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 2007

Environment Canterbury
Your regional council

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Introduction

The Healthy Estuary and Rivers of the City: Water quality and ecosystem health monitoring programme of Ihutai was written in 2006. It includes monitoring programmes for four environmental values. This report summarises data collected in 2007 from the estuary as part of Value B – Healthy Ecosystems – water quality of the estuary. Other parts of this value include water quality of the Avon and Heathcote rivers, soft sediments of the estuary and tidal reaches and river habitat and its biota. These aspects are covered by separate summary reports.

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.

The water within the Avon-Heathcote Estuary/Ihutai is primarily a mix of the freshwater flowing out of the Avon and Heathcote rivers, the sea water from Pegasus Bay that flows into the estuary as the tide rises and the tertiary treated wastewater that is discharged from the oxidation ponds. The wastewater consists of nutrient enriched freshwater that is discharged into the estuary twice a day around high tide.

Water quality is monitored[1] at sites within and just outside the estuary. This is a summary report of the water quality data collected at these sites in 2007. Along with the water quality data is information on what the data show. At the end of the report is an overall evaluation of the water quality in the estuary in 2007. This is the first summary report to be produced. 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.

Sampling

Sampling sites

The sites sampled are shown in Figure 1.

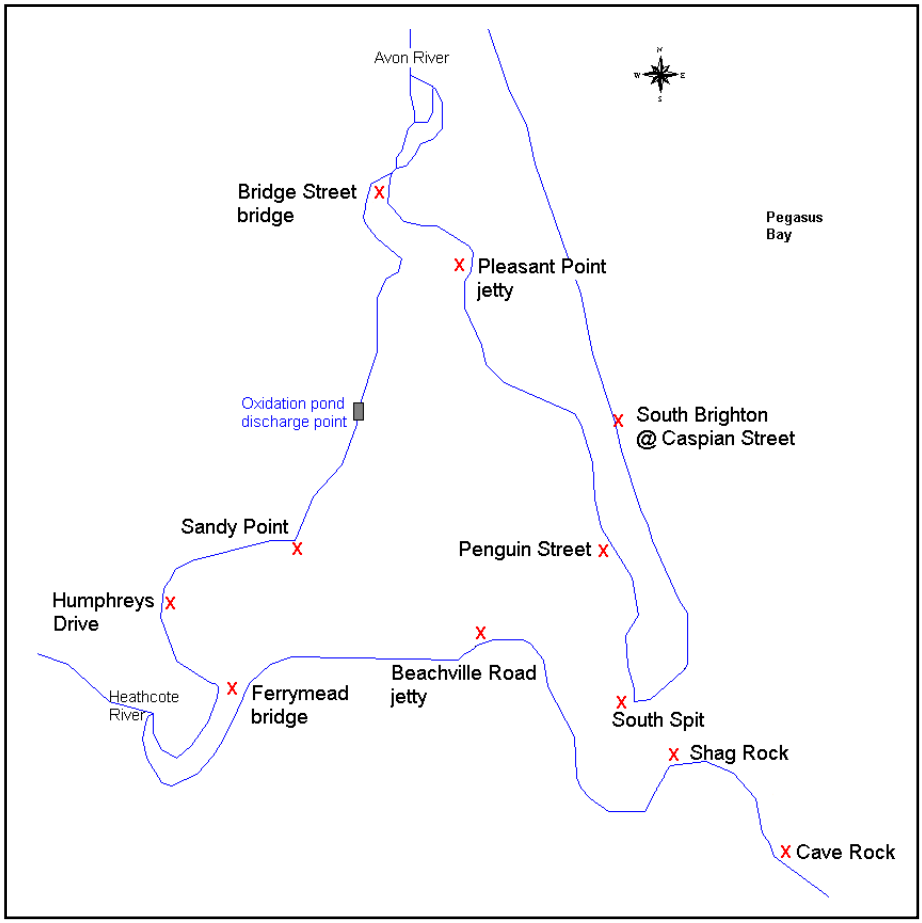


Figure 1 The location of the water quality sampling sites

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).

All water samples were collected by Environment Canterbury staff.

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

Results

The results are presented on the following pages. The data are typically presented as bar graphs. The height of the bar depicts the median[2] 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)[3] guidelines specify trigger values for nutrients and other water quality parameters in Australian estuarine waters. However, there are no New Zealand-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. The recorded ammonia-nitrogen concentrations have been compared to the trigger value that provides protection for 95 % of species.

[2] 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.

[3] 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.

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

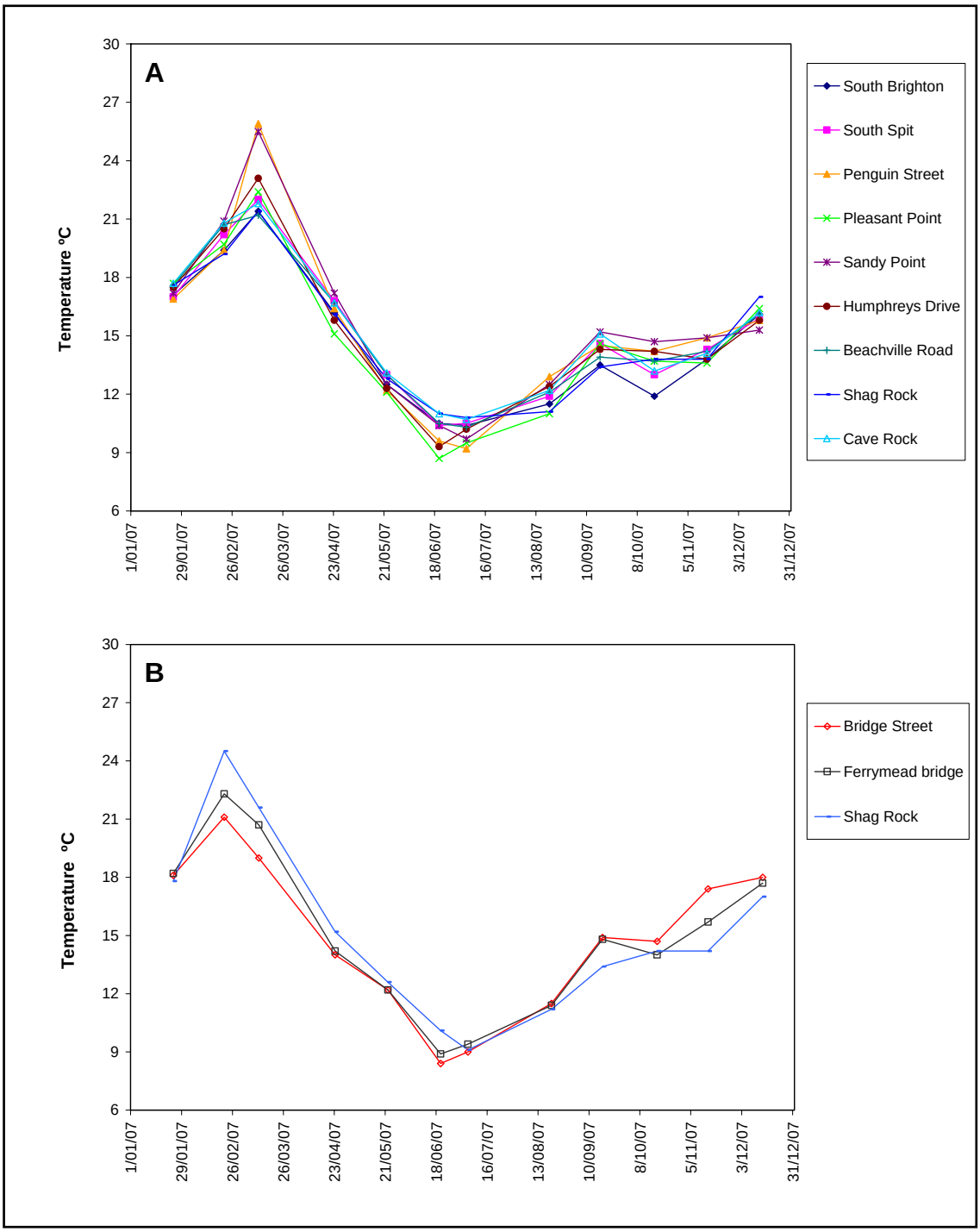


Figure 2 Water temperatures (ºC) at each site A – High tide B – Low tide

Water temperature is affected by air temperature, sunlight and water depth.
There were bigger differences in water temperature between sites in spring and summer than in autumn and winter. The difference in water temperature between sites is probably because:

- shallow water is heated by the sun quicker than deep water
- as the tide comes in the water crosses the mudflats; the wider the mudflat the longer the time the water is shallow enough to be heated by the sun

Salinity

This is a measure of how salty the water is. The sea water 2.5 to10 kilometres from shore in Pegasus Bay typically has a salinity of 33 -34.5 ppt (parts per thousand). Freshwater has a salinity of 0 ppt.

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

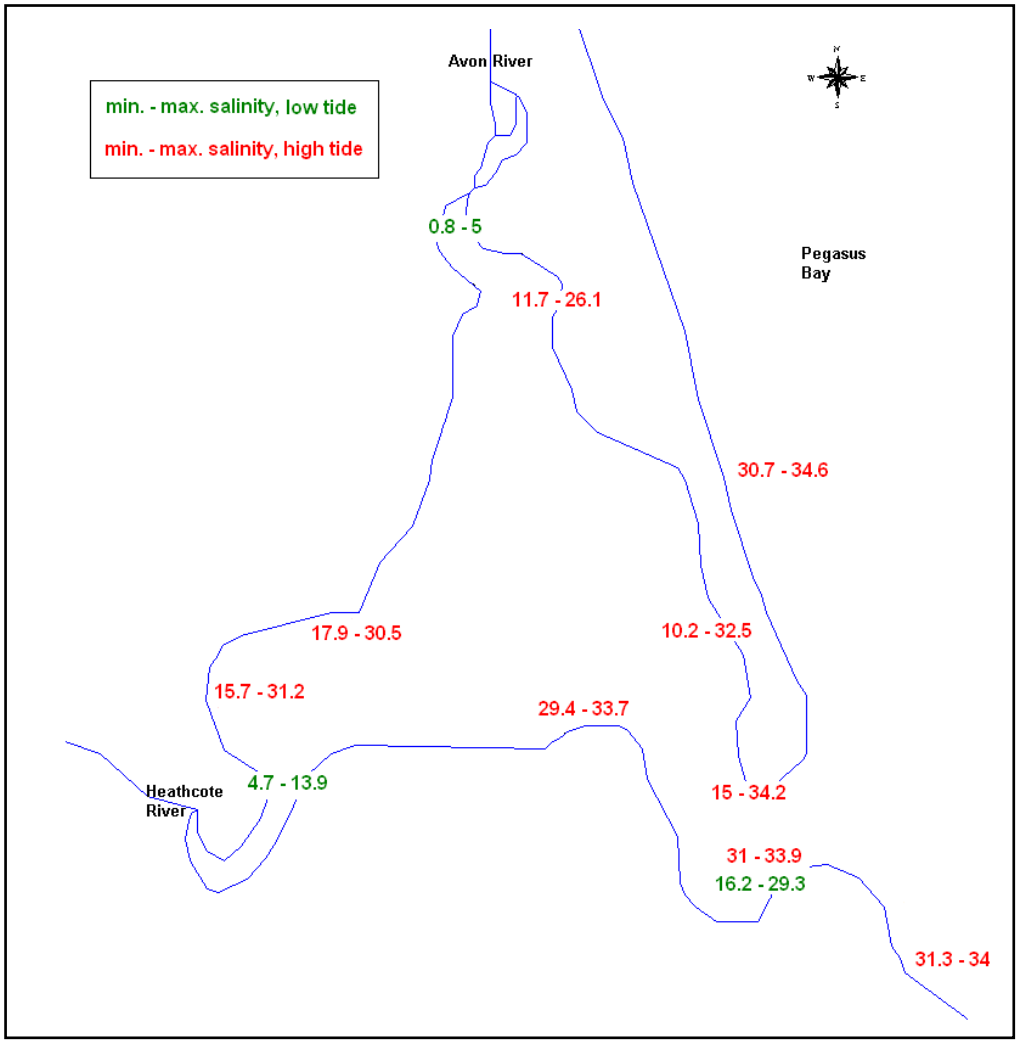


Figure 3 Range in salinity (ppt) at the high and low tide sites

At high tide the salinity at sites within the estuary, including South Spit but excluding Beachville Road jetty, was very variable. At high tide the salinity within the estuary results from the mixing of the freshwater from the Avon and Heathcote rivers and the discharged wastewater with the incoming sea water. The mixing of the freshwater with the sea water is influenced by the wind and weather conditions as well as the volumes of freshwater flowing into the estuary. The salinity at the mouth of the estuary and the sites in Pegasus Bay was less variable than that within the estuary, even so the less salty water from the estuary does affect the salinity at these sites.

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 freshwater and seawater with the salinity depending on wind, weather and sea conditions.

Ammonia-nitrogen (NH_3N)

The ammonia-nitrogen 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 with the discharged tertiary treated wastewater a contributor of this nutrient to the estuary.

The ammonia-nitrogen (NH_3N) concentrations at high tide are shown in Figure 4 while those at the low tide are shown in Figure 5.

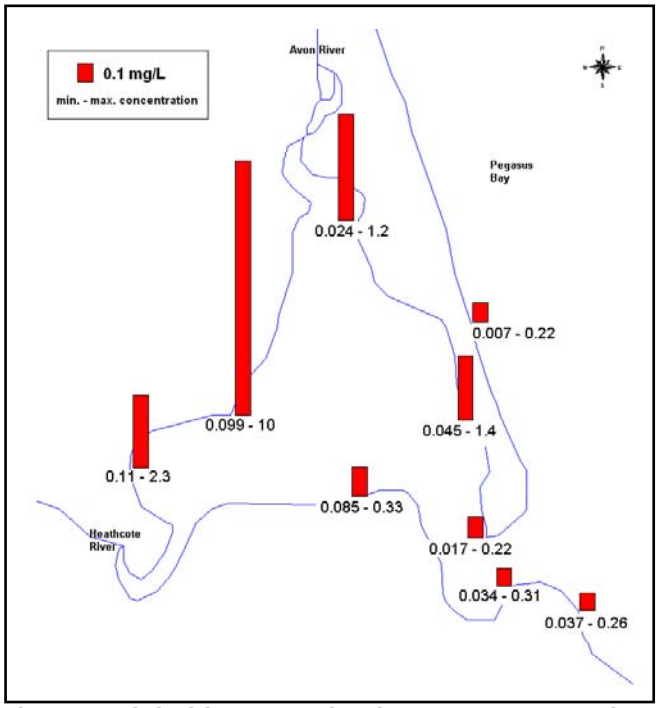


Figure 4 High tide ammonia-nitrogen concentrations (mg/L)

Around high tide the highest concentrations of ammonia-nitrogen occurred at sites close to the wastewater discharge point. The further away the site from the discharge point the lower the NH_3N concentrations.

These results indicate that the wastewater is a major source of NH_3N to the estuary.

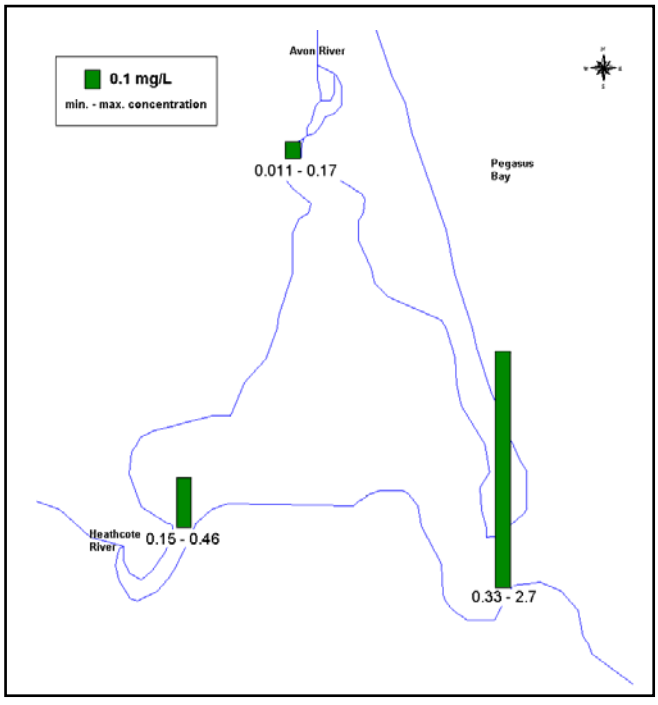


Figure 5 Low tide ammonia-nitrogen concentrations (mg/L)

Around low tide the highest concentrations of ammonia-nitrogen occurred at the mouth of the estuary. That is, as the tide goes out it carries the NH_3N that was discharged into the estuary around high tide, out of the estuary.

These results indicate that the Avon and Heathcote rivers do not contribute high concentrations of NH_3N to the estuary. However, the NH_3N concentrations in the Heathcote River were higher than those in the Avon River.

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	**17**
Pleasant Point jetty	**42**
Sandy Point	**75**
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	**67**

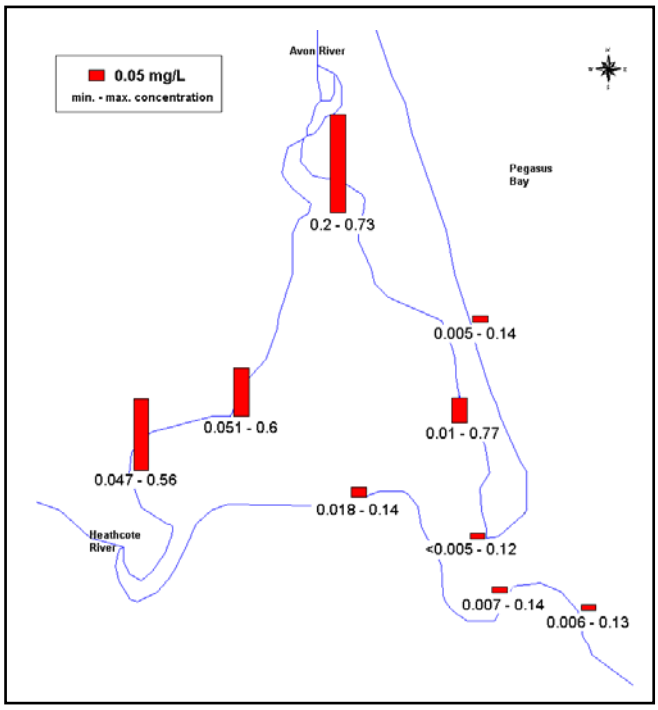
The ammonia-nitrogen concentrations at some sites in the estuary are potentially toxic to life in the estuary. Of the sites sampled around high tide it is those sites in proximity to the wastewater discharge point, i.e. Penguin Street, Pleasant Point jetty, Sandy Point and Humphreys Drive, where the trigger value was exceeded. At the site closest to the discharge point (Sandy Point), the trigger value was exceeded in the highest percentage (75 %) of samples. The ammonia-nitrogen carried out of the estuary by the outgoing tide caused the concentrations in 67 % of the samples from the mouth of the estuary (at low tide) to be higher than the trigger level. The actual impact of these high concentrations of ammonia-nitrogen on the life in this estuary is largely unknown.

Nitrate-nitrite 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.

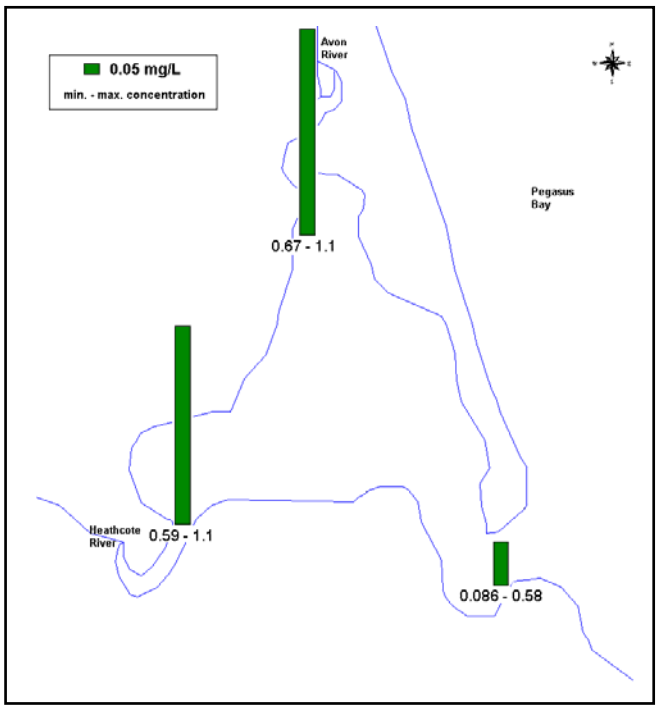
The nitrate-nitrite nitrogen (NNN) concentrations at high tide are shown in Figure 6 while those at the low tide are shown in Figure 7.



Around high tide the highest concentrations of nitrate-nitrite nitrogen occurred at sites closest to the river mouths, i.e. Pleasant Point Jetty and Humphreys Drive. NNN concentrations at Sandy Point and Penguin Street were higher than those towards the mouth of, and outside, the estuary.

These results indicate that the rivers are the major source of NNN to the estuary but the discharged wastewater does contain some NNN.

Figure 6 High tide nitrate-nitrite nitrogen concentrations (mg/L)



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

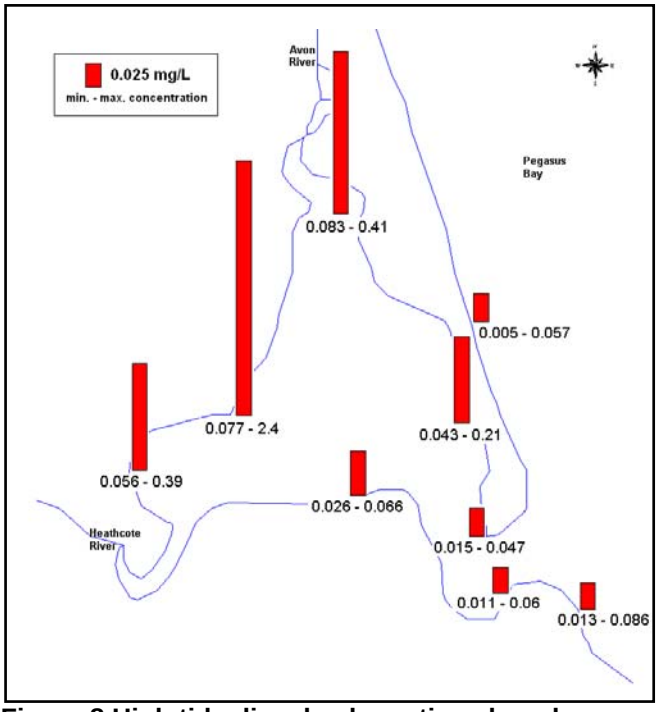
These results indicate that the rivers are the major source of NNN to the estuary. The springs that feed the Avon and Heathcote rivers contain high NNN concentrations.

Figure 7 Low tide nitrate-nitrite nitrogen concentrations (mg/L)

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 the wastewater.

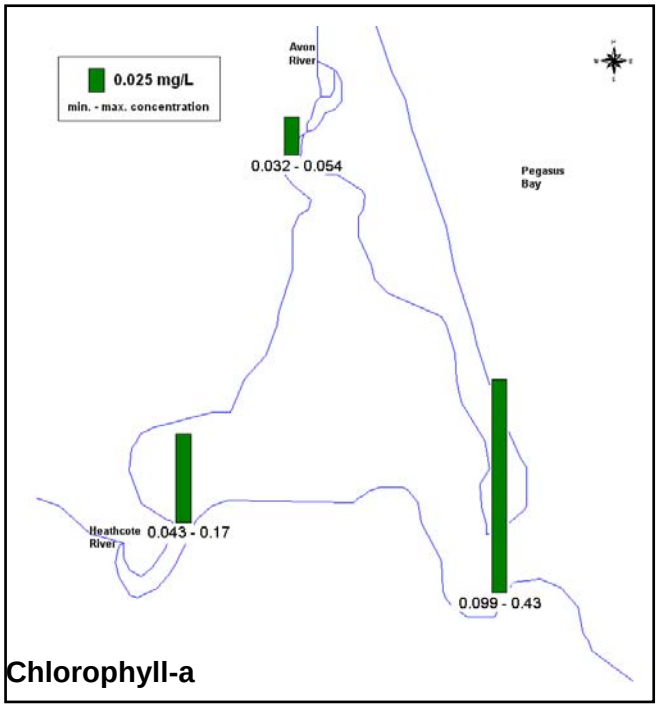
Dissolved reactive phosphorus (DRP) is the dissolved form of phosphorus that is available for plant growth. The DRP concentrations at high tide are shown in Figure 8 while those at the low tide are shown in Figure 9.



Around high tide the highest concentrations of dissolved reactive phosphorus occurred at Sandy Point. There were higher concentrations at sites closer to the wastewater discharge point than at sites further away, within, at the mouth, and outside, the estuary.

These results indicate that the wastewater is a major source of DRP to the estuary.

Figure 8 High tide dissolved reactive phosphorus concentrations (mg/L)



Around low tide the highest concentrations of dissolved reactive phosphorus occurred at the mouth of the estuary. That is, as the tide goes out it carries the DRP that was discharged into the estuary around high tide, out of the estuary.

The Avon and Heathcote rivers do not contribute high concentrations of DRP to the estuary. However, the DRP concentrations in the Heathcote River were higher than those in the Avon River.

Chlorophyll-a

Figure 9 Low tide dissolved reactive phosphorus concentrations (mg/L)

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 10 while those at the low tide are shown in Figure 11.

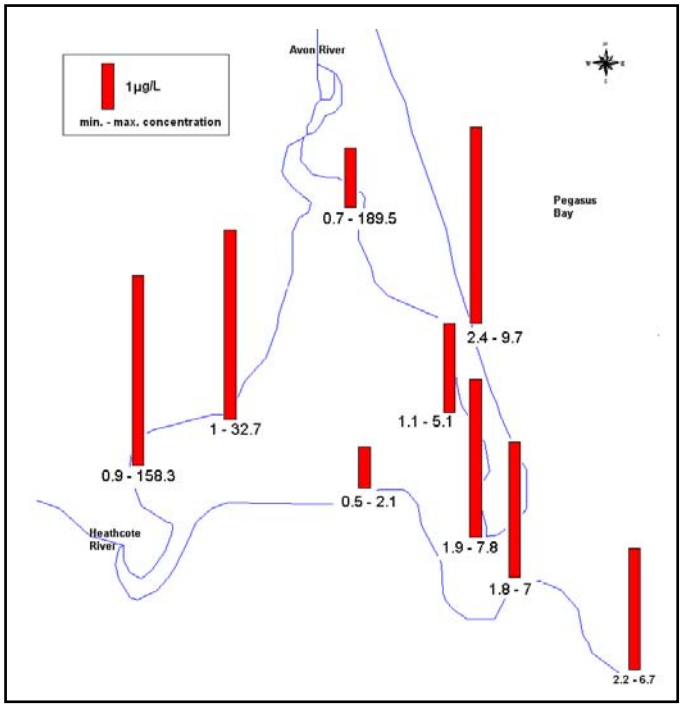


Figure 10 High tide chlorophyll-a concentrations (µg/L)

Around high tide chlorophyll-a concentrations at Beachville Road and Pleasant Point jetties and Penguin Street were considerably lower, while those at South Brighton@ Caspian Street were typically higher, than those at the other sites.

The very high chlorophyll-a concentrations at Humphreys Drive and Pleasant Point jetty on one occasion (March), represent a plankton bloom. This bloom resulted in obvious discolouration (red-brown) of the water. In March there was also a comparatively high chlorophyll-a concentration at Sandy Point.

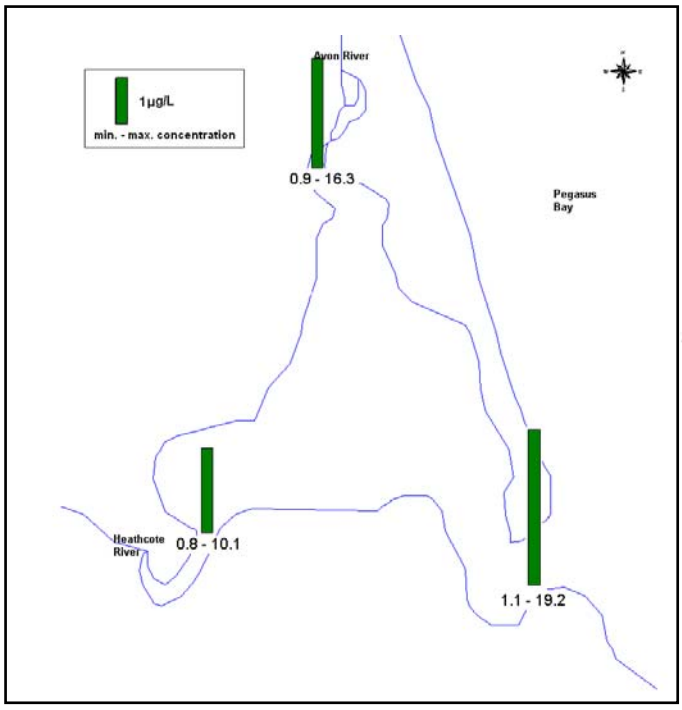


Figure 11 Low tide chlorophyll-a concentrations (µg/L)

Around low tide the chlorophyll-a concentrations were higher at the mouth of the estuary than in the Avon and Heathcote rivers. This indicates that the sea and estuary water typically contain more chlorophyll-a than do the rivers.

The highest concentrations in the Heathcote River and at the estuary mouth occurred in November while that in the Avon River occurred in February.

Dissolved oxygen saturation

Dissolved oxygen (DO) is essential for aquatic animals including fish and invertebrates. 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 12 while those at the low tide are shown in Figure 13.

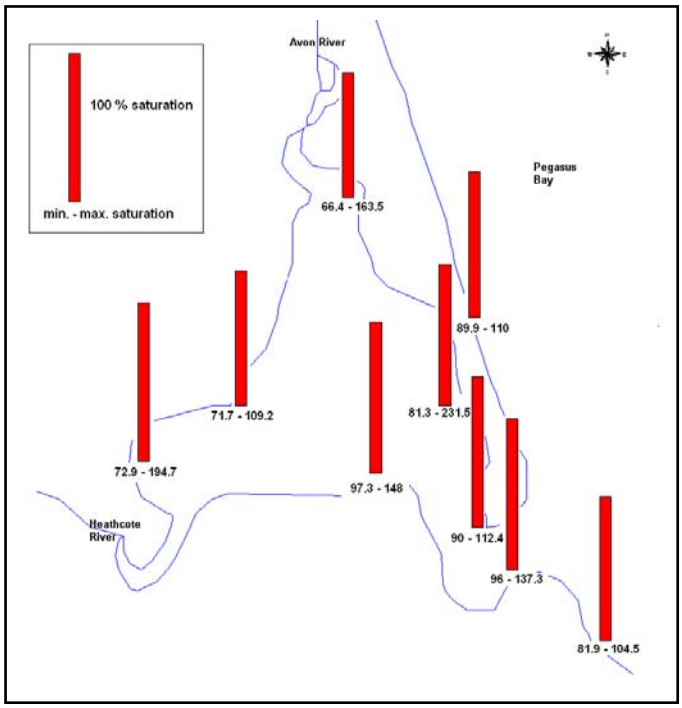


Figure 12 High tide dissolved oxygen saturation (%)

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

While median DO saturations were very similar, there were differences in the minimum and maximum values, between sites. DO saturation was very high at the same time chlorophyll-a concentrations were high. That is, the elevated oxygen within the water was likely due to the release of oxygen by the plant plankton.

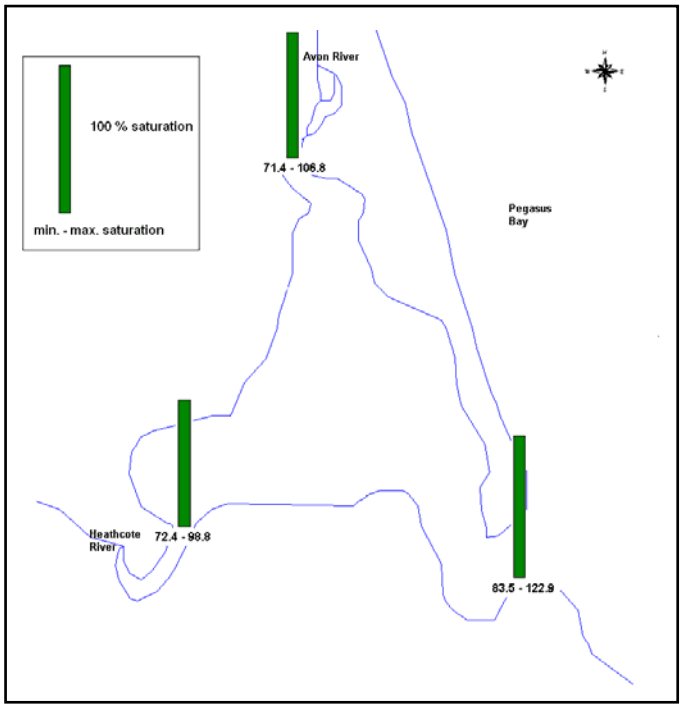


Figure 13 Low tide dissolved oxygen saturation (%)

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

The highest DO saturation at the mouth of the estuary occurred at the same time as the high chlorophyll-a concentration.

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 the 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%

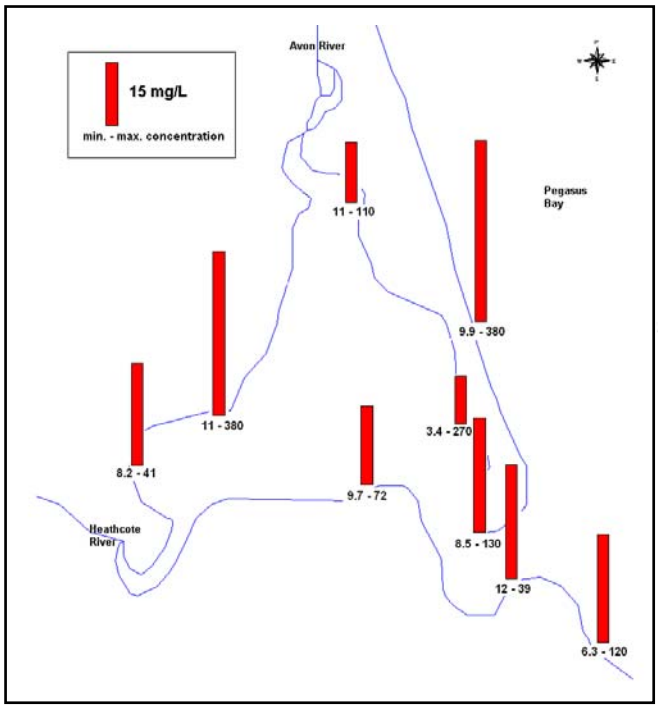
	Percentage of samples
High tide sites	
South Brighton@Caspian Street	**0**
South Spit	**0**
Penguin Street	**0**
Pleasant Point jetty	**33**
Sandy Point	**17**
Humphreys Drive	**8**
Beachville Road jetty	**0**
Shag Rock	**0**
Cave Rock	**0**
Low tide sites	
Bridge Street bridge	**25**
Ferrymead bridge	**17**
Shag Rock	**0**

These results indicate that DO saturation at some 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, 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.

Total suspended solids (TSS)

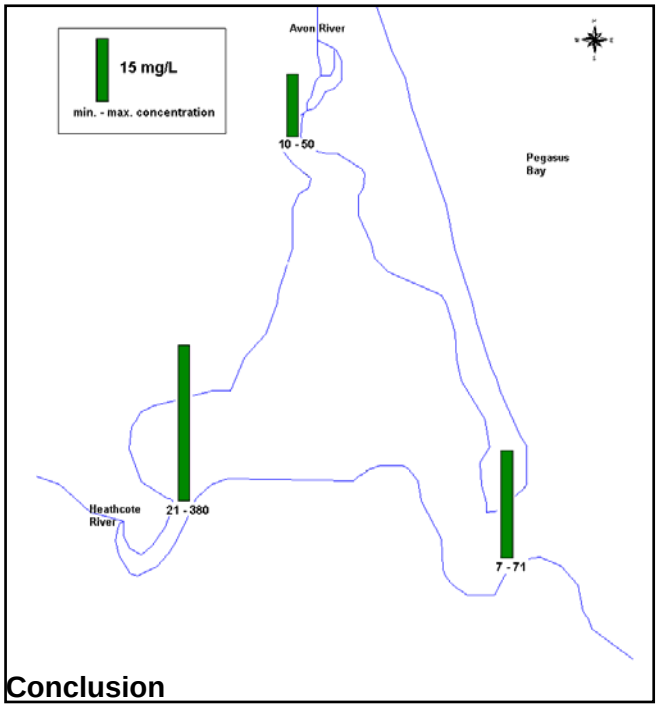
Total suspended solid (TSS) concentration is a measure the amount of particles within the water. It includes inorganic (non living) particles such as the sand and mud stirred up from the seabed and soil washed off the land and organic (from living things) particles like detritus (dead plant or animal 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 sediment concentrations at high tide are shown in Figure 14 while those at the low tide are shown in Figure 15.



Around high tide the highest total suspended solid concentrations were at South Brighton @ Caspian Street. The suspended solids at this site typically consisted of sand stirred up by wave action. Within the estuary the highest TSS concentrations were at Sandy Point. The TSS at this site likely consists of inorganic particles from the seabed and land as well as organic particles from the discharged wastewater and the seaweeds growing on the mudflats (see report on the soft sediments).

Figure 14 High tide total suspended sediment 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.

The maximum concentrations indicate that at times there are considerable amounts of soil in the Heathcote River. Such high concentrations did not occur in the Avon River.

Figure 15 Low tide total suspended sediment concentrations (mg/L)

Conclusion

The quality of the water within the Avon-Heathcote Estuary/Ihutai is affected by the quality of the water in the Avon and Heathcote rivers and the quality of the tertiary treated wastewater that is discharged into the estuary twice a day around high tide.

The rivers are a significant contributor of nitrate-nitrite nitrogen to the estuary. The wastewater is a significant contributor of ammonia-nitrogen and dissolved reactive phosphorus to the estuary. The ammonia-nitrogen concentrations that occur at some sites in the estuary are potentially toxic to aquatic life. At high tide such toxic concentrations occurred at sites closer to than further away from the wastewater discharge point, while at low tide they occurred at the mouth of the estuary as the wastewater was carried out of the estuary with the tide.

The dissolved 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 are more than likely to enhance plant plankton and sea weed growth. Weather and sea conditions, temperature, sunlight and the availability of other chemicals such as silica and iron also influence such growth. The prolific growth of seaweeds in certain areas of the estuary and the plant plankton bloom in March 2007, are attributed to favourable environmental conditions in combination with the concentrations of dissolved nitrogen and phosphorus present. The plant plankton species that bloomed in March 2007 was *Navicula* cf. *radiosa.* .

It is likely that the discharged wastewater directly or indirectly caused the low dissolved oxygen saturations. Decaying seaweeds, plant plankton and other organic matter within the water gets broken down by bacteria. When there is a plentiful supply of food, such as after a bloom of plant plankton or when there are excessive amounts of seaweed, there will be millions of bacteria. Bacteria need oxygen so when there are millions of them they will be using the oxygen in the water. Hence the amount of oxygen in the water will decrease.

Water quality within the Avon-Heathcote Estuary/Ihutai is expected to change once wastewater is no longer discharged into the estuary. Routine monitoring will provide information on what this change will be. Such information will be available in future summary reports. When wastewater is no longer discharged into the estuary, any consequent changes in the presence and abundance of fish and other life in the estuary will be assessed. This will provide some understanding of the effect of the concentrations of ammonia-nitrogen and possibly DO saturation, on the life in the estuary.

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