6.3 aftershock on 22 February 2011 and the numerous other sizeable aftershocks on water quality in the rivers and estuary.

5 References

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