Water and sediment quality in the Bennett Brook catchment

October 2010 Snapshot

Prepared by

SERCUL
South East Regional Centre for Urban Landcare

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Perth Region NRM

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Executive Summary

This assessment of the water and sediment quality within the Bennett Brook catchment was undertaken in October 2010 and is part of an annual water and sediment quality monitoring snapshot of the catchment. Initiated in 2002, the program aims to provide baseline data on the water and sediment quality within the catchment, identifying any contaminant 'hotspots' and emergent trends.

This assessment is based on a one-off snapshot of water and sediment collected in October 2010, and where appropriate, compared to data from previous years (2002, 2003, 2004, 2005, 2006, 2007, 2008 and 2009) snapshots. The effect of seasonal and flow variations on the water and sediment quality in the Bennett Brook catchment were therefore not a part of this investigation. Consequently, the results represent the condition of the water in the catchment at the time of sampling only.

On October 6th and 7th 2010, water and sediment samples were collected and analysed from 14 and 11 sites respectively within the Bennett Brook catchment area, with two of these being located along the brook itself, and the remaining twelve sites being located along the major drainage systems which discharge into the brook including 4 sites in the Malaga industrial area.

The laboratory results are compared to trigger values provided in ANZECC guidelines. Results that exceed the referenced trigger values are an indication that further investigation should be considered, as there is the potential for an environmental impact. The key findings of the 2010 snapshot are outlined below.

Key findings

The key findings from the 2010 Bennett Brook Water Quality investigation were:

For Water:

- The pH at the Widgee Road Drain, sites 2 and 26 (Lightning Swamp – drain downstream and Malaga Compensation Basin - Glyde Court Outfall) were above the acceptable range for lowland rivers (6.5 – 8).
- Dissolved oxygen concentrations were varied, 11 out 14 samples did not meet the guidelines. 7 of them recorded concentrations below the acceptable range (80 – 120%).
- The electrical conductivity was above the acceptable range (0.12 – 0.3 mS/cm) for all sites, except site 24 (RSPCA Compensating Basin).
- Sites 5, 10 and 15 (Altone Road - Optus, Emu Swamp drain exit and Patricia Close) recorded total nitrogen concentrations above the ANZECC trigger value (1.2 mg/L).
- During the 9-year snapshot sampling period, site 10 has consistently recorded TN concentrations above the ANZECC trigger value. Site 15 also recorded concentrations above the trigger value in 2009, 2008, 2006, 2005 and 2002. These results suggest an ongoing source of TN to the system localised around these sites.
- 13 out of 14 sites recorded total phosphorus concentrations below the ANZECC trigger value (0.065 mg/L). Only site 24 (RSPCA Compensating basin) exceeded the trigger value.
- All the sites recorded TSS concentrations below the Department of Water interim guideline of 6 mg/L.
- All the sites recorded high concentrations of aluminium, above the ANZECC trigger value (0.055 mg/L). The highest concentrations were recorded at sites 7, 4 and 10 (Altone Park Golf Course, Madeira Ave – Altone Park and Emu Swamp drain exit).
- 9 out of 14 sites recorded high concentrations of iron, exceeding the ANZECC trigger value (0.3 mg/L). The highest concentrations were recorded at sites 16, 7 and 5 (Clarry Small Park, Altone Park Golf Course and Altone Road – Optus).

- All the sites recorded undetectable concentrations (below limits of reporting) for arsenic (<0.001 mg/L), mercury (<0.0001 mg/L), cobalt (<0.001 mg/L) and selenium (<0.001 mg/L). 11 out of 14 sites recorded undetectable concentrations of molybdenum (<0.001 mg/L).
- Concentrations of Manganese were below the trigger value (<1.9 mg/L) at all sites.
- All the sites recorded concentrations below the specific adjusted trigger value for cadmium, chromium, lead and nickel.
- Copper concentrations in the water were varied throughout the catchment; 4 out of 14 sites recorded undetectable concentrations (<0.001 mg/L) and sites 2, 26 and 27 (Lightning Swamp – drain downstream, comp. basin outfall at Glyde Court and comp basin outfall at Victoria Rd and Cogla St) exceeded the specific adjusted trigger value.
- Sites 1 and 7 (Malga Drive - Ivory St and Altone Park Golf Course) recorded zinc concentrations exceeding the specific adjusted trigger value. These sites also recorded concentrations above the trigger value in the 2009 snapshot sampling event.

For sediments:

- With the exception of sites 4 and 28 (Madeira Ave – Altone Park and Comp Basin Outfall at Cogla St and Mulgul Rd) metals in the sediments were generally low and below trigger values (where trigger values exist). These two sites also recorded concentrations for some metals above trigger values in the 2009 snapshot sampling event.
- Site 4 exceeded the sediment ANZECC higher trigger value for lead (50 mg/Kg), recorded the highest concentrations of all sites for aluminium (3,690 mg/Kg), arsenic (2.6 mg/Kg), iron (5,730 mg/Kg), manganese (21 mg/Kg), molybdenum (0.71 mg/Kg), copper (18 mg/Kg) and zinc (120 mg/Kg); the second highest concentration of cobalt (1.3 mg/Kg) and the third highest concentrations of chromium (1.8 mg/Kg) and nickel (3.6 mg/Kg).
- Site 28 exceeded the sediment ANZECC higher trigger value for nickel (52 mg/Kg), recorded the highest concentrations of all sites for cobalt (2.1 mg/Kg) and chromium (17 mg/Kg), the second highest concentrations of aluminium (2,100 mg/Kg), arsenic (1.9 mg/Kg), copper (12 mg/Kg) and zinc (47 mg/Kg) and the third highest concentration of manganese (18 mg/Kg). The source of the elevated metal concentrations is unknown. In 2009 this site also exceeded the sediment ANZECC lower trigger values for arsenic, chromium, copper, nickel and zinc plus the ANZECC higher trigger value for nickel.

Background

Bennett Brook is located in the north east of the Perth metropolitan area and was once a natural creek system. However, its tributaries to the west have been significantly modified into deeply incised drains to allow the surrounding land to be utilised for development. The Brook is a slow flowing stream 17km in length, with headwaters in Whiteman Park. The Brook is fed primarily from groundwater seepage from the Gnangara mound and discharges into the Swan River at Success Hill in Bassendean. Increased groundwater pumping in the northern part of the catchment for metropolitan water supply has lowered groundwater levels and hence reduced flow into the Brook. Conversely, the southern part of the catchment has elevated flow due to the construction of drainage networks and the increase in runoff from hard surface areas such as roads and roofs.

The Bennett Brook catchment covers an area of 217 km^2 with just over half this area being covered by the Gnangara pine plantation and Whiteman Park. Some native vegetation remains within Whiteman Park, however it is in a highly degraded state. The remainder of the catchment is cleared for residential, rural, commercial and industrial uses.

In 1999, Bennett Brook was identified as a Priority 2 Focus catchment by the Swan River Trust through the Swan Canning Clean-up Program, based on its annual nitrogen and phosphorus contributions to the Swan River. A snapshot of water and sediment quality in the Bennett Brook catchment was conducted in September/October 2002 to determine the location of pollution hotspots throughout the catchment area which may be contributing to the contamination of Bennett Brook and the Swan River. This snapshot was conducted again in December 2003, December 2004, September 2005, October 2006, November 2007, October 2008 and September 2009. The 2010 snapshot of water and sediment quality in the Bennett Brook catchment aims to follow up the previous year's snapshots based on the previous year's result and budget restrictions.

Sampling Procedures

Site Location

Due to the low rainfall levels during Winter and Spring 2010 many of the 24 sites could not be sampled; therefore water was sampled in only 14 sites and sediments only could be taken from 11 sites within the Bennett Brook catchment (Figures 1 and 2). Two of the 14 sites were located along the Bennett Brook itself and twelve along the three major drainage lines, which flow into the Bennett Brook from the west. Table 9 (Appendix A) provides a description of the location of each of the sites, including GPS coordinates.

Bennett Brook sites:

- Bennett Brook – two sites (sites 15 and 16). Sampling of these sites was undertaken to determine the water quality of the Bennett Brook and to assess the impact contributing stormwater drains has upon the water and sediment quality in the brook. In 2010 it was not possible to sample sediment from these sites.

Major drainage system sites:

- Emu Swamp Main Drain – two sites (sites 8 and 10). The catchment area of the Emu Swamp Main Drain has been, and continues to be, subjected to high levels of residential development, such as Ballajura Estates and Bennett Springs Estate. These sites were selected to determine the water quality entering the Brook from this major drainage line, and to assess the impact urban development has upon the water quality. Sediment sampling at site 8 was not possible in 2010.

- Widgee Road Drain – seven sites:
    - Malaga Drive RSPCA Basin - one site (site 24). This basin is located upstream of Lightning Swamp and receives stormwater from the Malaga industrial area. Sampling at this site was conducted to determine the water quality within the basin as a result of the surrounding land use and as an indication on the quality of water entering Lightning Swamp. Sediment was collected from this site.

    - Malaga industrial area Basins - 3 sites (sites 26, 27 and 28). These sites are compensation basins located at the industrial area above the Lightning Swamp and receive stormwater from the Malaga industrial area between Malaga Dr and Beringarra Av. Sampling of these sites was conducted to determine the quality of water from the Malaga Industrial area entering Lightning Swamp between sites 2 and 3. Sediment samples from these three sites were collected in 2010.

    - Lightning Swamp - three sites (sites 1, 2 and 3). Lightning swamp is a 70ha nature reserve with the natural creek being converted into a Water Corporation main drainage line. Site 1 is located at the beginning of the open water section of the Lightning Swamp reserve. Sites 2 and 3 are located up and downstream of a stormwater drain inlet pipe that discharges stormwater from the Malaga Industrial area into Lightning Swamp. Sampling of these sites was conducted to determine the impact of the inflow of water from the Malaga Industrial area on the water quality of Lightning Swamp. Sediment sampling at these three sites was possible in 2010.

    - Altone Park Recreation Complex and Golf Course - two sites (sites 4 and 7). These sites were sampled to determine the water quality entering the Altone Park Recreation Complex wetland from surrounding residential areas, and to establish the quality of the stormwater as it leaves the Altone Park golf course. Sediment from these two sites was collected in 2010.

- Wonga Road Drain - one site (site 5)
    - This site was sampled to establish the quality of stormwater and sediment within the Wonga Road Branch Drain. Sediment was collected in 2010 from this site.

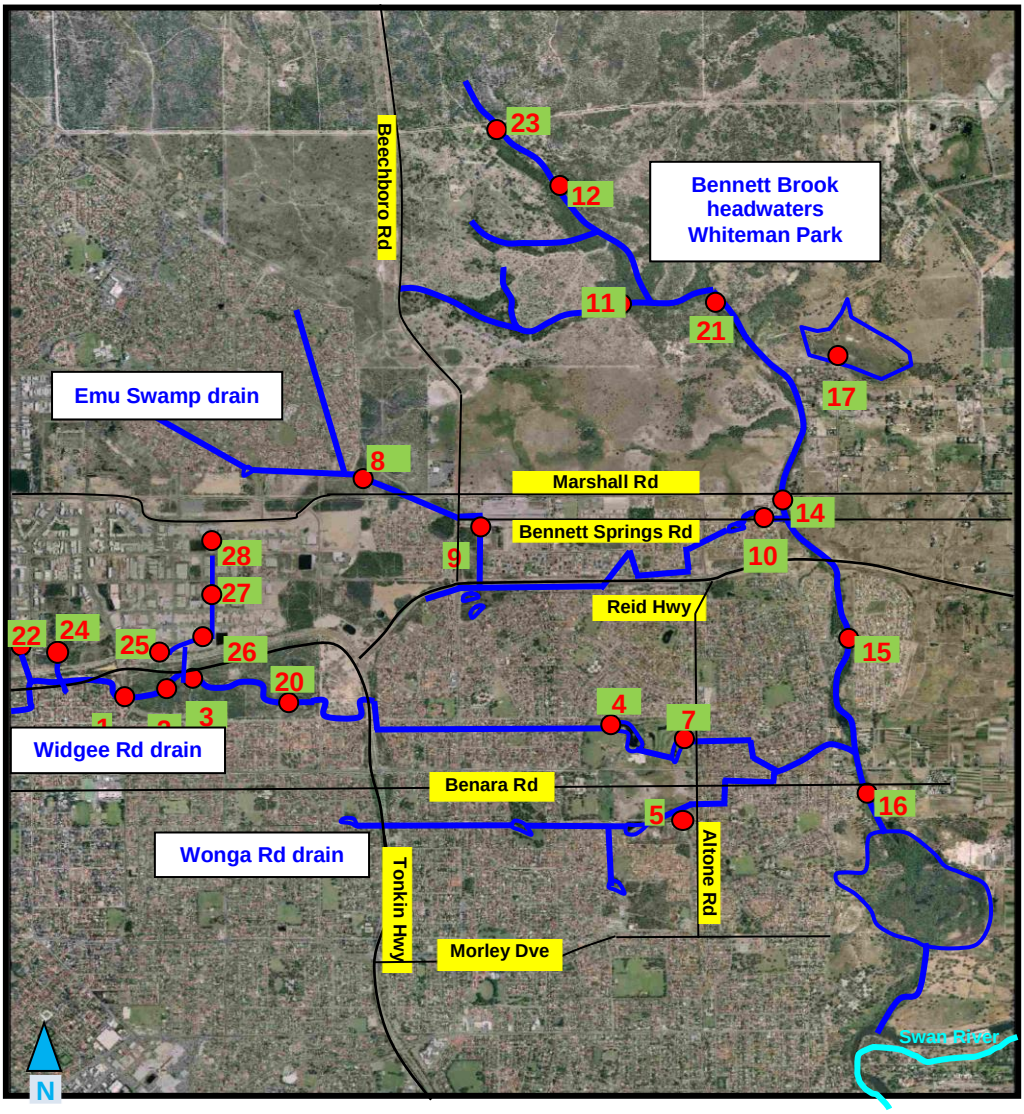

Figure 1: Location of sampling sites in the Bennett Brook catchment

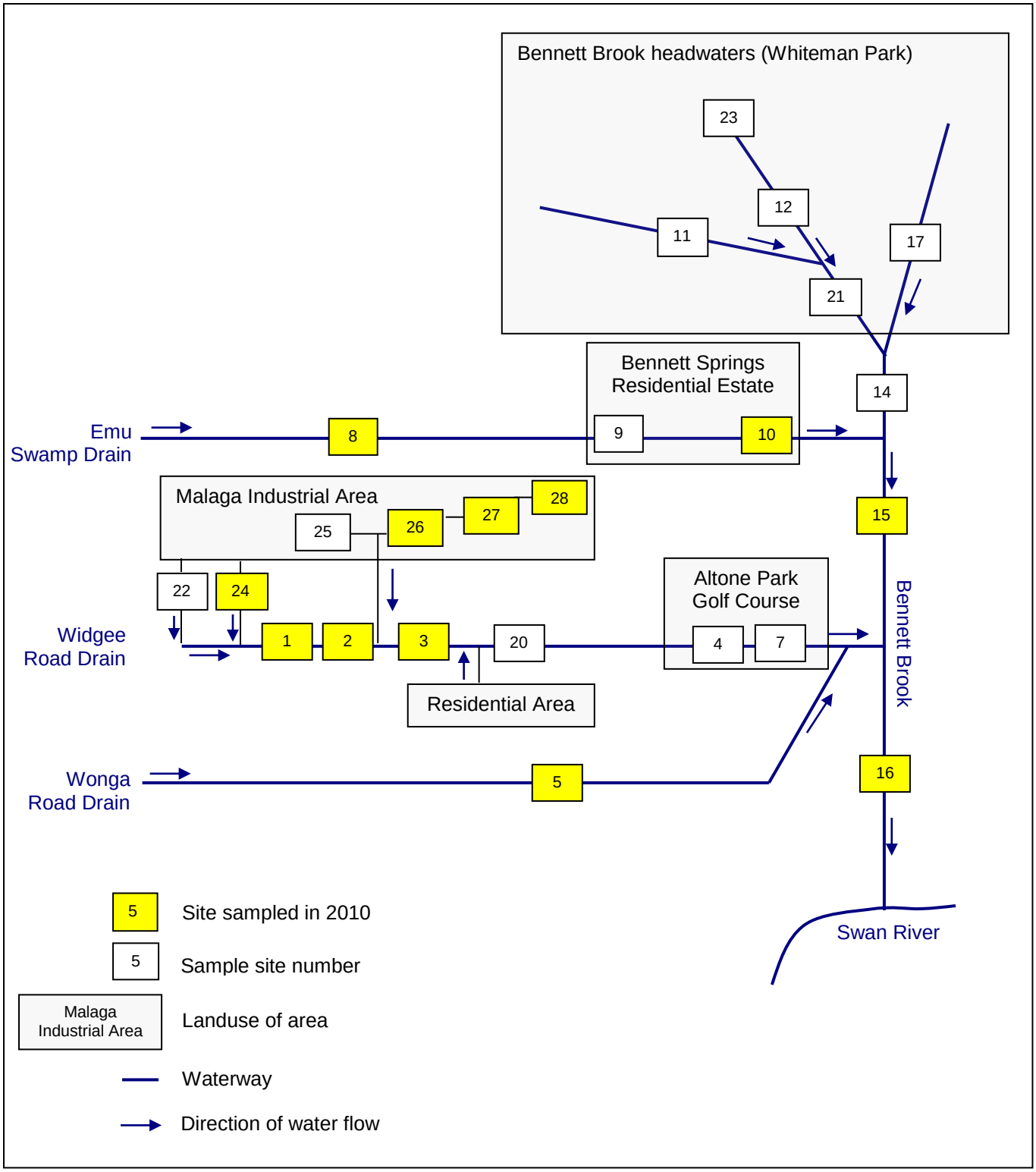

Figure 2: Schematic diagram illustrating sampling locations (not to scale)

Methods

Samples were collected on the 6th and 7th of October 2010. Field observation forms were filled out for each sample. All water and sediment samples were transported under "chain of custody" to the National Measurement Institute (NMI) laboratory and analysed in accordance with the laboratory methods. Samples were collected in accordance with the Bennett Brook Sampling and Analysis Plan 2010 (SERCUL 2010).

Water

Water in 14 out of 24 of the Bennett Brook catchment sites was measured *in situ* for physical properties, including:

- Dissolved oxygen;
- pH;
- Electrical conductivity;
- Salinity; and
- Temperature.

Samples at those 14 sites were collected and analysed for:

- Nutrients – total nitrogen (TN), total phosphorus (TP), soluble reactive phosphorus (SRP), nitrogen as ammonia (NH_3-N), total oxidised nitrogen (TON), total organic nitrogen (TOrgN), and dissolved organic nitrogen (DOrgN);
- Total suspended solids (TSS);
- Hardness (as Ca and Mg); and
- Soluble heavy metals – aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), cobalt (Co), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), and zinc (Zn).

Sediments

Sediments were collected at 11 sites and analysed for total heavy metals: aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), cobalt (Co), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), and zinc (Zn).

Results and Discussion

Comparison of results with guidelines

To provide a general frame of reference as to the state of water quality in the Bennett Brook catchment, this report compares the results of sampling with trigger levels from the Australian and New Zealand guidelines for fresh and marine water quality ANZECC guidelines that are most applicable to this water body. To select which set of guidelines to use, the environmental value (EV) and level of protection of any water resource (including its receiving environment), needs to be determined and agreed upon between all key stakeholders. The guidelines recognise three levels of protection for aquatic ecosystem; those with high conservation value, slightly to moderately disturbed ecosystems and highly disturbed ecosystems. To assess the level of toxicant contamination in aquatic ecosystems, trigger values were developed from data using toxicity testing on a range of test species. The trigger values (99%, 95%, 90% and 80%) approximately correspond to the levels of protection described above. An exceedence of the referenced trigger level does not indicate that “standards” are not being met, but is an indication that further consideration should be given to the situation.

Nutrient concentrations and physical parameter results of the surface water of the Bennett Brook catchment are compared to the statistically derived default trigger values for slightly disturbed ecosystems of southwest Australia (ANZECC & ARMCANZ 2000). The results are compared to the ‘lowlands river’ ecosystem type, as this is considered to be most applicable to the brook and its tributaries (open drains).

Urban and industrial catchments tend to be highly modified and often artificial ecosystems where the risk of toxicant contamination is high and current environmental value is low. On that basis many of the waterways in the Bennett Brook catchment would be compared to the 80% level based on ANZECC guidance. However, the Bennett Brook flows directly into the Swan River where environmental values are high and for this reason, the toxicant results, heavy metals and metalloid concentrations of the surface water of the Bennett Brook catchment will be compared to the trigger values for 95% protection levels, applicable to high conservation value and slightly to moderately disturbed ecosystems. Where no trigger values currently exist, results will be compared to interim or low-reliability trigger values, provided in the ANZECC guidelines (ANZECC & ARMCANZ 2000).

From a human-use perspective, the surface waters of the Bennett Brook catchment are not a source of drinking water but may be accessed by the public, either as unfenced sections or as water bodies in parks. It is therefore reasonable to compare the toxicant results to recreational guidelines that take into account risks to public health.

The concentrations of heavy metals in the sediments of the Bennett Brook catchment are compared to the interim sediment quality guidelines where both low and high trigger values are reported (ANZECC & ARMCANZ 2000). Where metal concentrations exceed the low trigger value further consideration should be given to the situation and a further assessment of the bioavailability of the metal may be required.

The results of the chemical analysis of sediment samples collected from the Bennett Brook catchment will be compared to the ANZECC guidelines for fresh and marine water quality (ANZECC 2000), specifically the Interim Sediment Quality Guidelines. These guidelines provide both low and high trigger values. Where concentrations are between the low and high values background concentrations should be investigated. If the results exceed the high guidelines or are above the background concentrations a further assessment for the bioavailability of the metal is required.

Appendix C displays the ANZECC trigger values and other guidelines used in the data analysis.

Flow and Depth

As a result of groundwater seepage, flow from Bennett Brook into the Swan River occurs all year round. The greatest flow generally occurs as a result of winter rainfall between May and September. There is a delay between the onset of winter rain and the commencement of consistent flow in the upper reaches of the Brook. The Wonga/Widgee Road Drain has perennial flow due to groundwater inflow, while the Emu Swamp Drain flows in response to rainfall events only. However, during 2010, very much below average rainfall occurred in western parts of Western Australia (WA). The dry conditions were a result of a very poor wet season (January to April) in much of the Pilbara and Gascoyne regions, combined with persistent and anomalously high pressure over southern WA for most of the year. Both, the winter and autumn of 2010, were characterised by an unusual absence of westerly winds and a very low number of significant cold fronts passing over southern WA. This deprived the region of its main rain producing mechanism (Western Australia Climate Services Centre 2010).

Figure 3 below highlights the sampling dates, the maximum temperature and the daily rainfall received in the Perth metro area at that time. The monthly rainfall for September (43.6 mm) was around half the average that Perth would expect in September. Sampling was conducted on the 6th and 7th of October 2010, with no rainfall on either sampling days. The air maximum temperatures recorded for the two sampling days were 23.8 and 28.2^{o}C respectively.

Due to the very much below average rainfall during the year, there was not a substantial amount of flow at the majority of the sites and many of them were completely dry. The southwest corner in Western Australia has experienced in 2010 its driest year-to-date on record (34 mm below the previous record of 390 mm) and its driest November to October on record (Western Australia Climate Services Centre 2010).

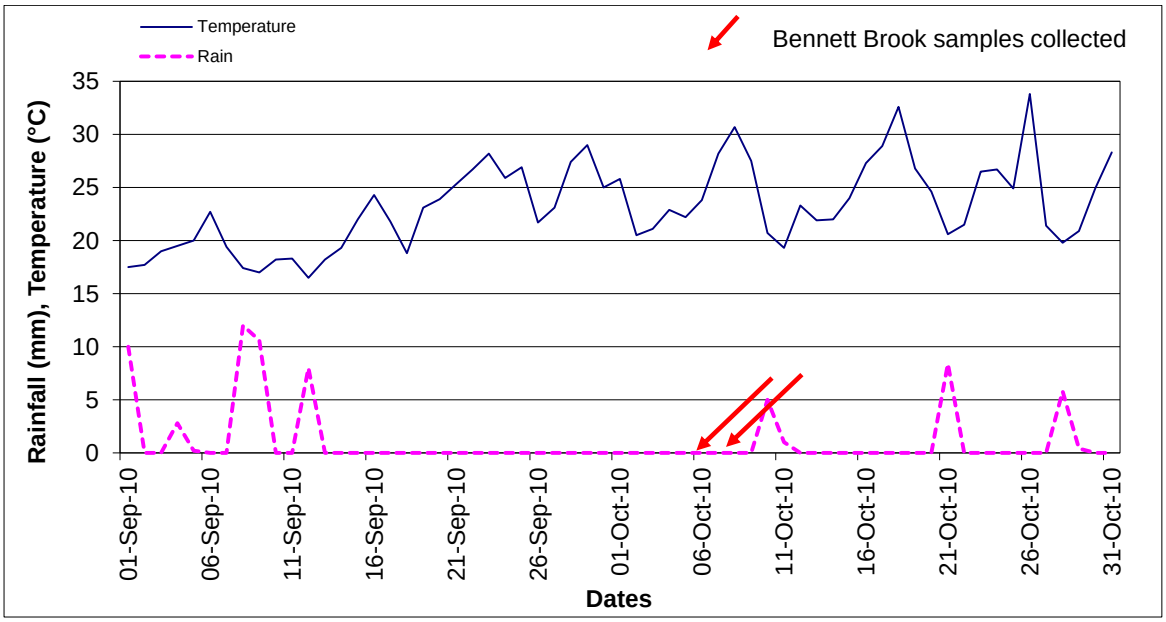

Figure 3: Rainfall from September – October 2010

Source: Bureau of Meteorology (Commonwealth of Australia 2010)

Physical Properties

Refer to Appendix 2 for all physical parameter data (pH, dissolved oxygen, electrical conductivity and temperature) for the Bennett Brook 2010 snapshot.

pH

pH is a measure of the acidity or alkalinity of a water body. pH is measured on a logarithmic scale, with a pH of 7.0 being neutral, a pH of less than 7 being acidic, and a pH of greater than 7 being alkaline or basic. The importance of pH on water quality lies mainly in its effect on other water quality parameters and on chemical reactions. pH can also affect the solubility and toxicity of a wide range of metallic contaminants (IEA 2003).

A pH between 6.5 and 8.0 is required to sustain aquatic life in lowland rivers (ANZECC & ARMCANZ 2000). The pH of the surface water of the 14 sampled sites at Bennett Brook catchment were within the acceptable ANZECC range except for two sites (2 and 26) that exceeded it.

The highest pHs (9.65 and 9.54) were recorded at sites 26 and 2 (Malaga Compensation Basin - Glyde Court Outfall and Lightning Swamp – drain downstream respectively) and the lowest pH (6.91) was recorded at site 8 (Emu Swamp drain – Whiteman Park - Ballajura).

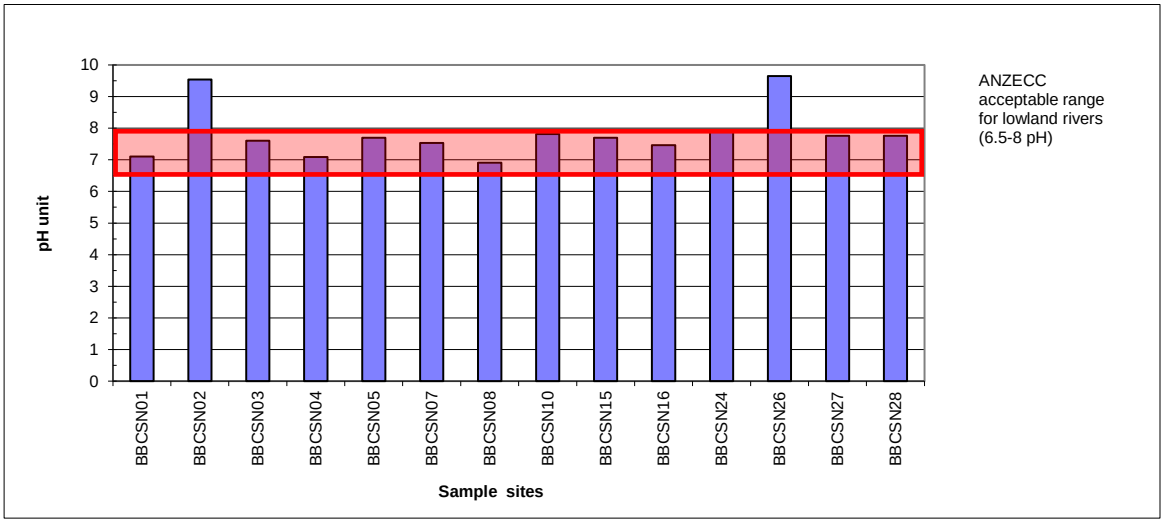

Figure 4: pH of the surface waters of the Bennett Brook catchment

The overall pH of the Bennett Brook catchment has varied over the years with no clear trend emerging. Unlike previous years, in 2010 there were no recorded pH values below the acceptable range (<6.5). Table 1 shows the sites that have recorded pHs below or above the acceptable range during the 9-year sampling period. Sites 11, 12 and 23 (Bennett Brook – upstream Mussel Pool, Bennet Brook – top Whiteman Park and Keith Maine sump – adjacent to Keith Maine Camp) have recorded pHs below the acceptable range every time samples have been taken.

Table 1: Record of pH below and above the acceptable range in the Bennett Brook Catchment 2002 - 2010

Site number	2010	2009	2008	2007	2006	2005	2004	2003	2002
BBCSN01	N	N	N	**6.39**	N	NS	NS	NS	NS
BBCSN02	**9.54**	N	N	**6.73**	N	**6.03**	N	N	N
BBCSN03	N	N	N	N	N	**6.18**	N	N	N
BBCSN04	N	N	N	N	N	**5.8**	N	**5.9**	N
BBCSN05	N	N	N	**6.09**	N	**5.76**	N	**6.48**	N
BBCSN07	N	N	N	N	N	**5.89**	N	N	**6.3**
BBCSN08	N	**6.36**	N	**6.04**	**6.44**	**5.28**	**6.45**	**5.87**	**5.6**
BBCSN09	NS	N	N	N	N	**5.91**	NS	N	**6.3**
BBCSN10	N	N	N	N	N	**6.43**	N	N	**6.8**
BBCSN11	NS	**4.46**	**5.49**	**5.54**	NS	**4.69**	NS	NS	**6**
BBCSN12	NS	**4.1**	**3.98**	**4.26**	**3.95**	**4.03**	NS	**4.93**	**4.2**
BBCSN13	NS	NS	NS	NS	NS	NS	NS	NS	**4.5**
BBCSN14	NS	N	**6.48**	**6.29**	N	**6.04**	NS	NS	**6**
BBCSN15	N	N	N	N	N	**6.37**	N	N	N
BBCSN16	N	N	N	N	N	**6.34**	N	NS	N
BBCSN17	NS	N	N	N	**9.16**	**6.66**	NS	NS	NS
BBCSN20	NS	N	**8.53**	N	N	**6.06**	NS	NS	NS
BBCSN21	NS	**5.63**	**5.6**	**6.46**	N	**5.04**	NS	NS	NS
BBCSN22	NS	N	N	N	**9**	**8.54**	NS	NS	NS
BBCSN23	NS	**3.48**	**3.38**	**3.33**	**2.33**	**3.3**	NS	NS	NS
BBCSN25	NS	**3.41**	NS	NS	NS	NS	NS	NS	NS
BBCSN26	**9.65**	N	NS	NS	NS	NS	NS	NS	NS

N= concentration was not above trigger value

NS= no sample was taken in this site

Above range

Below range

Dissolved Oxygen

Dissolved Oxygen (DO) is a measure of the quantity of oxygen present in water and is often used as an indication of the 'general health' of a water body. Low DO levels in water leads to several environmental problems including stresses on the aquatic community and facilitation of chemical reactions (IEA 2003). Stress within the aquatic environment can result in the release of sediment-bound nutrients and toxicants into the water column. Low DO concentrations can also increase the toxicity of certain heavy metals.

Systems generally have natural DO concentrations that fluctuate diurnally. Differences can be noted between morning concentrations where only aeration has introduced oxygen to the ecosystem and late afternoon where photosynthesising organisms have also introduced oxygen to the system during the day. Low DO concentrations are normally a result of processes consuming oxygen at a rate faster than the environments capacity to provide or retain oxygen. These include the decay of organic matter, the oxidation of hydrocarbons, the reduction of metals and the microbial conversion of ammonia to nitrate and nitrites through the process of nitrification. These however are still natural processes within the environment. DO concentrations throughout the year also change with seasonal changes. When monitoring for DO low concentrations usually indicate systems which are under some stress or where large amounts of organic material are being decomposed.

A dissolved oxygen concentration of between 80 and 120 % is required to sustain aquatic life in freshwater lowland rivers (ANZECC 2000). The DO concentration of the surface waters of the Bennett Brook catchment was varied. Half (7 out of 14 samples) of the DO concentrations were below the acceptable DO range and 4 of them were above it. Dissolved oxygen can fluctuate greatly over a diurnal cycle and it is preferable to measure it over a full diurnal cycle for a few days (ANZECC & ARMCANZ 2000). This type of DO monitoring was not conducted as part of this monitoring program.

Site 8 (Emu Swamp drain - Whiteman Park - Ballajura) recorded the lowest DO concentration (38.3 %) within the sampled sites at Bennett Brook catchment. Overall, and being consistent with previous year's findings, sites 15 and 16 were below the ANZECC acceptable range. The source of the low dissolved oxygen requires further investigation and monitoring, but is likely due to low flow and poor mixing of the water.

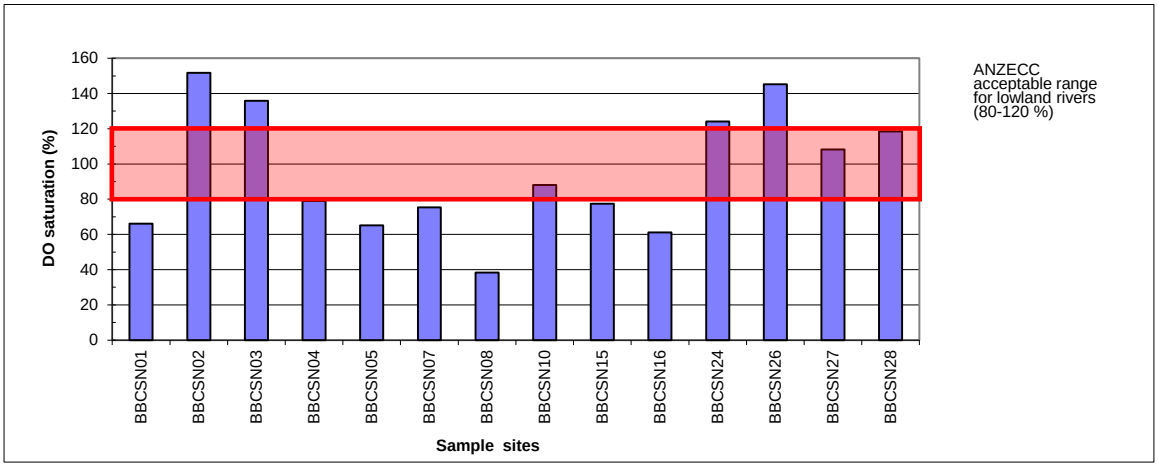

Figure 5: Dissolved oxygen concentrations of the Bennett Brook catchment

Table 2 shows the records of DO% that have been below and above the acceptable range for lowland rivers during the 9-year sampling period. Sites 8, 15, 16 and 23 have recorded concentrations below the acceptable range when samples have been taken.

Table 2: Record of DO% below and above the acceptable range in the Bennett Brook Catchment 2002 – 2010

Site number	2010	2009	2008	2007	2006	2005	2004	2003	2002
BBCSN01	**66.1**	N	**173.5**	**68.2**	N	NS	NS	NS	NS
BBCSN02	**151.8**	N	**75.4**	N	N	**128.0**	**127.8**	N	N
BBCSN03	**135.9**	N	N	N	N	N	N	**78.6**	N
BBCSN04	**78.9**	N	N	**76.8**	N	N	N	**78.6**	N
BBCSN05	**65.2**	N	**79.5**	N	**78.9**	N	N	N	N
BBCSN07	**75.3**	**73.8**	N	N	N	N	N	N	N
BBCSN08	**38.3**	**41.2**	**65.6**	**63.6**	**59**	**46.3**	**68.5**	**63.4**	**64.6**
BBCSN09	NS	N	**128.3**	N	76	N	NS	**123.4**	**64.5**
BBCSN10	N	N	N	N	N	N	N	N	N
BBCSN11	NS	**43.8**	**18.8**	**8.8**	NS	**66.9**	N	NS	**9.4**
BBCSN12	NS	**24.4**	**34.8**	**25.4**	**33.2**	**33.6**	N	**40.7**	**40.3**
BBCSN13	NS	NS	NS	NS	NS	NS	NS	NS	**57.8**
BBCSN14	NS	**46.1**	**33.3**	**34.6**	**42**	**54.6**	N	NS	**49.9**
BBCSN15	**77.5**	**58.8**	**73.3**	**70.2**	**72.5**	**68.8**	**78.9**	**74.4**	**67.3**
BBCSN16	**61.1**	**62.3**	**55.2**	**42**	**49**	**72.8**	**44.1**	**58.1**	**75.9**
BBCSN17	NS	**77.2**	N	N	**134.3**	**90.1**	NS	NS	NS
BBCSN18	NS	NS	NS	NS	NS	**137.2**	NS	NS	NS
BBCSN19	NS	NS	NS	NS	NS	**133.8**	NS	NS	NS
BBCSN20	NS	N	**145.7**	N	N	N	NS	NS	NS
BBCSN21	NS	**56.2**	**59.4**	**70**	**70.2**	**65.9**	NS	NS	NS
BBCSN22	NS	N	**29.7**	N	N	N	NS	NS	NS
BBCSN23	NS	**41**	**22.3**	**63.2**	**37.3**	**43**	NS	NS	NS
BBCSN24	**124.1**	N	N	N	NS	NS	NS	NS	NS
BBCSN26	**145.2**	N	NS	NS	NS	NS	NS	NS	NS
BBCSN27	N	**70**	NS	NS	NS	NS	NS	NS	NS

N= concentration was not above trigger value

NS= no sample was taken in this site

Above range
Below range

Electrical Conductivity

Electrical conductivity (EC) is the total concentration of inorganic ions (particularly sodium, chlorides, carbonates, magnesium, calcium, potassium and sulphates). Conductivity is often used as a measure of salinity. The ANZECC acceptable range for lowland rivers is 0.12 to 0.3 mS/cm.

13 out of 14 sites recorded electrical conductivity above the acceptable range, the exception was site 24 (Malaga Compensation Basin – RSPCA) which recorded 0.285 mS/cm. Average conductivity in the catchment was 0.495 mS/cm.

The highest electrical conductivity levels were recorded at sites 5, 7 and 16 (Altone Road – Optus 0.696 mS/cm, Altone Park Golf Course0.628 mS/cm and Clarry Small Park 0.631 mS/cm respectively). However it is worth noting that all of these results would be classed as freshwater, not brackish or saline.

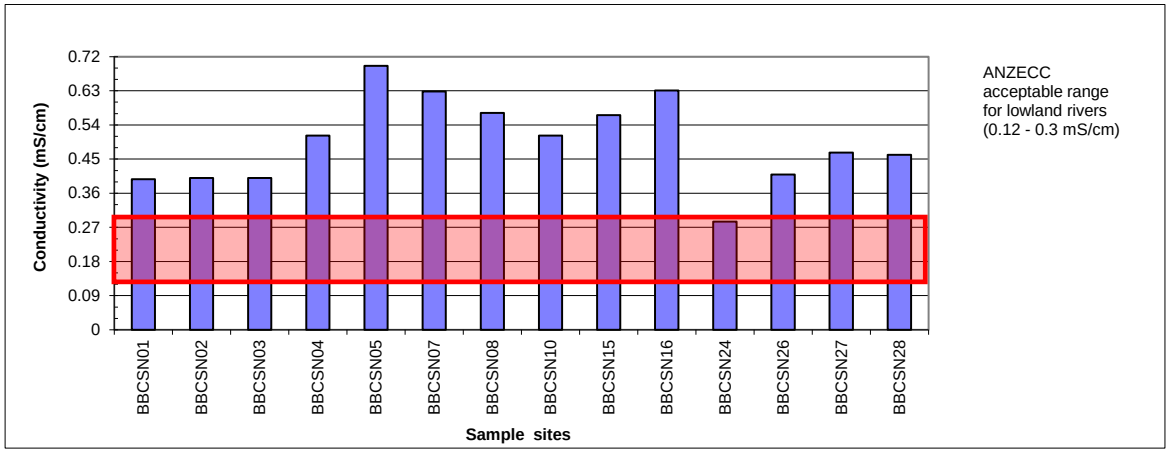

Figure 6: Electrical conductivity of the Bennett Brook catchment

Table 3 presents the record of EC along the snapshot monitoring period. Sites 4, 5, 7, 8 10, 15, 16, 27 and 28 have recorded concentrations below or above the acceptable range when samples have been taken.

Table 3: Record of EC below and above the acceptable range in the Bennett Brook Catchment 2002 – 2010

Site number	2010	2009	2008	2007	2006	2005	2004	2003	2002
BBCSN01	**0.397**	N	**0.0387**	**0.4**	N	NS	NS	NS	NS
BBCSN02	**0.4**	N	**0.0353**	**0.391**	N	N	**0.383**	NS	**0.4**
BBCSN03	**0.4**	N	**0.0355**	**0.357**	N	N	**0.342**	NS	**0.346**
BBCSN04	**0.512**	**0.37**	**0.05**	**0.499**	**0.482**	**0.346**	**0.507**	NS	**0.462**
BBCSN05	**0.696**	**0.655**	**0.0732**	**0.765**	**0.5689**	**0.646**	**0.708**	NS	**0.432**
BBCSN07	**0.628**	**0.38**	**0.0541**	**0.541**	**0.506**	**0.349**	**0.615**	NS	**0.353**
BBCSN08	**0.572**	**0.539**	**0.0555**	**0.601**	**0.4677**	**0.476**	**0.545**	NS	**0.507**
BBCSN09	NS	**0.516**	**0.0543**	**0.499**	N	**0.437**	NS	NS	**0.39**
BBCSN10	**0.512**	**0.498**	**0.0505**	**0.53**	**0.4531**	**0.452**	**0.562**	NS	**0.498**
BBCSN11	NS	**1.401**	N	**3.88**	**NS**	**0.781**	NS	NS	**0.871**
BBCSN12	NS	**1.77**	N	**2.33**	**2.059**	**1.033**	NS	NS	**0.906**
BBCSN13	NS	NS	NS	NS	NS	NS	NS	NS	**0.784**
BBCSN14	NS	**1.15**	**0.1023**	**1.041**	**0.8672**	**0.728**	NS	NS	**0.923**
BBCSN15	**0.566**	**0.642**	**0.0586**	**0.596**	**0.547**	**0.538**	**0.584**	NS	**0.65**
BBCSN16	**0.631**	**0.572**	**0.062**	**0.645**	**0.5675**	**0.506**	**0.654**	NS	**0.536**
BBCSN17	NS	**0.461**	**0.0748**	**0.971**	**1.266**	**0.536**	NS	NS	NS
BBCSN20	NS	N	**0.0343**	**0.336**	N	N	NS	NS	NS
BBCSN21	NS	**1.53**	N	**1.96**	**1.096**	**0.87**	NS	NS	NS
BBCSN22	NS	N	**0.018**	**0.23**	N	N	NS	NS	NS
BBCSN23	NS	**1.33**	N	**1.51**	**1.434**	**1.239**	NS	NS	NS
BBCSN24	**0.285**	N	**0.036**	**0.369**	NS	NS	NS	NS	NS
BBCSN25	NS	N	NS	NS	NS	NS	NS	NS	NS
BBCSN26	**0.409**	N	NS	NS	NS	NS	NS	NS	NS
BBCSN27	**0.467**	**0.433**	NS	NS	NS	NS	NS	NS	NS
BBCSN28	**0.461**	**0.835**	NS	NS	NS	NS	NS	NS	NS

N= concentration was not above trigger value

NS= no sample was taken in this site

Above range
Below range

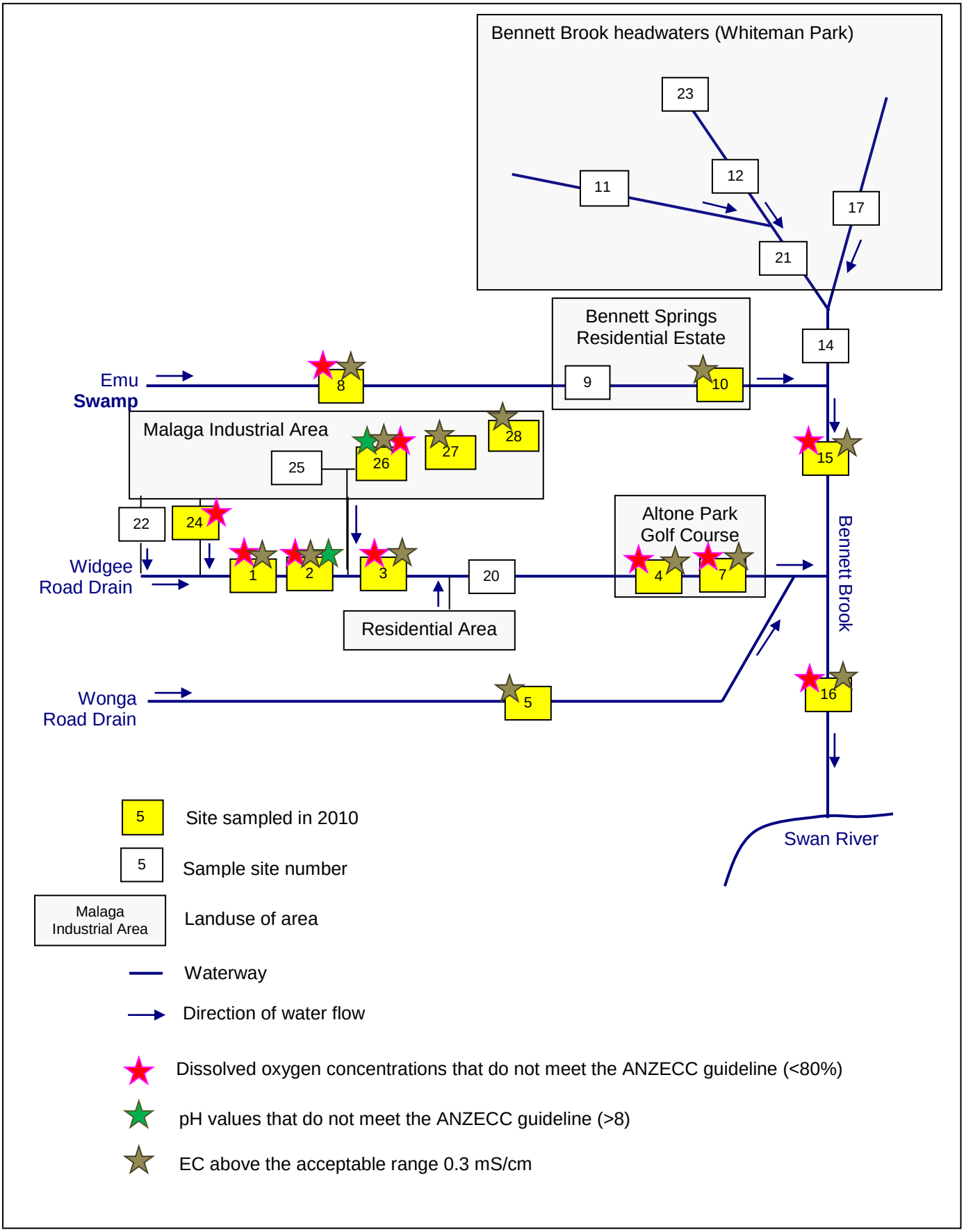

Figure 7: DO concentrations, pH and EC of water samples which do not meet ANZECC guidelines

Total Suspended Solids

Total Suspended Solids (TSS) is the total amount of suspended material in the water that can be removed by filtration. TSS can include a wide variety of material such as silt, sand, organic material such as algae, microorganisms, decaying plant and animal matter or industrial wastes from a variety of sources including erosion by wind and water, construction and demolition operations as well as wear of roads and vehicles. Deposition of suspended solids can block pipes, change flow conditions in open channels and increase turbidity which reduces light penetration (IEA 2003). Nutrients, particularly phosphorus and other contaminants are often adsorbed to the surface of the particles of suspended solids, and therefore a high suspended solid concentration often coincides with high nutrient (particularly phosphorus) or contaminant concentrations.

The TSS concentrations throughout the Bennett Brook catchment were low and below the DoW interim guideline of 6 mg/L at all sites.

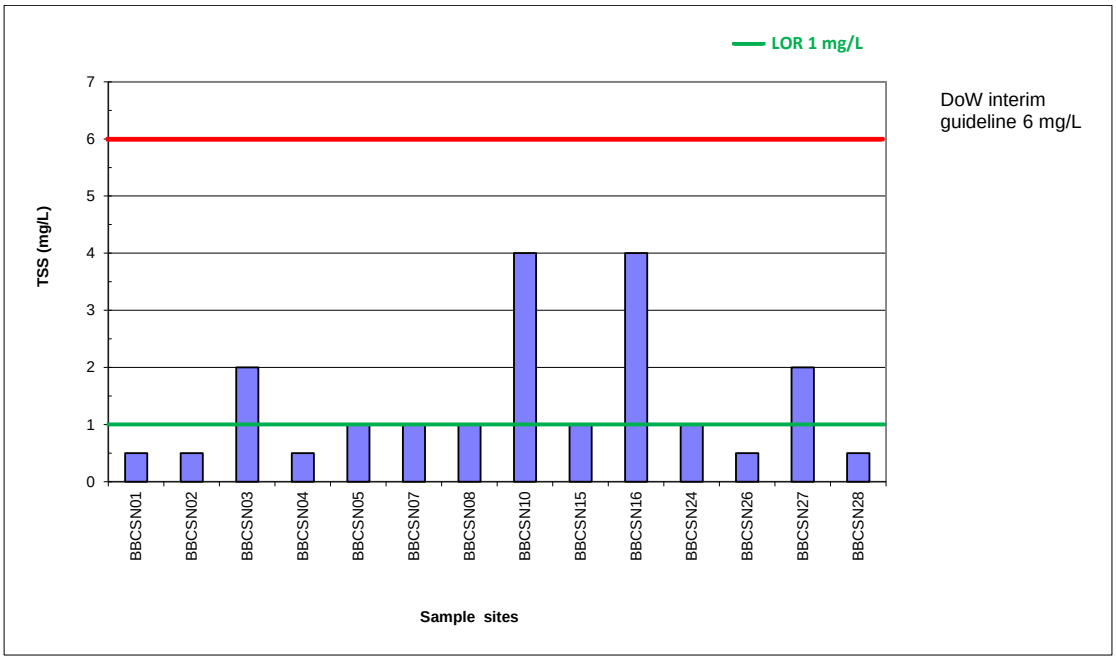

Figure 8: Total suspended solids in the Bennett Brook catchment

Table 4 shows the TSS record during the 9-year snapshot sampling period. When this parameter has been analysed, a trend has not been evident and the concentrations have only exceeded the interim guideline of 6 mg/L on a few occasions.

Table 4: Record of TSS above the DoW interim guideline in the Bennett Brook Catchment 2002 – 2010

Site number	2010	2009	2008	2007	2006	2005	2004
BBCSN01	N	N	**10**	N	N	NS	NS
BBCSN05	N	N	N	**8**	N	N	N
BBCSN10	N	N	N	N	N	N	**8**
BBCSN11	NS	N	**52**	N	NS	N	NS
BBCSN14	NS	**20**	**42**	N	**24**	N	NS
BBCSN15	N	N	**7**	N	N	N	N
BBCSN16	N	N	**19**	**7**	N	N	N
BBCSN17	NS	N	N	N	**30**	N	NS
BBCSN23	NS	**10**	N	**7**	N	NS	NS
BBCSN24	N	N	**10**	N	NS	NS	NS

N= concentration was not above trigger value

NS= no sample was taken in this site

Above guide

Nutrient concentrations in water

The general sources of nutrients in water are from fertilisers, soil erosion, detergents, sewerage, plant matter, animal wastes, organic wastes and vehicle exhausts (IEA 2003). Excessive amounts of nutrients can result in eutrophication of waterways. Eutrophication is broadly described as the enrichment of waters by inorganic (and to a lesser extent organic) plant nutrients (predominantly nitrogen and phosphorus). When an ecosystem is in a eutrophic condition, plant and algae density and productivity generally increases, but species diversity is often reduced, nuisance insect numbers often increase, and eventually the ecosystem becomes less diverse and more degraded with more frequent nuisance algal blooms and higher plant nutrient flux.

Nutrients analysed as part of this project include nitrogen in the form of ammonia, nitrate and nitrite, and phosphorus in the form of phosphate either dissolved (soluble reactive phosphorus) or particulate (suspended).

Nutrient concentration data for water samples of the Bennett Brook catchment in 2010 are displayed in Appendix 2.

Nitrogen

Nitrogen is recycled continually by plants and animals in a number of inorganic and organic forms. Forms include nitrate, nitrite and ammonium. Nitrogen concentrations vary considerably under natural conditions, depending on factors such as local soil types, vegetation and seasonal conditions. Total nitrogen (TN) is a measure of all forms of nitrogen in the water including ammonia, nitrate and nitrite and organic nitrogen. External or additional sources of nitrogen include fertilisers, industrial and household cleaning products; feed lots, animal droppings combustion of fossil fuels and plant debris (IEA 2003).

The TN concentrations in the surface water varied across the catchment, with the majority of sites (11 out of 14) below the ANZECC trigger value of 1.2 mg/L. Concentrations which exceeded or equalled the trigger value were recorded at sites 7, 10 and 15 (Altone Park Golf Course – 1.2 mg/L, Emu Swamp drain exit – 1.8 mg/L and Patricia Close respectively -1.2 mg/L). Site 10 has recorded values exceeding the trigger value every year since 2002, suggesting an ongoing source of TN to the system localised around this vicinity. Site 15 has also recorded concentrations exceeding the trigger value in 2010, 2009, 2008, 2006, 2005 and 2002 and site 7 in 2010, 2008, 2007 and 2006.

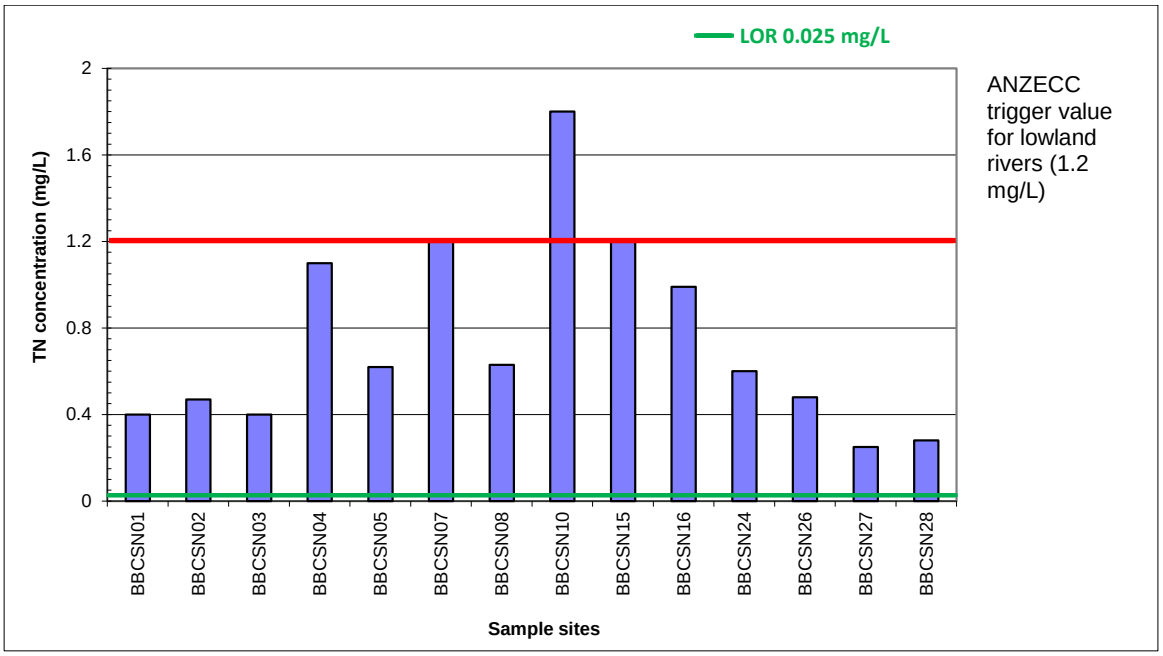

Figure 9: Total nitrogen concentration in water throughout the Bennett Brook catchment

Table 5 shows the sites that have recorded TN concentrations above the trigger value during the 9-year snapshot sampling period.

Table 5: Sites recording TN concentrations above the trigger value in the Bennett Brook Catchment 2002 - 2010

Site number	2010	2009	2008	2007	2006	2005	2004	2003	2002
BBCSN04	N	N	**1.2**	**1.3**	N	N	N	**1.3**	N
BBCSN07	**1.2**	N	**1.2**	**1.2**	**1.2**	N	N	N	N
BBCSN10	**1.8**	**2.1**	**1.9**	**2.2**	**1.9**	**2.3**	**2.3**	**1.9**	**1.8**
BBCSN11	NS	**1.3**	**1.8**	**2.7**	NS	N	NS	NS	**1.2**
BBCSN14	NS	**2.1**	**2.9**	N	**2.1**	**2**	NS	NS	**2.2**
BBCSN15	**1.2**	**1.9**	**1.7**	N	**1.5**	**1.9**	N	N	**1.6**
BBCSN16	N	**1.4**	**1.5**	N	N	**1.4**	N	N	**1.2**
BBCSN17	NS	**3**	**4.3**	N	**4.2**	**3**	NS	NS	NS
BBCSN21	NS	**1.2**	N	N	N	**1.3**	NS	NS	NS

N= the concentration was not above trigger value

NS= no sample was taken in this site

Total oxidised nitrogen (TON or NO_X) is the sum of the oxidised forms of nitrogen and includes nitrite (NO_2) and nitrate (NO_3). Nitrates in excessive amounts with phosphorous can cause eutrophication, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in the waterway. This, in turn, may increase diurnal fluctuations in dissolved oxygen levels which in turn will impact upon aquatic life in the waterways.

Of particular concern are the high TON concentrations at sites 10, 15 and 16 (Emu Swamp drain exit, Patricia Close and Clarry Small Park respectively), which reported the highest concentrations (1.1, 0.54 and 0.38 mg/L respectively). These 3 sites have recorded high TON concentrations in previous years.

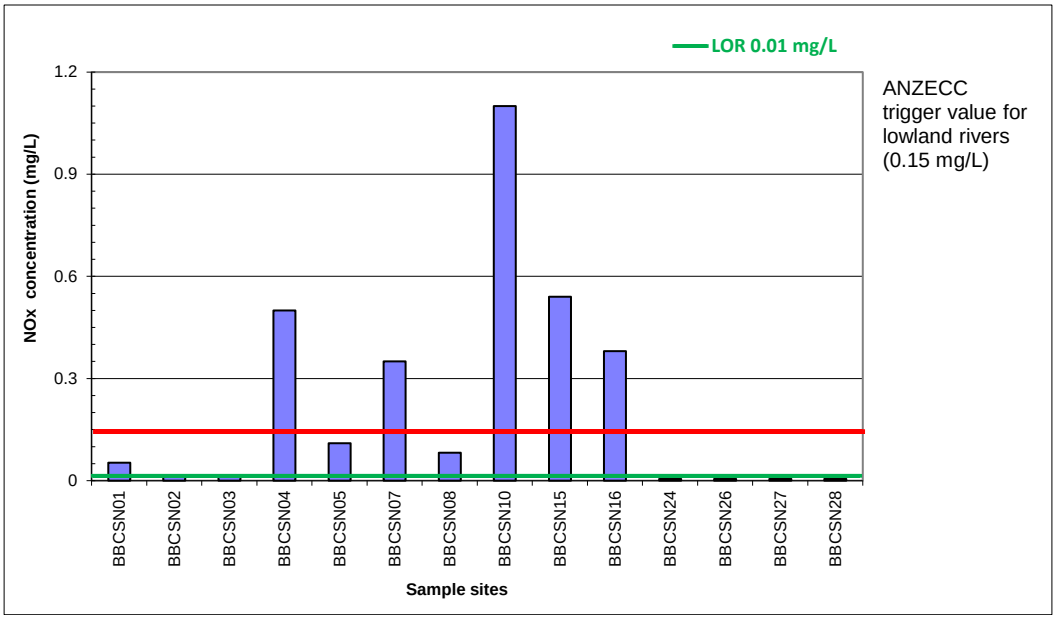

Figure 10: Total oxidised nitrogen concentration in the Bennett Brook catchment

In 2010, 40% of the TN recorded at site 10 was in the form of total oxidised nitrogen (TON) and 55 as nitrogen in the form of ammonia/ammonium. TON includes nitrate and nitrite, which are commonly found in fertilisers. This site is downstream of a heavily urbanised area and the over-use of fertiliser on gardens or previous historical land uses may be possible sources. Sites 15 and 16 recorded TON concentrations above the trigger value in all the years, except for 2007.

Phosphorus

Total Phosphorus (TP) is a measure of all phosphorus in the water including the bio-available, soluble, particulate forms and the unavailable (but potentially available) forms of phosphorus. Sources of phosphorus include fertilisers, plant debris, detergents, industrial wastes and lubricants (IEA 2003).

The concentrations of TP across the catchment were varied but only 1 site out of 14 recorded a concentration above the trigger value of 0.065 mg/L. Site 24 (RSPCA compensating basin) recorded 0.086 mg/L.

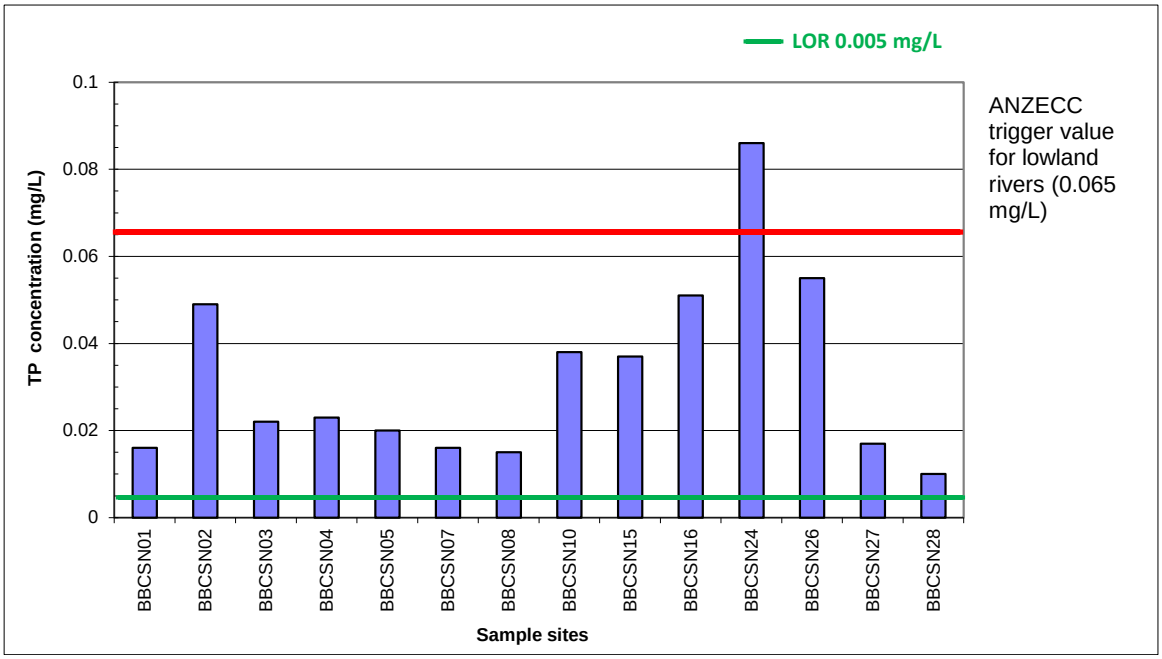

Figure 11: Total phosphorus concentrations in surface water of the Bennett Brook catchment

Table 6 shows the sites that have recorded TP concentrations above the trigger value during the 9-year snapshot sampling period since 2002. Sites 9, 12, 14, and 17 were not included in the 2010 snapshot due to lack of water. However, site 17 has recorded TP concentrations above the ANZECC trigger value every year since 2005. The filtering effect of the new fringing vegetation after the revegetation work occurred in Horse Swamp in 2006 may be the reason for the reduction of TP in 2007 (to 0.068 mg/L); however, it seems the elevated levels of TP may be an ongoing trend. The TP concentration at site 14 has exceeded the ANZECC trigger value each year samples have been taken, always exceeding the trigger value and being far greater than the concentration recorded at any other site. These results suggest an ongoing source of TP in the vicinity. A similar situation exists at site 15; even though it did not record a TP concentration above the trigger value in the 2010 and 2004 snapshots, and this is most likely a result of TP enriched water being received from upstream sites (17 and 14).

Table 6: Sites recording TP concentrations above the trigger value in the Bennett Brook Catchment 2002 – 2010

Site number	2010	2009	2008	2007	2006	2005	2004	2003	2002
BBCSN09	NS	N	N	N	N	N	NS	**0.078**	N
BBCSN10	N	N	N	N	**0.073**	**0.086**	**0.067**	N	N
BBCSN12	NS	**0.084**	N	N	N	N	NS	N	N
BBCSN14	NS	**0.32**	**0.6**	**0.39**	**0.46**	**0.25**	NS	NS	**0.6**
BBCSN15	N	**0.08**	**0.093**	**0.069**	**0.071**	**0.088**	N	**0.076**	**0.085**
BBCSN16	N	N	**0.094**	**0.086**	N	N	N	**0.067**	N
BBCSN17	NS	**0.19**	**0.32**	**0.068**	**0.48**	**0.17**	NS	NS	NS
BBCSN24	**0.086**	N	**0.083**	N	NS	NS	NS	NS	NS

N= concentration was not above trigger value

NS= no sample was taken in this site

Soluble Reactive Phosphorus (SRP) measures only the dissolved phosphorus in water and provides a measure of the immediately available phosphate in the system at the time of sampling. SRP is readily available for plant uptake and as such is attributed to algal blooms of rapid growth in aquatic flora.

In the 2010 snapshot SRP concentrations at all sampled sites were below the ANZECC trigger value for lowland rivers (0.04 mg/L).

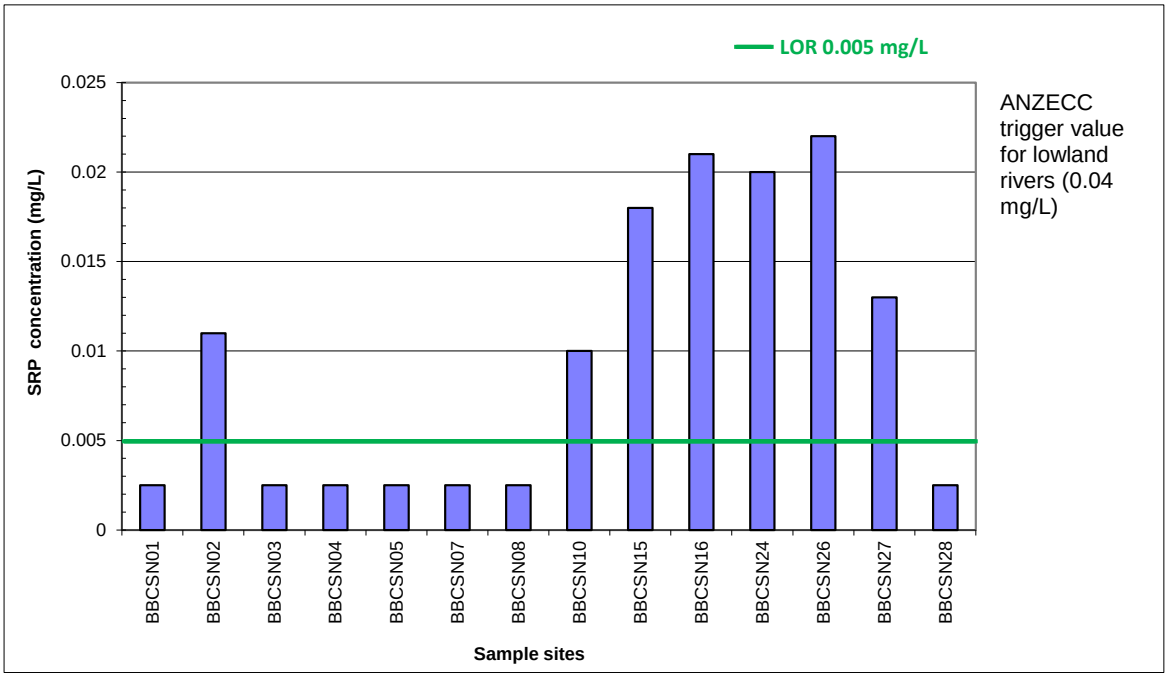

Figure 12: Total phosphorus concentrations in surface water of the Bennett Brook catchment

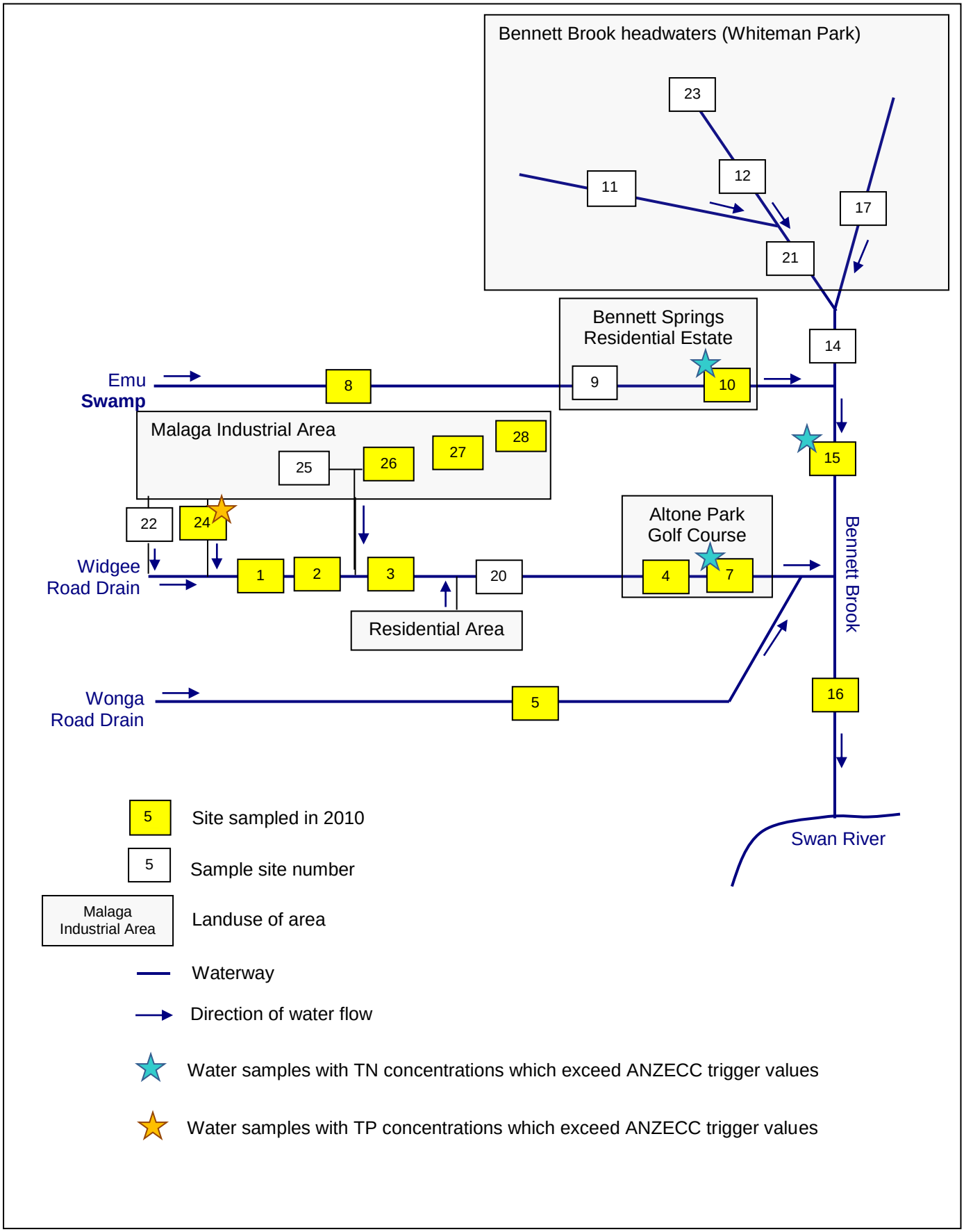

Figure 13: Total nitrogen and total phosphorus concentrations in water samples which exceeded ANZECC trigger values

Water hardness

Total hardness, expressed as calcium carbonate (CaC03), is the combined concentration of earth-alkali metals, predominantly magnesium (Mg2+) and calcium (Ca2+), and some strontium (Sr2+) in the water. The source of this hardness is limestone dissolved by water that is rich in carbon dioxide. Hardness levels range from <60mg/L being very soft to >400 mg/L being extremely hard.

Water hardness can have an effect on trigger values for particular metals concentrations such as copper, cadmium, zinc, lead, nickel and chromium. Water samples with higher concentrations of water hardness need to have the trigger values for these metals amended by a certain multiplication factor, as recommended in ANZECC (2000) guidelines. As water hardness is variable between sites, the trigger values for these particular heavy metals can be different for each site. Trigger values for these metals have been corrected based on the concentration of water hardness for each site, using the hardness-dependant algorithm provided in ANZECC and ARMCANZ (2000).

In the 2010 snapshot sampling 13 out 14 sites recorded moderate water hardness (60 to 119 mg/L) and only 1 was hard (120 to 179 mg/L).

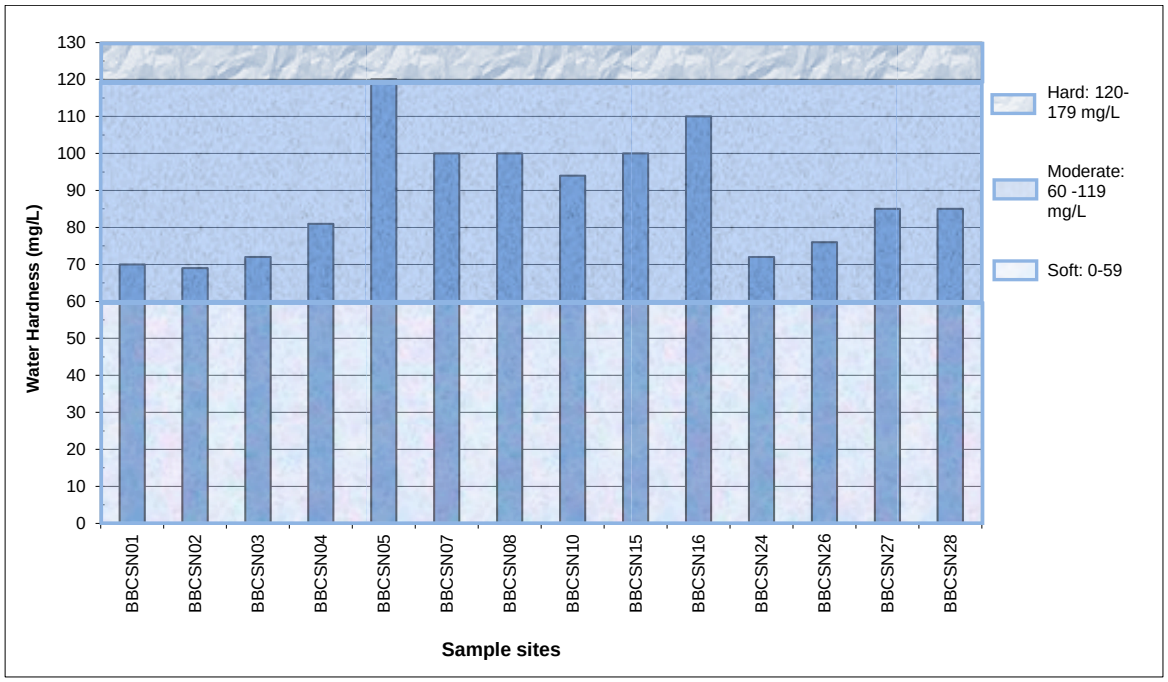

Figure 14: Water Hardness in surface water of the Bennett Brook catchment

Metals in water (soluble)

Metals are derived from a variety of sources such as motor vehicles, tyres, rubber, industrial waste, fertilisers and pesticides, refuse leachate and corrosion of pipes and roofs. Some of these metals are toxic to aquatic organisms at varying concentrations and may accumulate in animals and in the human body (IEA 2003).

The concentrations of arsenic, cadmium, cobalt, chromium, mercury and selenium were equal or below the laboratory limit of reporting (LOR) at all sites throughout the Bennett Brook catchment. The metals which recorded concentrations above the LOR and close to their ANZECC trigger values at any site or had isolated spikes of concentrations are discussed below. Refer to Appendix 2 for the Bennett Brook 2010 snapshot data for metals in water samples.

For all graphs, a value equal to half the limit of reporting was substituted for those occasions where concentrations were recorded as 'below the laboratory limit of reporting' which is a standard technique to allow these 'unknown' values to be represented graphically.

Table 7 shows the sites that have recorded metals concentrations above the trigger value for the whole snapshot sampling period (2002-2010). It is difficult to analyse and compare the results found along the 9-year sampling period because of the difference in flows from one year to the next, frequently sites cannot be sampled due of lack of water flowing or there may be disconnection between pools. Also the periodicity of the sampling (only once a year) makes more difficult to have truly representative data to allow a more detailed analysis.

Aluminium

Aluminium is toxic to aquatic organisms and its toxicity increases as pH decreases (Australian Government 2006). Aluminium may be present in water through natural leaching from soil and rock, and is increased in soluble groundwater concentrations under acidic conditions and therefore it is strongly linked to Acid Sulphate Soils activity (ASS).

The ANZECC trigger value for aluminium is 0.055 mg/L but is only applicable when the pH is greater than 6.5. The aluminium concentration in the surface waters of the Bennett Brook catchment were elevated, with all 14 sites exceeding the ANZECC trigger value of 0.055 mg/L. 4 sites also exceeded the ANZECC recreational trigger value of 0.2 mg/L. All recorded aluminium concentrations are valid in 2010 since all sites recorded pH values greater than 6.5.

The cause (or causes) of the wide-spread elevated aluminium concentrations is currently unknown, but may be attributed to an accumulation of the natural release of aluminium from sediment, as it is a commonly occurring metallic element naturally, as well as possible contaminants flowing in from areas of industrial zone and historical land uses; these possible sources vary between sites throughout the catchment.

The highest concentrations of aluminium were recorded at sites 7, 4 and 10 (Altone Park Golf Course, Madeira Ave - Altone Park and Emu Swamp drain exit) with concentrations of 0.38, 0.34 and 0.22 mg/L respectively. Concentrations exceeding the trigger value have been recorded in sites 4, 7, 10, 15 and 16 since 2006, when this parameter was first included in the sampling and analysis plan (SAP). See table 7 for more details.

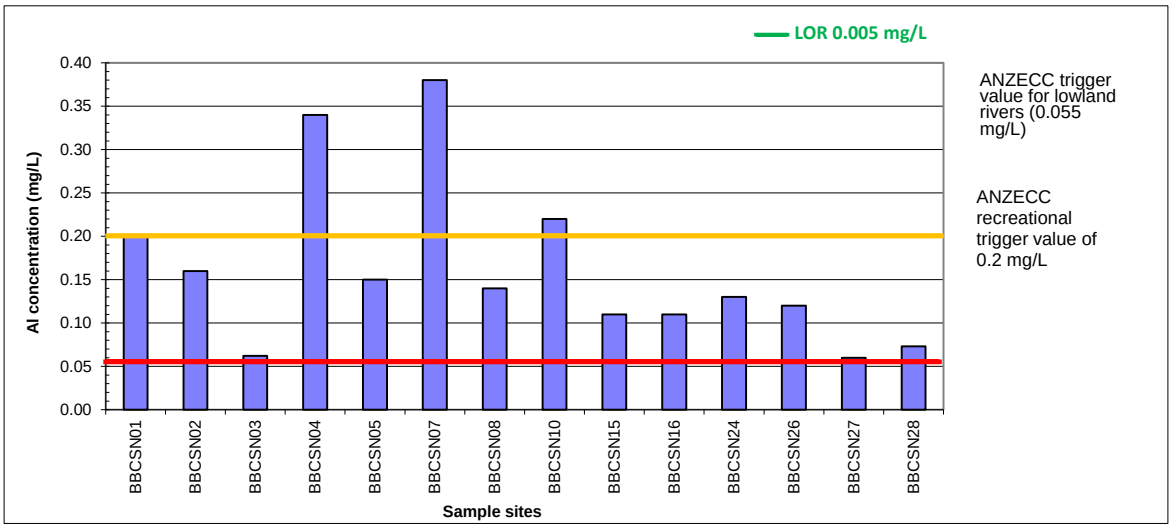

Figure 15: Aluminium concentrations in surface water of the Bennett Brook catchment

Copper

Copper is commonly found as the Cu^{2+} ion in natural waters, and this ion is potentially very toxic to aquatic life, both acutely and chronically (Australian Government 2006), and is quickly accumulated in both plants and animals (IEA 2003). The toxicity of copper greatly increases with decreasing water hardness and dissolved oxygen concentrations (Australian Government 2006). Sources of copper include wear of vehicle tyres and brake pads, metal industry and domestic products, corrosion of brass and copper pipes, sewage treatment plant effluent, electroplating wastes, pesticides, fungicides, algaecides and brake lining.

The trigger values for copper are affected by water hardness. Therefore the trigger values shown on the graph vary depending on the water hardness recorded at each site. The concentrations at sites 2, 26 and 27 (Lightning Swamp – drain downstream, Glyde Court compensation basin outfall and Compensation basin outfall at Victoria Rd and Cogla St respectively) were above the specific adjusted ANZECC trigger value for each site. This apparent source of copper contamination in the Malaga industrial area is of concern due to the potential for downstream flow of copper enriched water and its possible effects on the ecology of Lightning swamp. These 3 sites recorded also concentrations above the adjusted trigger value in the 2009 snapshot sampling (see table 7).

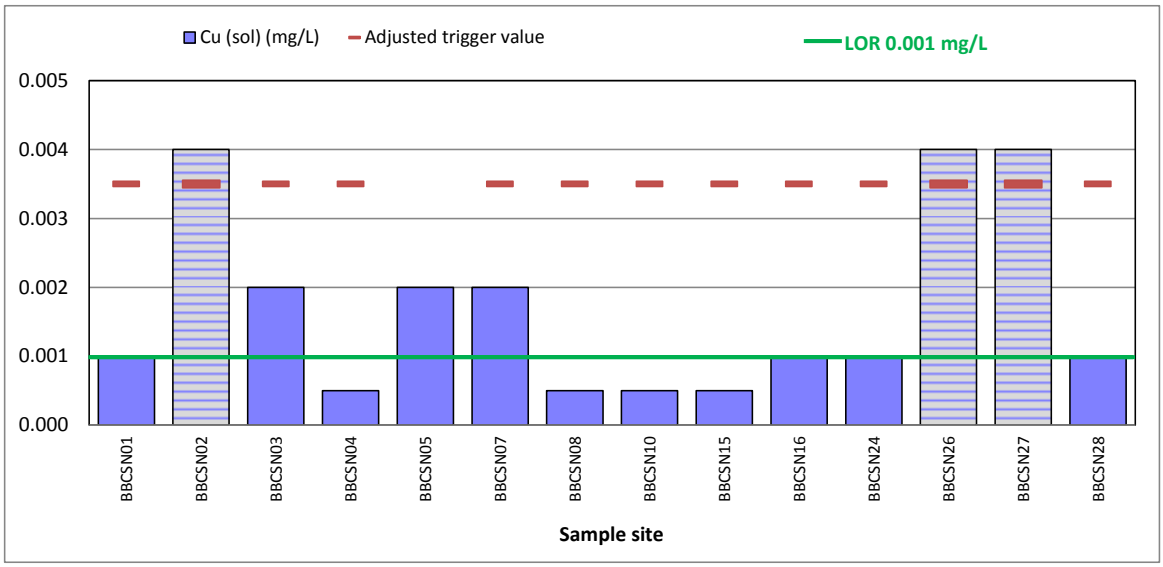

Figure 16: Copper concentrations in the surface waters of the Bennett Brook catchment

Lead

Lead is a cumulative general metabolic poison which bio-accumulates in animals, plants and bacteria and is highly poisonous to both plants and animals. Lead persists in the environment for long periods and does not readily breakdown (Australian Government 2006). The main source of lead in urban runoff is from oil leakage, dry atmospheric deposition (Allen Davis et al. 2001) and legacy of past land uses leading to a build-up of lead in urban soil over the years (De Miguel et al. 1998).

The trigger values for lead are affected by water hardness. Therefore the trigger values shown on the graph are variable, depending on the water hardness recorded at each site. Most sites recorded concentrations below or equal to the limit of reporting (0.001 mg/L), the exception was site 24 which recorded 0.002 mg/L (RSPCA basin) but was still below the ANZECC adjusted trigger value for the site.

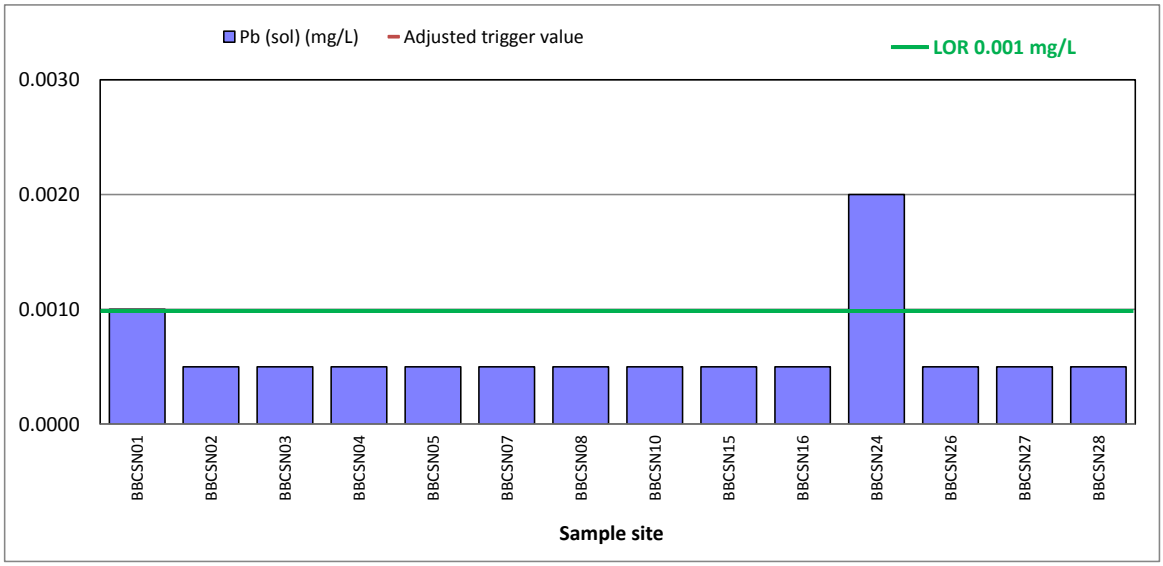

Figure 17: Lead concentrations in the surface waters of the Bennett Brook catchment

Iron

Iron may be present in natural waters in varying quantities depending upon the geology of the area and the chemical components of the waterway (ANZECC & ARMCANZ 2000). Iron is generally present in the ferrous (Fe^{2+}) or ferric (Fe^{3+}) states. In surface waters iron is generally present in the ferric state, in reducing waters the ferrous form can persist (ANZECC & ARMCANZ 2000). In the presence of oxygen, iron is often found as colloidal suspensions of ferric hydroxide, which may remain suspended in water or settle onto sediments and aquatic plants, which can cause problems with turbidity, decreased light penetration and smothering of benthic organisms (ANZECC & ARMCANZ 2000).

9 out of 14 sites in the surface waters of the Bennett Brook catchment recorded iron concentrations above the ANZECC recreational guideline of 0.3 mg/L. The highest concentration of 1.2 mg/L was recorded at sites 7 and 16 (Altone Park Golf Course and Clarry Small Park).

This is the fifth year iron has been included in the program and since then sites 5, 7, 10, 15 and 16 (Altone Road – Optus, Altone Park Golf Course, Emu Swamp drain exit, Patricia Close and Clarry Small Park, respectively) have recorded concentrations above the trigger value. Iron concentrations from sites exceeding the trigger value in 2010, and in previous years sampling, is presented in table 7.

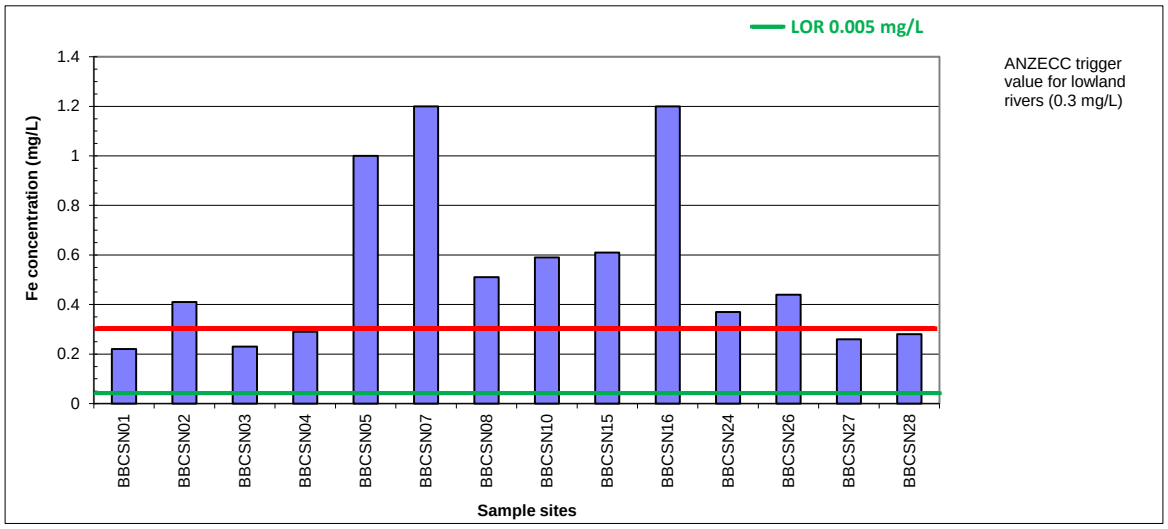

Figure 18: Iron concentrations in the surface waters of the Bennett Brook catchment

Manganese

Manganese is commonly associated with dissolved ferrous iron and is a naturally occurring constituent of groundwater (Department of Environment 2004). Other sources of manganese to waterways include agricultural and gardening applications, alkaline and dry cell batteries, some fertilisers and some disinfectants.

Manganese concentrations throughout the surface waters of the Bennett Brook catchment were below the ANZECC trigger value of 1.9 mg/L at all sites. The highest concentration (0.13 mg/L) was recorded at site 24 (RSPCA compensating basin) and the lowest (<0.001 mg/L, below limit of report) at site 28 (Comp basin outfall at Cogla St and Mulgul Rd).

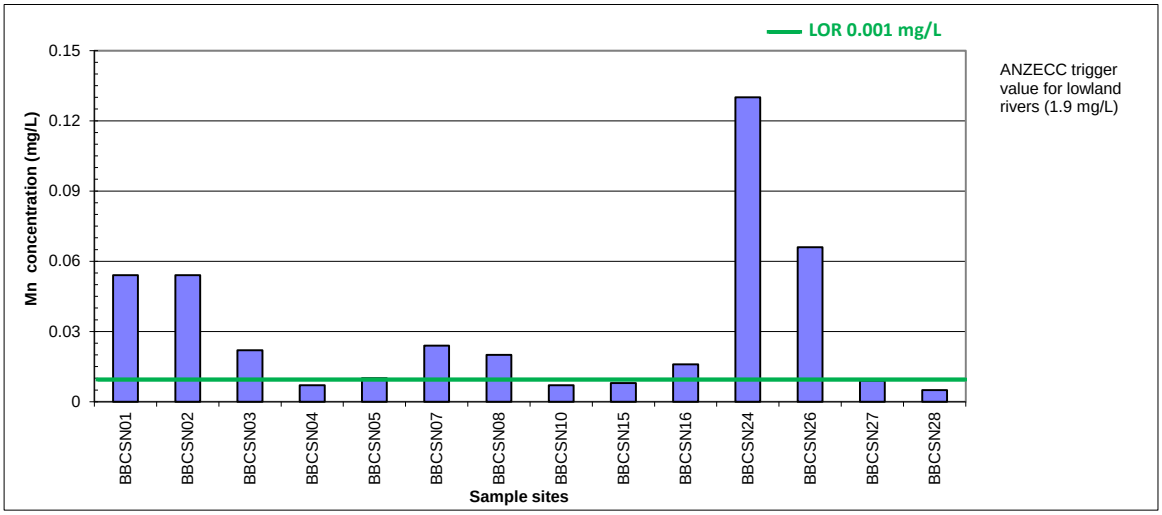

Figure 19: Manganese concentrations in the surface waters of the Bennett Brook catchment

Molybdenum

Molybdenum is used in the manufacture of specialty steel products and electrical apparatus and its compounds are used in the manufacture of glass, ceramics, fertilisers and pigments (ANZECC & ARMCANZ 2000).

The majority (11 out 14 sites) recorded undetectable concentrations of molybdenum (<0.001 mg/L) and only 3 sites recorded concentrations above the limit of reporting. These were sites 2, 24 and 26 (Lightning Swamp – drain downstream, RSPCA compensating basin and Glyde Court comp basin outfall) with concentrations of 0.002, 0.003 and 0.003 mg/L respectively.

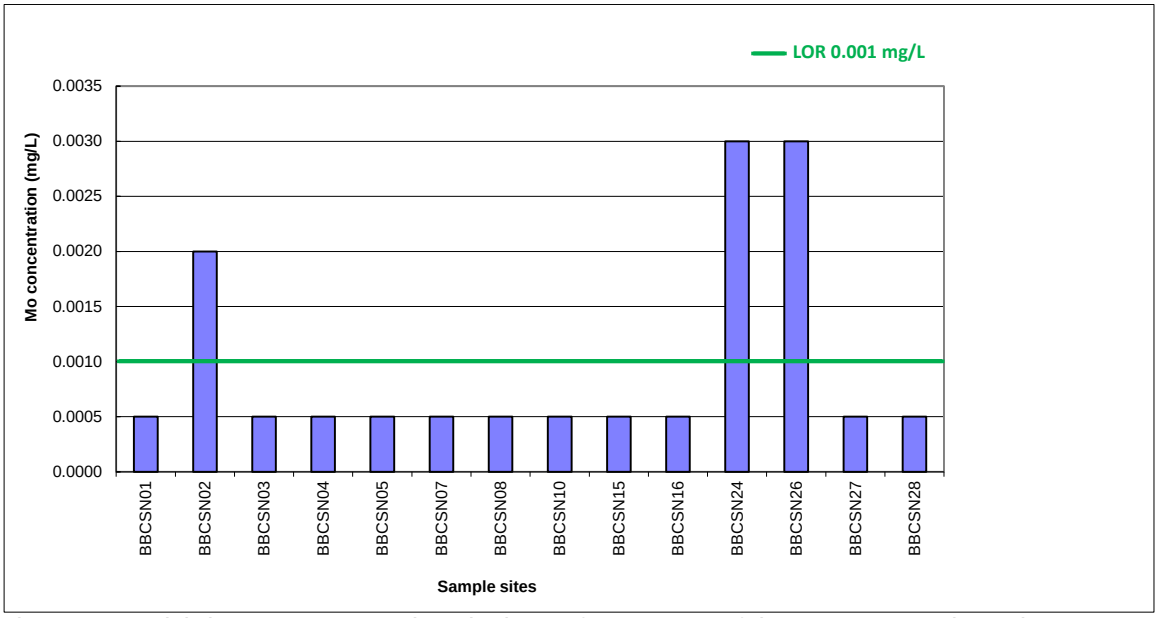

Figure 20: Molybdenum concentrations in the surface waters of the Bennett Brook catchment

Nickel

Nickel is relatively non-toxic and there is little evidence of bio-accumulation. Nickel in storm water is usually associated with suspended solids and organic matter (IEA 2003). Sources of nickel include corrosion of welded metal plating, wear of moving parts in engines, electroplating and alloy manufacture, and food production equipment (IEA 2003).

The trigger values for nickel are affected by water hardness. Therefore the trigger values shown on the graph are variable, depending on the water hardness recorded at each site. 6 out of 14 sites in the surface waters of the Bennett Brook catchment recorded nickel concentrations below of the limit of reporting (<0.005 mg/L) and all samples recorded concentrations below the specific adjusted trigger value for each site.

The highest concentrations were recorded at sites 26 and 22 (Glyde Court comp basin outfall and Lightning Swamp – drain downstream), recording 0.005 mg/l and 0.004 mg/L respectively. Storm water from this land use could potentially be a source of the nickel detected at these sites.

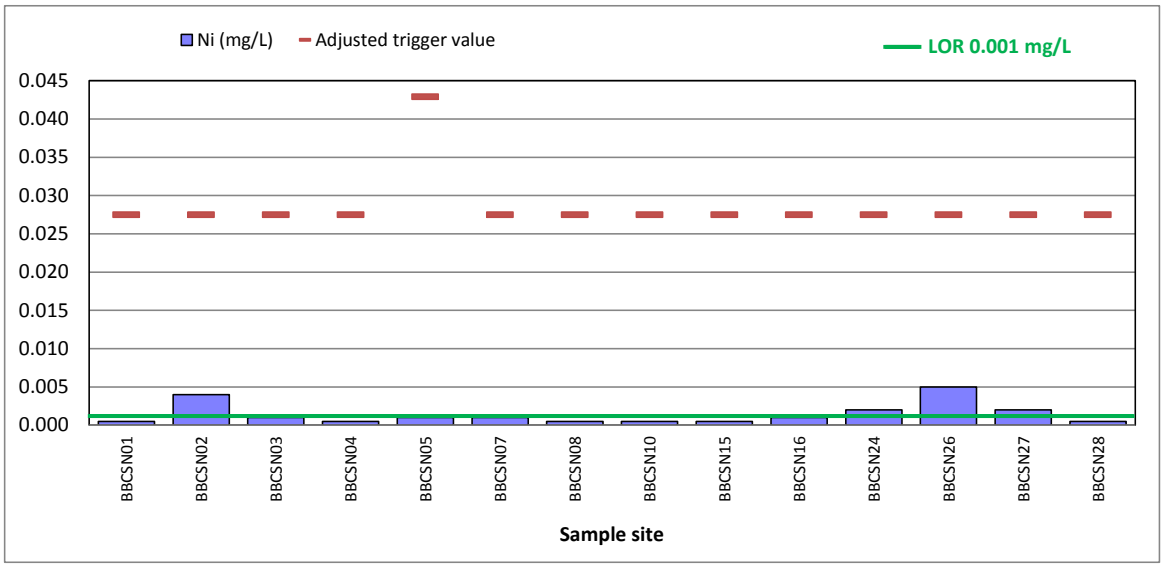

Figure 21: Nickel concentrations in the surface waters of the Bennett Brook catchment

Table 7: Sites recording heavy metals concentrations in water above the trigger value in the Bennett Brook Catchment 2002 - 2010

Site number	Metal (mg/L)	2010	2009	2008	2007	2006	2005	2004	2003	2002
BBCSN01	Al	0.2	0.079	0.098	NA	0.095	NS	NS	NS	NS
	Cu	N	0.002	N	N	UN	UN	NS	NS	NS
	Zn	0.023	0.034	N	N	0.02	N	NS	NS	NS
BBCSN02	Al	0.16	0.067	N	0.092	0.093	NS	NS	NS	NS
	Fe	0.41	N	0.39	N	N	NS	NS	NS	NS
	Cu	0.004	0.002	N	N	UN	UN	UN	N	UN
	Zn	N	0.036	N	N	0.019	0.033	0.012	0.012	UN
BBCSN03	Al	0.062	0.061	N	0.078	0.079	NS	NS	NS	NS
	Cu	N	0.002	N	N	UN	UN	UN	N	UN
	Ni	N	N	N	N	N	N	0.15	N	UN
	Zn	N	0.05	N	0.022	0.034	0.055	0.016	0.013	UN
BBCSN04	Al	0.34	0.24	0.28	0.4	0.48	NS	NS	NS	NS
	Fe	N	N	0.81	0.64	N	NS	NS	NS	NS
	Zn	N	0.029	N	N	N	0.025	N	N	UN
BBCSN05	Al	0.15	0.33	0.17	NA	0.2	NS	NS	NS	NS
	Fe	1	1.3	1.1	2.7	0.7	NS	NS	NS	NS
	Zn	N	0.027	N	N	N	N	N	N	UN
BBCSN07	Al	0.38	0.18	0.22	0.39	0.43	NS	NS	NS	NS
	Fe	1.2	0.4	0.76	1.2	1.3	NS	NS	NS	NS
	Zn	0.021	0.025	N	N	N	0.025	N	N	UN
BBCSN08	Al	0.14	NA	0.15	NA	NA	NS	NS	NS	NS
	Fe	0.51	0.6	N	0.69	0.51	NS	NS	NS	NS
	Cr	N	N	N	0.002	UN	UN	UN	UN	UN
	Zn	N	N	N	N	0.022	N	N	N	UN
BBCSN09	Al	NS	0.14	0.091	0.087	0.13	NS	NS	NS	NS
	Fe	NS	N	N	N	0.32	NS	NS	NS	NS
	Zn	NS	N	N	N	0.02	N	NS	N	UN
BBCSN10	Al	0.22	0.18	0.15	0.33	0.27	NS	NS	NS	NS
	Fe	0.59	0.51	0.51	0.76	0.64	NS	NS	NS	NS
BBCSN11	Fe	NS	3.3	19	3.7	NS	NS	NS	NS	NS
BBCSN12	Fe	NS	2.1	2.2	1.6	0.61	NS	NS	NS	NS
	Cr	N	N	N	0.003	UN	UN	UN	UN	UN
BBCSN14	Al	NS	0.36	NA	NA	0.29	NS	NS	NS	NS
	Fe	NS	4	5.8	N	6.2	NS	NS	NS	NS
BBCSN15	Al	0.11	0.16	0.17	0.16	0.18	NS	NS	NS	NS
	Fe	0.61	0.96	1.1	0.85	0.99	NS	NS	NS	NS
BBCSN16	Al	0.11	0.19	0.14	0.16	0.17	NS	NS	NS	NS
	Fe	1.2	0.97	1	0.99	0.94	NS	NS	NS	NS
BBCSN17	Al	NS	0.097	0.083	0.054	0.022	NS	NS	NS	NS
	Fe	NS	2	3.9	2.3	2.1	NS	NS	NS	NS
BBCSN20	Al	NS	N	0.071	NS	NS	NS	NS	NS	NS
	Cu	NS	0.002	N	NS	NS	NS	NS	NS	NS
	Zn	NS	0.048	N	NS	NS	NS	NS	NS	NS
BBCSN21	Al	NS	NA	NA	NA	0.066	NS	NS	NS	NS
	Fe	NS	2.2	3.4	1.8	1.2	NS	NS	NS	NS
	Zn	NS	N	0.042	N	N	N	NS	NS	NS
BBCSN22	Al	NS	N	N	0.026	0.089	NS	NS	NS	NS
	Fe	NS	N	0.33	1.3	0.32	NS	NS	NS	NS
	Zn	NS	0.016	N	N	0.017	0.13	NS	NS	NS
BBCSN23	Fe	NS	32	25	29	17	NS	NS	NS	NS
BBCSN24	Al	0.13	N	0.087	0.13	NS	NS	NS	NS	NS
	Fe	0.37	N	0.63	0.4	NS	NS	NS	NS	NS
	Cu	N	0.002	N	N	NS	NS	NS	NS	NS
	Zn	N	0.041	N	N	NS	NS	NS	NS	NS
BBCSN25	Fe	NS	1.2	NS	NS	NS	NS	NS	NS	NS
	Cu	NS	0.015	NS	NS	NS	NS	NS	NS	NS
	Pb	NS	0.006	NS	NS	NS	NS	NS	NS	NS
	Zn	NS	0.33	NS	NS	NS	NS	NS	NS	NS
BBCSN26	Al	0.12	N	NS	NS	NS	NS	NS	NS	NS
	Fe	0.44	0.33	NS	NS	NS	NS	NS	NS	NS
	Cu	0.004	0.004	NS	NS	NS	NS	NS	NS	NS
	Zn		0.062	NS	NS	NS	NS	NS	NS	NS
BBCSN27	Al	0.06	N	NS	NS	NS	NS	NS	NS	NS
	Cu	0.004	0.004	NS	NS	NS	NS	NS	NS	NS
	Zn	N	0.058	NS	NS	NS	NS	NS	NS	NS
BBCSN28	Al	0.073	N	NS	NS	NS	NS	NS	NS	NS
	Cu	N	0.01	NS	NS	NS	NS	NS	NS	NS
	Zn	N	0.12	NS	NS	NS	NS	NS	NS	NS

Notes:

N= concentration was not above trigger value (TV)

NS= a sample was not taken at this site or parameter was not included

NA= TV for Al was not applicable pH<6.5

UN= Unable to make comparison some years because the requested LOR was above or equal to the trigger values, so comparison was not possible

Cd: LOR requested 0.002 mg/L, TV=0.0002 mg/L

Co: LOR requested 0.005 mg/L, TV =0.001 mg/L

Cr: LOR requested 0.005 mg/L, TV =0.001 mg/L

Cu: LOR requested 0.005 mg/L, TV =0.0014 mg/L

Pb: LOR requested 0.01 mg/L, TV = 0.0034 mg/L

Water Hardness: was not requested in 2002

Zinc

Zinc bio-accumulates easily in plants and animals and is mostly associated with dissolved solids, although it will adsorb to suspended particles. Sources of zinc in storm water include wear from tyres and brake pads, combustion of lubricating oils, and corrosion of galvanised roofs, pipes and other metal objects (IEA 2003).

All concentrations of zinc in the surface waters of the Bennett Brook catchment were above the limit of reporting of 0.001mg/L, but only two sites recorded concentrations above the site specific adjusted ANZECC trigger value (sites 1 and 7).

Sites 1 and 7 (Malaga Drive – Ivory St and Altone Park Golf Course) recorded 0.23 and 0.21 mg/L respectively, exceeding the specific adjusted ANZECC trigger value. This is of concern due to the potential for downstream flow to transport zinc and the possible effects on the ecology of Lightning Swamp. Concentrations above the specific adjusted trigger value were also found at these 2 sites in the 2009 snapshot, when concentrations of 0.034 and 0.025 mg/L respectively were recorded (see table 7 for more details).

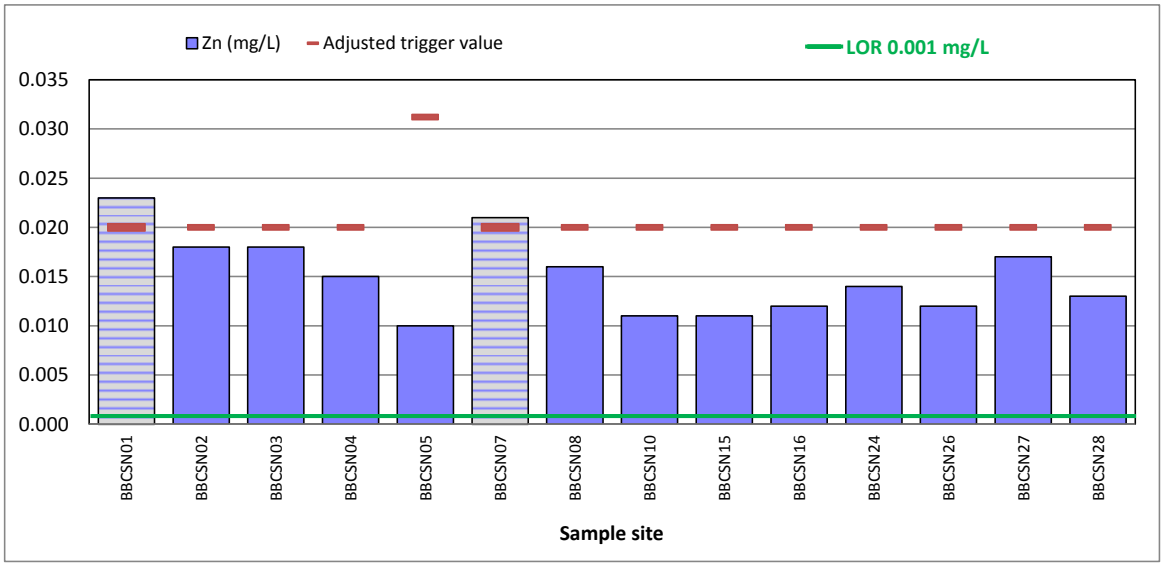

Figure 22: Zinc concentrations in the surface waters of the Bennett Brook catchment

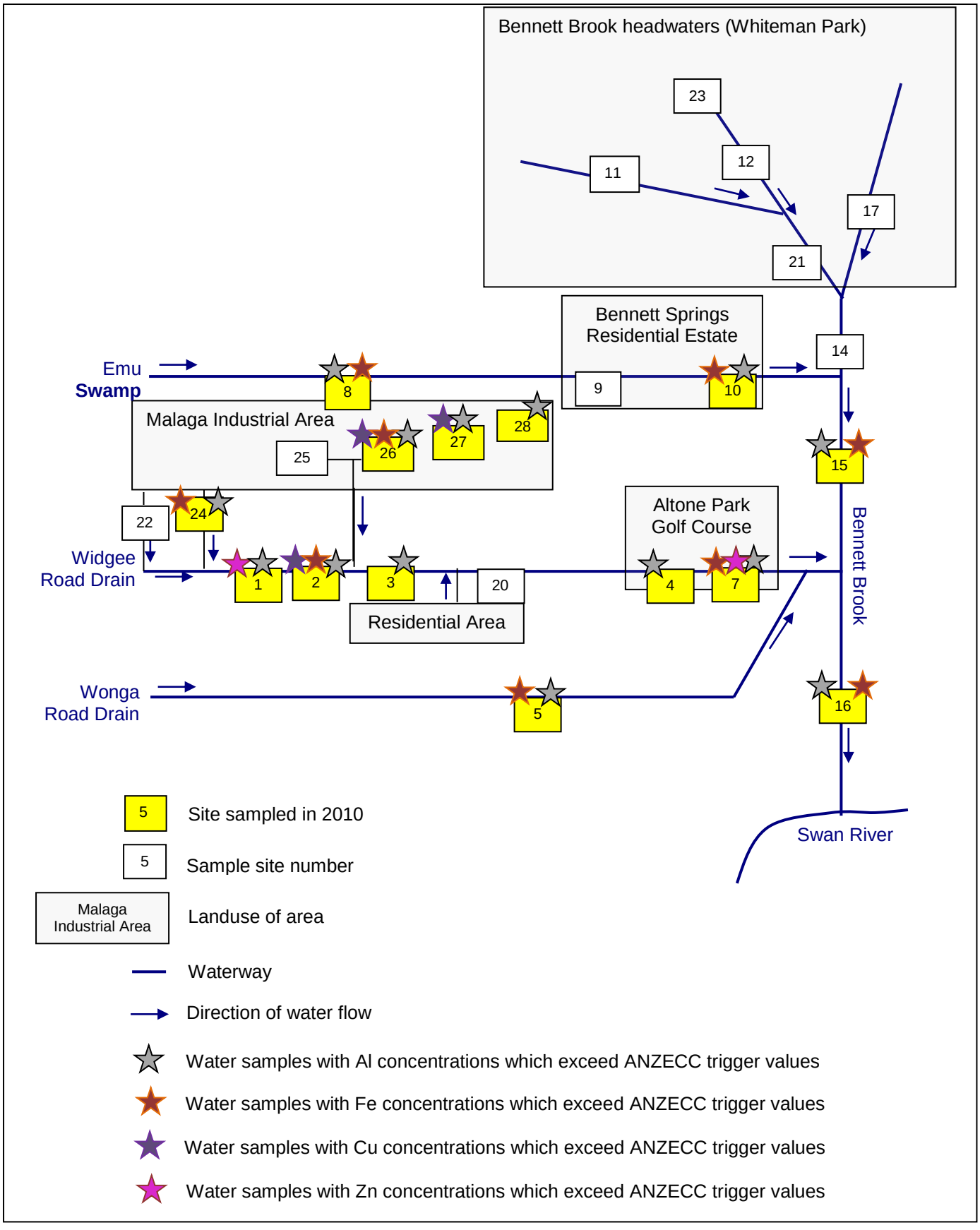

Figure 23: Metals concentrations in water samples which exceeded ANZECC trigger values

Metals in sediments

Sediment quality influences the nature of overlying waters through physical, chemical and biological processes. Sediments play a major role in the transport and storage of contaminants, they are therefore important in the identification of contaminant sources and determining dispersion pathways. Sediments also provide an important habitat for animals and are a food source for many species. Sediment quality thus determines, to a large degree, biodiversity and ecological health in aquatic systems.

Contaminants can become 'locked' into the sediments by adhering to the surface of the soil particles, where they can be stored for long periods. The capacity of sediments to remove contaminants from the overlying water depends on the type of soil and how 'full' it already is. Changes in the overlying water quality (particularly DO, pH and temperature) can promote the release of the toxicants that are stored in the sediments back into the water column. Additionally, changes in these physical parameters may increase the toxicity of certain contaminants, particularly metals. Areas with elevated concentrations of toxicants stored in the sediments may be a result of high toxicant concentrations in the overlying water (either recently or in the past) or as a result of past land uses.

Concentrations of metals varied spatially throughout the Bennett Brook catchment with most sites being below ANZECC low trigger values for all metals, with the exception of site 28 (comp basin outfall at Cogla St and Mulgul Rd) and site 4 (Madeira Ave – Altone Park) which exceeded nickel and lead trigger values respectively. Site 28 recorded 53 mg/Kg exceeding the ANZECC higher trigger value of 52 mg/Kg for nickel. Site 4 recorded 58 mg/Kg exceeding the ANZECC lower trigger value of 50 mg/Kg for lead. In 2009 site 28 recorded concentrations exceeding the specific trigger values for nickel, arsenic, chromium, copper, mercury and zinc. Site 4 also recorded a lead concentration above the trigger value in 2009.

Refer to Appendix 3 for metal concentration results from the sediments of the Bennett Brook catchment in 2010; metals which recorded concentrations above the LOR at any site are discussed below; therefore cadmium, mercury and selenium are not discussed.

As for the graphs for metals in water, a value equal to half the limit of reporting was substituted for those occasions where concentrations were recorded as 'below the laboratory limit of reporting'.

Table 8 shows the sites that have recorded metals concentrations above the trigger value throughout the snapshot sampling period (2002-2010). It is difficult to analyse and compare the results found during the 9-year sampling period because of the variation in flows from one year to the next (sites frequently cannot be sampled due of lack of water flowing or disconnection between pools). In some cases due the nature of the substrate (rock, gravel), it has not been possible to collect sediment samples at some sites. Additionally, the periodicity of the sampling (once a year), makes more difficult to have sufficient temporal coverage to perform a more detailed analysis with any degree of certainty.

Aluminium

No guideline currently exists for aluminium concentrations in sediments; therefore, it is difficult to gauge the severity of any potential impact arising from the concentrations recorded in the sediments of the Bennett Brook catchment, in terms of human and ecosystem health.

Concentrations were varied across the catchment area, with the highest concentrations being recorded at sites 4, 28 and 27 (Madeira Ave – Altone Park, Comp basin outfall at Cogla St and Mulgul Rd and Comp basin outfall at Victoria Rd and Cogla St) with 3,690, 2,100 and 1,610 mg/Kg respectively.

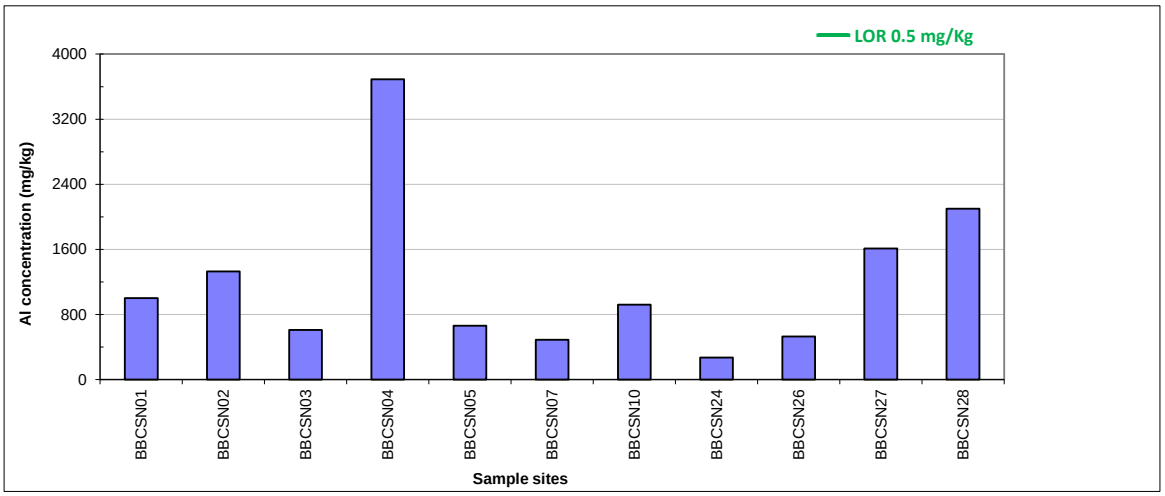

Figure 24: Aluminium concentrations in the sediments of the Bennett Brook catchment

Table 8: Sites recording heavy metals concentrations in sediments above the trigger value in the Bennett Brook Catchment 2002 - 2010

Site number	Metal (mg/Kg)	2010	2009	2008	2007	2006	2005	2004	2003	2002
BBCSN01	Pb	NO	**110**	NO	**92**	NO	NO	NO	NO	NO
	Zn	NO	**290**	NO	**220**	NO	NO	NO	NO	NO
BBCSN04	Pb	**58**	**55**	NO	NO	NO	NO	NO	NO	NO
BBCSN11	Pb	NS	NO	**55**	NO	NS	NO	NO	NO	NO
BBCSN14	As	NS	**25**	**81**	NO	NO	NO	NO	NO	NO
BBCSN16	As	NS	NO	**22**	NO	NO	NO	NO	NO	NO
	Hg	NS	UN	**0.2**	**UN**	NO	NO	NO	UN	UN
	Ni	NS	**170**	NO	NO	NO	NO	NO	NO	NO
	Pb	NS	**95**	**260**	NO	**90**	NO	NO	NO	NO
	Zn	NS	**230**	**380**	NO	NO	NO	NO	NO	NO
BBCSN22	Cd	NS	NO	NO	**22**	NO	NO	NO	NO	NO
	Cr	NS	NO	**97**	**89**	NO	NO	NO	NO	NO
	Cu	NS	NO	**170**	**190**	NO	NO	NO	NO	NO
	Hg	NS	UN	**0.42**	**0.36**	NO	NO	NO	UN	UN
	Ni	NS	NO	**36**	**36**	NO	NO	NO	NO	NO
	Pb	NS	**53**	**250**	**790**	**120**	NO	NO	NO	NO
	Zn	NS	**230**	**1530**	**1860**	NO	NO	NO	NO	NO
BBCSN28	As	NO	**22**	NS	NS	NS	NS	NS	NS	NS
	Cr	NO	**180**	NS	NS	NS	NS	NS	NS	NS
	Cu	NO	**95**	NS	NS	NS	NS	NS	NS	NS
	Hg	UN	**0.2**	NS	NS	NS	NS	NS	NS	NS
	Ni	**53**	**740**	NS	NS	NS	NS	NS	NS	NS
	Zn	NO	**320**	NS	NS	NS	NS	NS	NS	NS

NO= concentration was not above trigger value

NS= no sample was taken in this site or parameter was not included

NA= No applicable pH<6.5

UN= Unable to make comparison because some years the requested LOR was above the trigger value, so comparison is no possible

Hg: LOR requested 0.2 mg/Kg, Trigger value=0.15 mg/Kg

Arsenic

Arsenic concentrations in the sediments of the Bennett Brook catchment were varied. All sites recorded arsenic concentrations below the low trigger value of 20 mg/Kg. 8 out of 11 sites recorded concentrations below the limit of reporting of 0.5 mg/Kg. Sites 4, 28 and 10 (Madeira Ave – Altone Park, Comp basin outfall at Cogla St and Mulgul Rd and Emu Swamp drain exit) recorded the highest concentrations in 2010 of 2.6, 1.9 and 1.0 mg/Kg respectively.

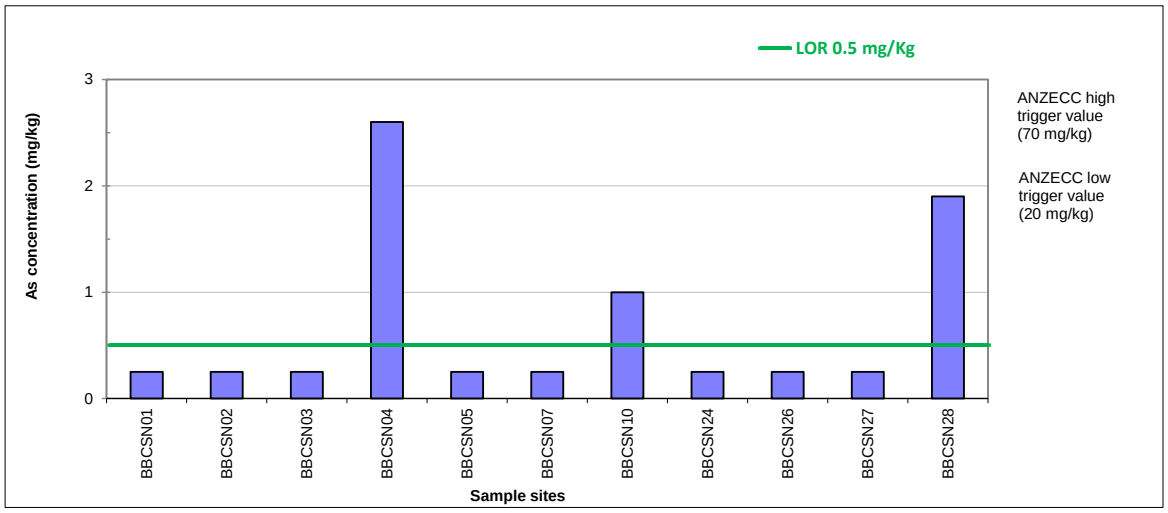

Figure 25: Arsenic concentrations in the sediments of the Bennett Brook catchment

Chromium

9 out of 11 sediments samples in the sediments of the Bennett Brook catchment recorded chromium concentrations above the limit of reporting of 0.5 mg/Kg but below the lower ANZECC trigger value of 80 mg/Kg. the remaining two samples were below the limit of reporting. The highest concentrations were recorded at sites 28 and 4 (comp basin outfall at Cogla St and Mulgul Rd and Madeira Ave – Altone Park) with 17 and 7.9 mg/Kg respectively, both well below the low trigger value; however site 28 (which recorded the highest concentration in 2010) recorded a concentration of 180 mg/Kg in 2009, exceeding the low ANZECC trigger value.

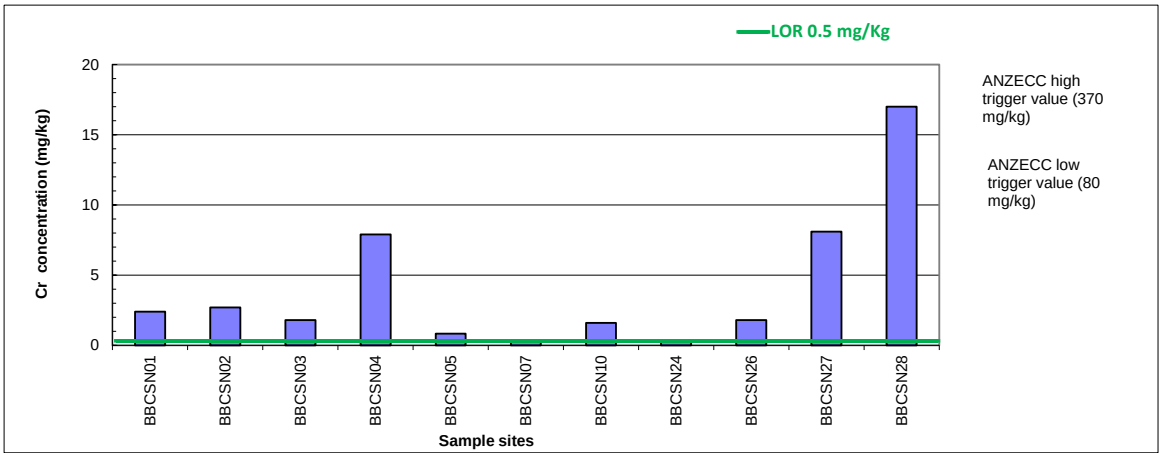

Figure 26: Chromium concentrations in the sediments of the Bennett Brook catchment

Site 28 receives stormwater from the Malaga industrial area (between Malaga Dr, Marshall Rd, Iron Rd and Mulgul Dr) which suggests a business there may be the potential source of the elevated chromium concentration observed in the sediment. The source of the chromium is currently unknown and it is difficult to determine if this is due to recent events or previous land use or it may be temporal variability, illustrated by the difference in concentrations in 2009 and 2010, which cannot be capture adequately with annual snapshot sampling.

Cobalt

Cobalt exists most commonly as Co^{2+} or Co^{3+} ions in water, although other forms are possible. It is adsorbed to suspended particles and sediment but its solubility may be increased by complexion with organic matter, such as from sewage works (ANZECC & ARMCANZ 2000). Cobalt and its compounds are highly persistent in water and the environment. They have an acute (short-term) and chronic (long-term) toxicity on aquatic life, where they can bio-accumulate in the tissues of some aquatic organisms and plants. For humans cobalt can have both beneficial and harmful effects, where small amounts are essential for good health but larger doses can be harmful (Australian Government 2006).

Sources of cobalt include the chemical manufacturing industry (e.g. additives of paint, ceramics, glass, ink, enamels and fertiliser), automotive repair shops (e.g. batteries) and metal industry (in the production of steel and other alloys). Small amounts have also been found in motor vehicle exhausts.

No trigger value or guideline currently exists for cobalt concentrations in sediments. The cobalt concentrations of the sediments of the Bennett Brook catchment were generally low; 9 out of 11 sites recorded concentrations below the detection limit (0.5 mg/kg). The exceptions were sites 28 and 4 (comp basin outfall at Cogla St and Mulgul Rd and Madeira Ave – Altone Park) with 2.1 and 1.3 mg/Kg respectively. In 2009 site 28 recorded the highest concentration (39 mg/kg) in the catchment.

As no current ANZECC trigger value exists for cobalt concentrations in sediments it is difficult to assess the concentrations in terms of threats to human health and the ecosystem. The results suggest continued monitoring to follow any trends and changes in the concentration.

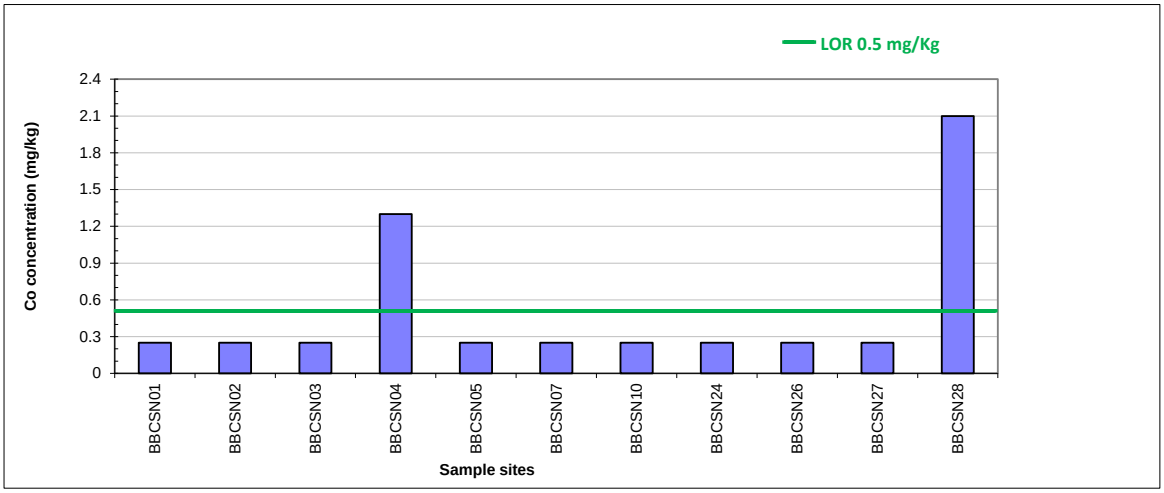

Figure 27: Cobalt concentrations in the sediments of the Bennett Brook catchment

Copper

Copper is commonly found as the Cu^{2+} ion in natural waters, and this ion is potentially very toxic to aquatic life, both acutely and chronically (Australian Government 2006), and is quickly accumulated in both plants and animals (IEA 2003). Sources of copper include wear of vehicle tyres and brake pads, metal industry and domestic products, corrosion of brass and copper pipes, sewage treatment plant effluent, electroplating wastes, pesticides, fungicides, algaecides and brake lining.

Copper concentrations in the sediments of the Bennett Brook catchment were generally low, with the concentrations at all sites being below the ANZECC low trigger value of 65 mg/kg. The highest concentrations were recorded at sites 4 and 28 (Madeira Ave – Altone Park and comp basin outfall at Cogla St and Mulgul Rd) with 18 and 12 mg/Kg respectively.

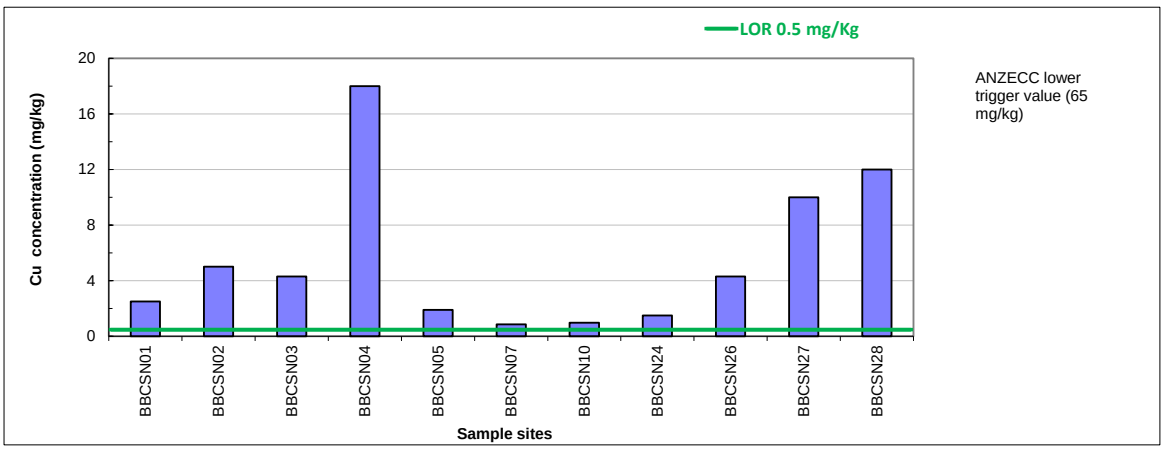

Figure 28: Copper concentrations in the sediments of the Bennett Brook catchment

Lead

The concentration of lead in the sediments of the Bennett Brook catchment was generally low and below the ANZECC low trigger value of 50mg/kg, with the exception of site 4 (Madeira Ave – Altone Park) which recorded 58mg/L. A similar result was recorded in 2009, when a concentration of 55mg/Kg was recorded.

The lead concentration in the sediments at site 1 (inlet to Lightning Swamp) has been varied since the site was first sampled in 2006. After an increase from 2006 to 2007 concentration (21 to 92 mg/kg) a decrease followed in 2008 (47 mg/kg), it went up again in 2009 (110 mg/kg) but in 2010 it decreased (5.2 mg/Kg). The reasons for the observed fluctuations in lead concentrations at site one, as well as the potential sources, is currently unknown.

The cause of the elevated lead concentrations in the sediments at site 4 is currently unknown; therefore, future, and more intensive monitoring is required to determine if this is an ongoing trend or merely a temporal variation which we are unable to ascertain by annual snapshot monitoring.

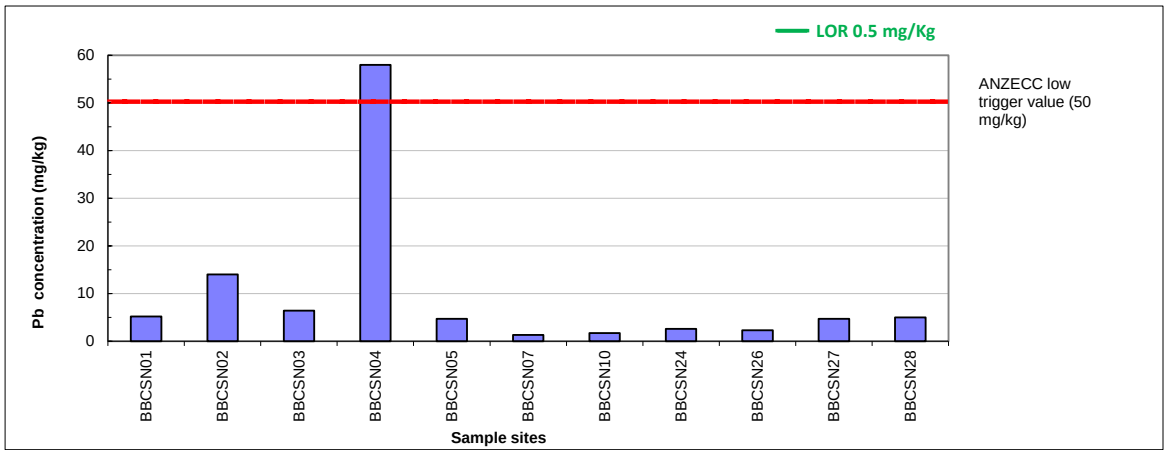

Figure 29: Lead concentrations in the sediments of the Bennett Brook catchment

Manganese

Manganese is commonly associated with dissolved ferrous ion and is a naturally occurring constituent of groundwater (Department of Environment 2004). Other sources of manganese to waterways include agricultural and gardening applications, alkaline and dry cell batteries, some fertilisers and some disinfectants.

No guideline for manganese in sediments currently exists. The manganese concentrations in the sediments of the Bennett Brook catchment were varied, with the highest concentrations being recorded at sites 4, 2, 28 and 3 (Madeira Ave – Altone Park, Lightning Swamp – drain downstream, Comp basin outfall at Cogla St and Mulgul Rd and Lightning Swamp – drain upstream respectively) with concentrations of 21, 20, 18 and 16 mg/Kg respectively.

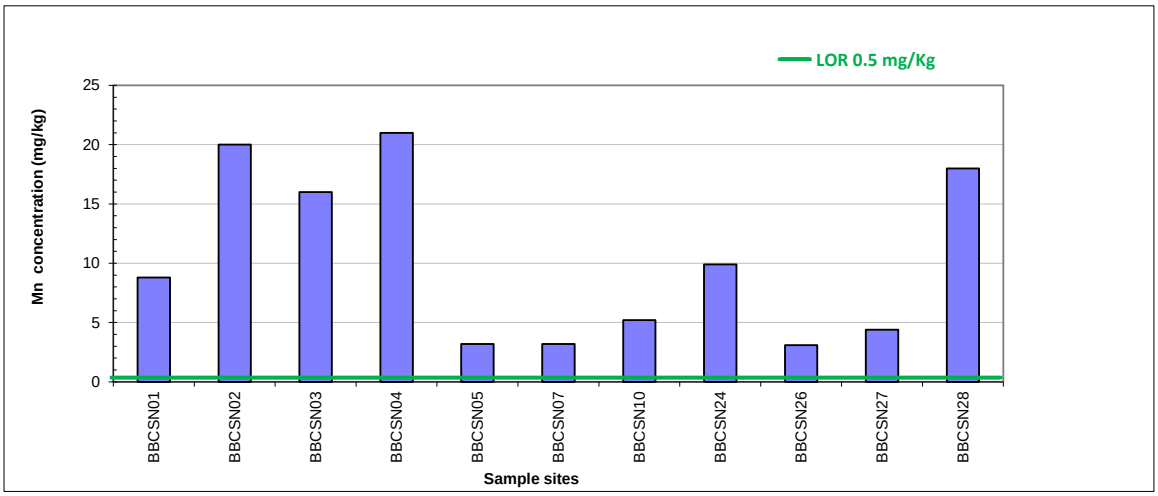

Figure 30: Manganese concentrations in the sediments of the Bennett Brook catchment

Iron

The iron concentrations in the sediments of the Bennett Brook catchment were varied. The highest concentrations were recorded at sites 4, 10 and 28 (Madeira Ave – Altone Park, Emu Swamp – drain exit and comp basin outfall at Cogla St and Mulgul Rd) with concentrations of 5,730, 2,450 and 1,870 mg/Kg respectively. As there is no current trigger value for iron in sediments it is not possible to evaluate these concentration in terms of human and ecosystem health.

These sites recorded also high iron concentrations in 2009. Site 10 recorded 38,400mg/Kg; site 4, 4,040 mg/Kg and site 28, 15,600 mg/Kg.

While there is currently no trigger value to compare results to, the elevated concentrations at certain sites while other sites recorded lower concentrations warrants further investigation and monitoring. It is currently not known if the large variability in iron concentrations is due to contamination of some kind or the local geology.

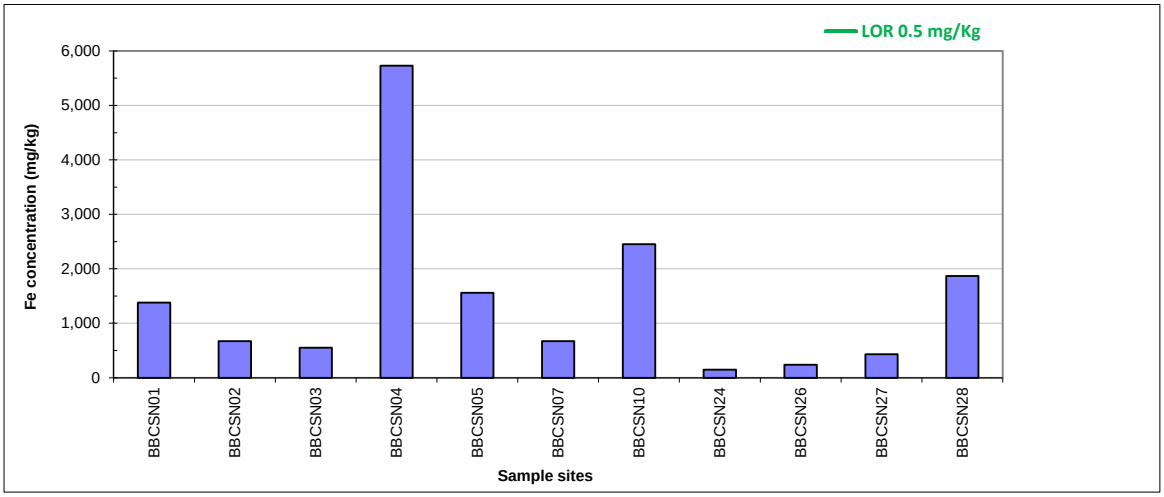

Figure 31: Iron concentrations in the sediments of the Bennett Brook catchment

Nickel

The nickel concentrations in the sediments of the Bennett Brook catchment were varied. 3 out of 11 sites recorded concentrations below the limit of reporting (0.5 mg/Kg) but all sites recorded concentrations below the ANZECC low and high trigger values of 21 mg/kg and 52 mg/Kg, with the exception of site 28 (comp basin outfall at Cogla St and Mulgul Rd) which recorded 53 mg/Kg. In 2009 this site also recorded a concentration above the high trigger value (740 mg/Kg), which was clearly a much greater exceedence of the high trigger value than was recorded in 2010.

The elevated level at site 28 suggests that the Malaga industrial area is a potential source of nickel to the system. As this is the second year of sampling at this site is difficult to determine if this is

due to ongoing and current contamination or a legacy of previous land uses. However, it seems the sediment is being contained within the basin and not moving downstream. Further investigation is recommended, along with an industry audit to attempt to locate the sources of contamination.

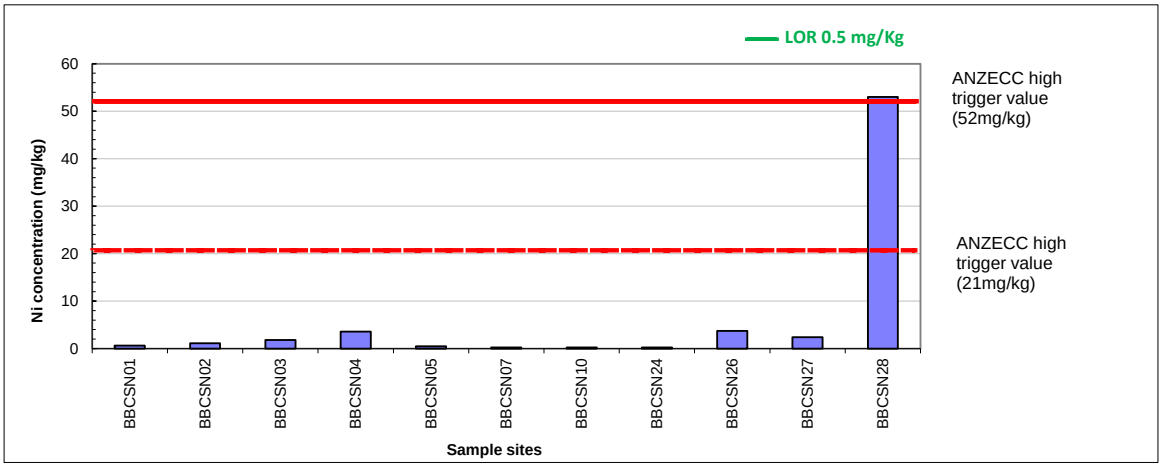

Figure 32: Nickel concentrations in the sediments of the Bennett Brook catchment

Molybdenum

No guideline for molybdenum in sediment currently exists. The molybdenum concentrations for the sediments of the Bennett Brook catchment were generally below the limit of reporting (0.5 mg/Kg) with the exception of site 4 (Madeira Ave – Altone Park) where a concentration of 0.71 mg/Kg was recorded.

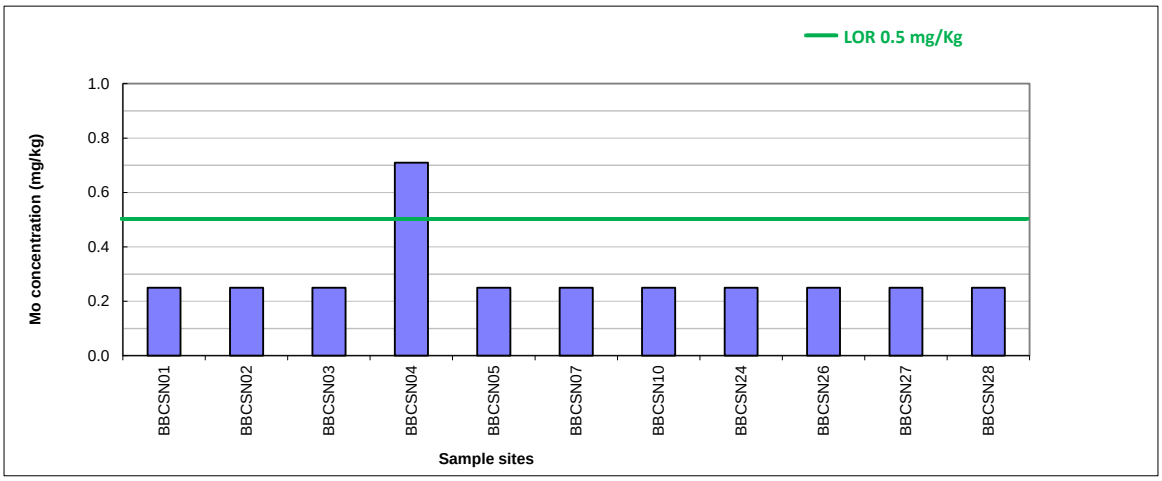

Figure 33: Molybdenum concentrations in the sediments of the Bennett Brook catchment

Zinc

The concentrations of zinc in the sediments of the Bennett Brook catchment were below the low and high ANZECC trigger value of 200 mg/kg and 410 mg/Kg at all sites. Again sites 4 and 28 (Madeira Ave – Altone Park and Comp basin outfall at Cogla St and Mulgul Rd) recorded the highest concentrations of 120 mg/Kg and 47 mg/Kg.

The zinc concentration at site 28 was higher than at the other sites in the Malaga industrial area, which suggests an isolated source in the immediate area, either from ongoing contamination or from historical land use. Further investigation and monitoring is recommended. The relatively high concentration at site 4 is of concern, with no immediately obvious source of contamination to explain the result, so further monitoring is recommended.

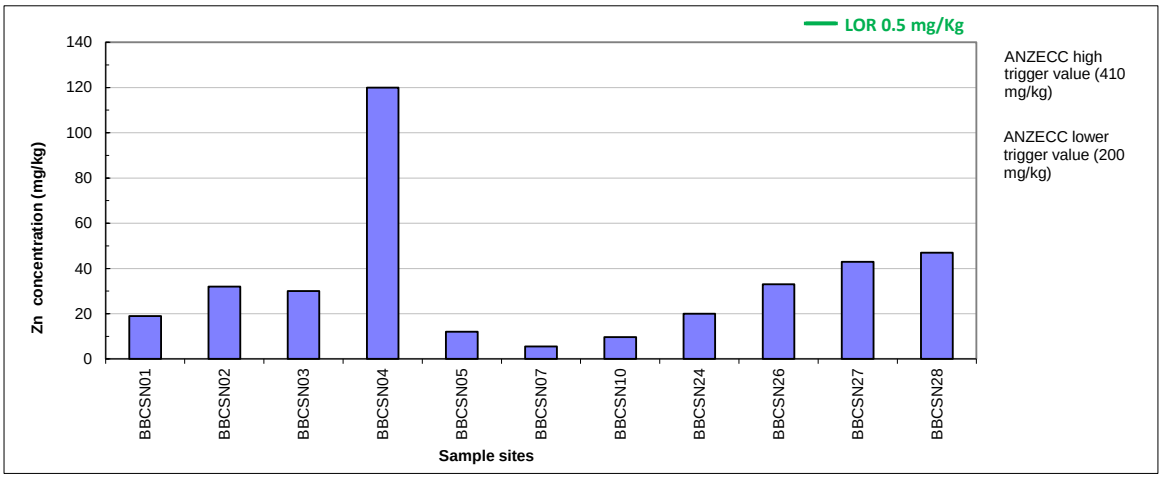

Figure 34: Zinc concentrations in the sediments of the Bennett Brook catchment

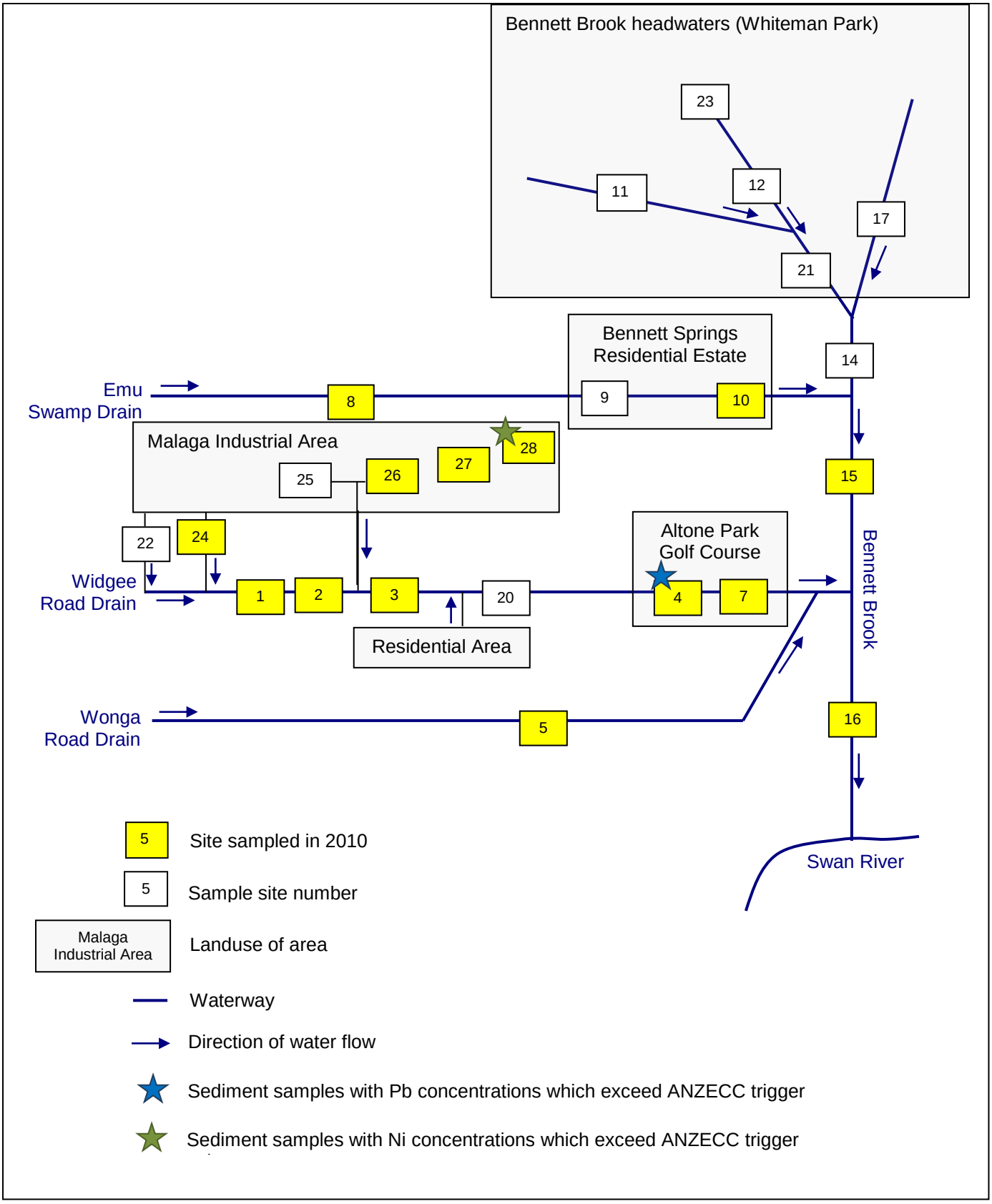

Figure 35: Metals concentrations in sediments samples which exceeded ANZECC trigger values

Recommendations

The improvement of water quality in the Bennett Brook catchment involves a wide range of management issues regarding the environment problems at each specific site. However there are some general recommendations, which are listed below:

- Continue monitoring the water and sediments quality in the catchment to detect changes in the concentrations of nutrients and metals. However, the periodicity of one sampling event per year is not enough to provide sufficient data about the condition of the catchment and to interpret trends and changes that are happening over time. Snapshots only provide information regarding a specific point in time and space and greater temporal coverage of the catchment would result in more data and therefore a more detailed picture of the water quality in the catchment. For this reason, increasing the annual frequency is paramount to be able to collect more information in order to analyse and discuss better the results and understand better the dynamics in the catchment. Considering budget restrictions it could be possible to drop some parameters from future sampling programs, especially those which do not have ANZECC trigger values or guidelines (such as molybdenum in water and aluminium, iron, cobalt, manganese, molybdenum and selenium in sediments) and/or reduce the number of sites. In this way, with a similar budget, more sampling events could be carried out.
- Exceedance of a trigger value, for any parameter, indicates that there is the potential for an impact to occur, management responses should be oriented to minimise or alleviate those impacts before water flows to the Swan River.
- The high concentrations of metals and nutrients recorded at some sites are of concern and should warrant further investigation along with some focus Light Industry Audits in the catchment area by local government to address the ongoing problems.
- It is recommended that local government authorities develop a best management practice education program to try and assist land users/ industry in addressing the ongoing problems. This could include an awareness program as well as auditing of businesses in the Malaga industrial area to prevent inappropriate disposal of wastes throughout the industrial area.
- Prepare an analysis of the findings for the 9-year water quality monitoring program to understand the results better and identify 'hot spots' and align them to specific management actions aimed at improving the water quality in the catchment. Besides, this analysis can provide information to suggest some sites that could be dropped from the sampling.
- Further investigation and monitoring is required to understand:
    - The ongoing source of TN localised around the vicinity of sites 10 and 15.
    - The ongoing source of TP in the vicinity of sites 14, 15 and 17.
- A more intensive monitoring program and desktop study of the Bennett Springs residential estate (site 10) to attempt to ascertain the source of the elevated nitrogen concentrations in the area.
- Investigation into nutrient reduction strategies at sites 14 and 17 is highly recommended.
- Investigation into the catchment-scale elevated aluminium concentrations.
- The high concentrations of copper at sites 2, 26 and 27 and zinc at sites 1 and 7 are of concern due to the potential for downstream flow of contaminated waters and the possible effects on the ecology of Lightning swamp. The results suggest continued monitoring to follow any trends and changes in copper and zinc concentrations.
- The source of the elevated sediment chromium concentration at site 28 is currently unknown and corresponds with high concentration in the surface water; therefore, it is difficult to determine if this is due to ongoing pollution events or previous land use or it may simply be temporal variability that cannot be capture adequately with snapshot sampling. However, it could be possible that a business there may be the potential source since this site receives storm water from the Malaga industrial area (between Malaga Dr, Marshall Rd, Iron Rd and Mulgul Dr). Therefore it is recommended that the light industry audits use information contained within this report to identify potential sources of contamination (i.e. light industrial land uses).

- Even though there is not a trigger value or guideline for cobalt in sediments, the results found at sites 4 and 28 suggest continue monitoring to follow any trends and changes in the concentration.
- The results of copper concentration in sediments at site 28, suggest further investigation is warranted as to have more information about the sources of copper and continued monitoring to follow any trends and changes in the concentration.
- The elevated lead concentrations in sediments at sites 1 and 4 currently suggest further investigation is warranted to determine if this is an ongoing trend or merely a temporal variation in results that is not adequately captured by this sampling program.
- Nickel concentrations in sediments at site 28 suggest that the Malaga industrial area may be a potential source to the system. It seems the sediment is being contained within the basin and not moving downstream. Further investigation is recommended, along with an industry audit to attempt to locate the sources of contamination.
- Zinc concentrations in sediments at sites 4 and 28 suggest an isolated source in the Malaga Industrial Area, either from ongoing pollution in the immediate area or previous historical land use, further investigation and monitoring is warranted.

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Appendix 1 – Site locations

Table 9: Location of sampling sites in the Bennett Brook Catchment

Site	Drain Section/component	Location	Easting	Northing
BBCSN01	Widgee Road Branch Drain	Lightning Swamp Beginning of open water, from culvert under Malaga Drive	395678	6473443
BBCSN02	Widgee Road Branch Drain	Lightning Swamp 20m upstream of input drain from Malaga industrial area	396026	6473628
BBCSN03	Widgee Road Branch Drain	Lightning Swamp 20m downstream of input drain from Malaga industrial area	396305	6473556
BBCSN04	Widgee Road Branch Drain	Altone Park Inlet to Recreation Centre, first lake, Madeira Ave. Beechboro	399480	6473233
BBCSN05	Wonga Road Branch Drain	Open drain, Altone Road, opposite Weddall Road, Beechboro	400155	6472616
BBCSN07	Widgee Road Branch Drain	Altone Park Open drain exiting Altone Park Golf course. Beechboro	400152	6473116
BBCSN08	Emu Swamp Main Drain	Open drain along road reserve, Marshall Rd, Ballajura	397504	6475229
BBCSN09	Emu Swamp Main Drain	Open drain. Bennett Springs Rd, Beechboro, east of intersection with Beechboro Rd	398446	6474883
BBCSN10	Emu Swamp Main Drain	Bennett Springs estate Compensation basin. Beechboro	400550	6474832
BBCSN11	Bennett Brook headwaters – workshops north	Upstream from Mussel Pool, Whiteman Park	399983	6476596
BBCSN12	Bennett Brook headwaters – Wunanga Bush Trail	Top of Whiteman Park	398995	6477595
BBCSN14	Bennett Brook	Crossing of Bennett Brook along Marshall Rd	400881	6475063
BBCSN15	Bennett Brook	Patricia Close Gardenvale estate, Beechboro	401436	6473919
BBCSN16	Bennett Brook	Clarry Small Park, Valley Brook Estate, Caversham	401581	6472654
BBCSN17	Bennett Brook headwaters	Horse Swamp Adjacent to bird hide	401407	6476314
BBCSN20	Widgee Road Branch Drain	5m downstream of local government input drain	396615	6473571
BBCSN21	Bennett Brook headwaters	Mussel Pool Adjacent to fish ladder dam wall	400470	6476510
BBCSN22	Widgee Road Branch Drain	Agett Way compensation basin Adjacent to outlet drain on eastern side of wetland	394159	6473767
BBCSN23	Bennett Brook headwaters	Keith Maine Sump Adjacent to Keith Maine camp complex, Whiteman Park north	398544	6478019
BBCSN24	RSPCA basin, Malaga Drive	Large open waterbody, adjacent to the RSPCA fauna rehabilitation centre, Malaga Dve, Malaga. Outlet drain, southwestern corner.	395083	6473964
BBCSN25	City of Swan	Outfall of comp basin at Juna Dr.	395952.2	6473828.9
BBCSN26	City of Swan	Outfall of comp basin at Glyde Ct.	396371.8	6473880.4
BBCSN27	City of Swan	Outfall of comp basin south of junction of Victoria Rd and Cogla St	396340.5	6474255.2
BBCSN28	City of Swan	Outfall of comp basin at Cogla St and Mulgul Rd	396248.6	6474647.2

Appendix 2 – Bennett Brook Catchment Water Quality Results

a) Physical parameters results

pH ANZECC trigger value for lowland rivers of SW Australia 6.5 - 8.0

Max (red) 9.65 Min (blue) 6.91

				Comparison to ANZECC trigger value	
Site name	**Site number**	**Date**	**pH (no units)**	**pH lower limit 6.5**	**pH upper limit 8.0**
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	7.1	Acceptable	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	9.54	Acceptable	Does not meet guidelines
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	7.6	Acceptable	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	7.09	Acceptable	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	7.7	Acceptable	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	7.53	Acceptable	Acceptable
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	6.91	Acceptable	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	7.81	Acceptable	Acceptable
PATRICIA CLOSE	BBCSN15	07/10/2010	7.7	Acceptable	Acceptable
CLARRY SMALL PARK	BBCSN16	07/10/2010	7.46	Acceptable	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	7.93	Acceptable	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	9.65	Acceptable	Does not meet guidelines
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	7.76	Acceptable	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	7.76	Acceptable	Acceptable

Dissolved oxygen (DO) ANZECC trigger value 80-120% saturation

Max (red) 151.8 Min (blue) 38.3

Comparison to ANZECC trigger value

Site name	Site number	Date	O - DO (%)	DO lower limit 80	DO upper limit 120
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	66.1	Does not meet guidelines	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	151.8	Acceptable	Does not meet guidelines
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	135.9	Acceptable	Does not meet guidelines
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	78.9	Does not meet guidelines	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	65.2	Does not meet guidelines	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	75.3	Does not meet guidelines	Acceptable
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	38.3	Does not meet guidelines	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	88.1	Acceptable	Acceptable
PATRICIA CLOSE	BBCSN15	07/10/2010	77.5	Does not meet guidelines	Acceptable
CLARRY SMALL PARK	BBCSN16	07/10/2010	61.1	Does not meet guidelines	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	124.1	Acceptable	Does not meet guidelines
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	145.2	Acceptable	Does not meet guidelines
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	108.3	Acceptable	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	118.5	Acceptable	Acceptable

Electrical Conductivity (EC) ANZECC trigger value 0.12-0.3 mS/cm

Max (red) 0.696 Min (blue) 0.285

Site name	Site number	Date	Cond comp (mS/cm)	lower limit 0.12	upper limit 0.3
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.397	Acceptable	Does not meet guidelines
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.4	Acceptable	Does not meet guidelines
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.4	Acceptable	Does not meet guidelines
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.512	Acceptable	Does not meet guidelines
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.696	Acceptable	Does not meet guidelines
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.628	Acceptable	Does not meet guidelines
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.572	Acceptable	Does not meet guidelines
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.512	Acceptable	Does not meet guidelines
PATRICIA CLOSE	BBCSN15	07/10/2010	0.566	Acceptable	Does not meet guidelines
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.631	Acceptable	Does not meet guidelines
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.285	Acceptable	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.409	Acceptable	Does not meet guidelines
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.467	Acceptable	Does not meet guidelines
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.461	Acceptable	Does not meet guidelines

Total Suspendid Solids (TSS) DoW interim guideline 6 mg/L All data in blue were <1 (LOR)

Max (red) 4 Min (blue) 0.5

Site name	Site number	Date	TSS (mg/L)	DoW interim guideline 6 mg/L
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.5	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.5	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	2	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.5	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	1	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	1	Acceptable
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	1	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	4	Acceptable
PATRICIA CLOSE	BBCSN15	07/10/2010	1	Acceptable
CLARRY SMALL PARK	BBCSN16	07/10/2010	4	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	1	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.5	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	2	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.5	Acceptable

Temperature (°C)

Max (red) 25.5 Min (blue) 15.26

Site name	Site number	Date	°C
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	17.36
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	23.82
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	18.59
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	19.49
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	17.53
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	18.97
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	18.61
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	18.53
PATRICIA CLOSE	BBCSN15	07/10/2010	15.26
CLARRY SMALL PARK	BBCSN16	07/10/2010	16.36
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	20.98
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	21.2
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	20.46
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	25.5

a) Nutrients results

Total nitrogen (TN) (mg/L) N (tot) {TN, pTN} (mg/L)

ANZECC trigger value: 1.2mg/L Max (red) 1.8 Min (blue) 0.25

Site name	Site number	Date	TN	Comparison to ANZECC trigger value (1.2mg/L)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.4	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.47	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.4	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	1.1	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.62	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	1.2	Guideline exceeded
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.63	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	1.8	Guideline exceeded
PATRICIA CLOSE	BBCSN15	07/10/2010	1.2	Guideline exceeded
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.99	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.6	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.48	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.25	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.28	Acceptable

Nitrogen as ammonia/ammonium (mg/L) NH3-N/NH4-N (sol) (mg/L) All data in blue were <0.01 (LOR)

ANZECC trigger value: 0.9mg/L Max (red) 0.28 Min (blue) 0.005

Site name	Site number	Date	NH3-N/NH4-N (sol)	Comparison to ANZECC trigger value (0.9mg/L)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.042	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.011	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.014	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.11	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.026	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.28	Acceptable
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.24	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.087	Acceptable
PATRICIA CLOSE	BBCSN15	07/10/2010	0.005	Acceptable
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.012	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.01	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.011	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.01	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.005	Acceptable

Total Oxidised Nitrogen (NOx) (mg/L) sol ox) {NOx-N, TON} (mg/L) All data in blue were <0.01 (LOR)

ANZECC trigger value: 0.15mg/L Max (red) 1.1 Min (blue) 0.005

Site name	Site number	Date	N (sum sol ox) {NOx-N, TON}	Comparison to ANZECC trigger value (0.15mg/L)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.053	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.013	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.015	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.5	Guideline exceeded
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.11	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.35	Guideline exceeded
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.082	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	1.1	Guideline exceeded
PATRICIA CLOSE	BBCSN15	07/10/2010	0.54	Guideline exceeded
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.38	Guideline exceeded
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.005	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.005	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.005	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.005	Acceptable

Total Phosphorus (TP)	(mg/L)	P (tot) {TP, pTP} (mg/L)		All data in blue were <0.005 (LOR)
ANZECC trigger value: 0.065mg/L	Max (red)	0.086	Min (blue)	0.01

Site name	Site number	Date	P (tot) {TP, pTP} (mg/L)	Comparison to ANZECC trigger value (0.065mg/L)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.016	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.049	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.022	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.023	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.02	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.016	Acceptable
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.015	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.038	Acceptable
PATRICIA CLOSE	BBCSN15	07/10/2010	0.037	Acceptable
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.051	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.086	Guideline exceeded
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.055	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.017	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.01	Acceptable

Soluble Reactive Phosphorus (SRP)	(mg/L)	(sol react) {SRP, FRP} (mg/L)		All data in blue were <0.005 (LOR)
ANZECC trigger value: 0.04mg/L	Max (red)	0.022	Min (blue)	0.0025

Site name	Site number	Date	PO4-P (sol react) {SRP, FRP}	Comparison to ANZECC trigger value (0.04mg/L)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.0025	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.011	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.0025	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.0025	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.0025	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.0025	Acceptable
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.0025	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.01	Acceptable
PATRICIA CLOSE	BBCSN15	07/10/2010	0.018	Acceptable
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.021	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.02	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.022	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.013	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.0025	Acceptable

b) Metals results

Aluminium (Al) (sol)

(mg/L) (Note: ANZECC guideline only applicable if pH>6.5)

ANZECC trigger value: 0.055mg/L Max (red) 0.38 Min (blue) 0.06

Site name	Site number	Date	Al (sol) (mg/L)	Comparison to ANZECC trigger value (0.055mg/L)	pH (in situ)(no units)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.2	Guideline exceeded	7.1
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.16	Guideline exceeded	9.54
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.062	Guideline exceeded	7.6
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.34	Guideline exceeded	7.09
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.15	Guideline exceeded	7.7
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.38	Guideline exceeded	7.53
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.14	Guideline exceeded	6.91
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.22	Guideline exceeded	7.81
PATRICIA CLOSE	BBCSN15	07/10/2010	0.11	Guideline exceeded	7.7
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.11	Guideline exceeded	7.46
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.13	Guideline exceeded	7.93
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.12	Guideline exceeded	9.65
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.06	Guideline exceeded	7.76
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.073	Guideline exceeded	7.76

Arsenic (As) (sol)

(mg/L) All data in blue were <0.001 (LOR)

ANZECC trigger value: 0.024mg/L Max (red) 0.001 Min (blue) 0.0005

Site name	Site number	Date	As (sol) (mg/L)	Comparison to ANZECC trigger value (0.024mg/L)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.0005	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.0005	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.0005	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.0005	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.0005	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.0005	Acceptable
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.0005	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.0005	Acceptable
PATRICIA CLOSE	BBCSN15	07/10/2010	0.0005	Acceptable
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.0005	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.001	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.0005	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.0005	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.0005	Acceptable

Iron (Fe) (sol) (mg/L)

ANZECC trigger value: 0.3 mg/L Max (red) 1.2 Min (blue) 0.22

Site name	Site number	Date	Fe (sol) (mg/L)	Comparison to ANZECC trigger value (0.3mg/L)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.22	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.41	Guideline exceeded
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.23	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.29	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	1	Guideline exceeded
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	1.2	Guideline exceeded
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.51	Guideline exceeded
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.59	Guideline exceeded
PATRICIA CLOSE	BBCSN15	07/10/2010	0.61	Guideline exceeded
CLARRY SMALL PARK	BBCSN16	07/10/2010	1.2	Guideline exceeded
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.37	Guideline exceeded
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.44	Guideline exceeded
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.26	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.28	Acceptable

Mercury (Hg) (sol) (mg/L)

All data in blue were <0.0001 (LOR)

ANZECC trigger value: 0.0006mg/L Max (red) 0.00005 Min (blue) 0.00005

Site name	Site number	Date	Hg (sol) (mg/L)	Comparison to ANZECC trigger value (0.0006mg/L)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.00005	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.00005	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.00005	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.00005	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.00005	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.00005	Acceptable
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.00005	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.00005	Acceptable
PATRICIA CLOSE	BBCSN15	07/10/2010	0.00005	Acceptable
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.00005	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.00005	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.00005	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.00005	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.00005	Acceptable

Cobalt (Co) (sol)

(mg/L) All data in blue were <0.001 (LOR)

Marine ANZECC trigger value: 0.001mg/L Max (red) 0.0005 Min (blue) 0.0005

Site name	Site number	Date	Co (sol) (mg/L)	Comparison to ANZECC trigger value (0.001mg/L)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.0005	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.0005	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.0005	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.0005	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.0005	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.0005	Acceptable
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.0005	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.0005	Acceptable
PATRICIA CLOSE	BBCSN15	07/10/2010	0.0005	Acceptable
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.0005	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.0005	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.0005	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.0005	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.0005	Acceptable

Manganese (Mn) (sol)

(mg/L)

ANZECC trigger value: 1.9 mg/L Max (red) 0.13 Min (blue) 0.005

Site name	Site number	Date	Mn (sol) (mg/L)	Comparison to ANZECC trigger value (1.9 mg/L)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.054	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.054	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.022	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.007	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.01	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.024	Acceptable
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.02	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.007	Acceptable
PATRICIA CLOSE	BBCSN15	07/10/2010	0.008	Acceptable
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.016	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.13	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.066	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.009	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.005	Acceptable

Molybdenum (Mo) (sol)

(mg/L) All data in blue were <0.001 (LOR)

ANZECC trigger value: ND Max (red) 0.003 Min (blue) 0.0005

Site name	Site number	Date	Mo (sol) (mg/L)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.0005
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.002
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.0005
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.0005
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.0005
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.0005
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.0005
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.0005
PATRICIA CLOSE	BBCSN15	07/10/2010	0.0005
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.0005
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.003
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.003
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.0005
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.0005

Selenium (Se) (sol)

(mg/L) All data in blue were <0.001 (LOR)

ANZECC trigger value: 0.011 mg/L Max (red) 0.0005 Min (blue) 0.0005

Site name	Site number	Date	Se (sol) (mg/L)	Comparison to ANZECC trigger value (0.011mg/L)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.0005	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.0005	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.0005	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.0005	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.0005	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.0005	Acceptable
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.0005	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.0005	Acceptable
PATRICIA CLOSE	BBCSN15	07/10/2010	0.0005	Acceptable
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.0005	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.0005	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.0005	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.0005	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.0005	Acceptable

Water Hardness (mg/L)

Site name	Site number	Water Hardness (mg/L)
MALGA DRIVE - IVORY ST	BBCSN01	70
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	69
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	72
MADEIRA AVE - ALTONE PARK	BBCSN04	81
ALTONE ROAD - OPTUS	BBCSN05	120
ALTONE PARK GOLF COURSE	BBCSN07	100
WHITEMAN PARK - BALLAJURA	BBCSN08	100
EMU SWAMP DRAIN EXIT	BBCSN10	94
PATRICIA CLOSE	BBCSN15	100
CLARRY SMALL PARK	BBCSN16	110
RSPCA COMPENSATING BASIN	BBCSN24	72
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	76
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	85
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	85

Cadmium (Cd)

All data in blue were <0.0001 (LOR)

Site name	Site number	Date	Cd (sol) (mg/L)	Hardness (tot) (CaCO3) {Ca+Mg} (mg/L)	Adjust factor	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value	Hardness (mg/L)	Cd	ANZECC trigger value*
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.00005	70	2.7	0.00054	Acceptable	0-59	1	0.0002
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.00005	69	2.7	0.00054	Acceptable	60-119	2.7	
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.00005	72	2.7	0.00054	Acceptable	120-179	4.2	
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.00005	81	2.7	0.00054	Acceptable	180-240	5.7	
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.00005	120	4.2	0.00084	Acceptable	400	10	
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.00005	100	2.7	0.00054	Acceptable			
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.00005	100	2.7	0.00054	Acceptable			
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.00005	94	2.7	0.00054	Acceptable			
PATRICIA CLOSE	BBCSN15	07/10/2010	0.00005	100	2.7	0.00054	Acceptable			
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.00005	110	2.7	0.00054	Acceptable			
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.00005	72	2.7	0.00054	Acceptable			
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.00005	76	2.7	0.00054	Acceptable			
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.00005	85	2.7	0.00054	Acceptable			
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.00005	85	2.7	0.00054	Acceptable			

Chromium (Cr)

All data in blue were <0.001 (LOR)

Site name	Site number	Date	Cr (sol) (mg/L)	Hardness (tot) (CaCO3) {Ca+Mg} (mg/L)	Adjust factor	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value	Hardness (mg/L)	Cr	ANZECC trigger value*
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.0005	70	2.5	0.0025	Acceptable	0-59	1	0.001
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.0005	69	2.5	0.0025	Acceptable	60-119	2.5	
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.0005	72	2.5	0.0025	Acceptable	120-179	3.7	
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.001	81	2.5	0.0025	Acceptable	180-240	4.9	
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.0005	120	3.7	0.0037	Acceptable	400	8.4	
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.001	100	2.5	0.0025	Acceptable			
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.001	100	2.5	0.0025	Acceptable			
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.001	94	2.5	0.0025	Acceptable			
PATRICIA CLOSE	BBCSN15	07/10/2010	0.0005	100	2.5	0.0025	Acceptable			
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.0005	110	2.5	0.0025	Acceptable			
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.0005	72	2.5	0.0025	Acceptable			
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.0005	76	2.5	0.0025	Acceptable			
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.001	85	2.5	0.0025	Acceptable			
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.001	85	2.5	0.0025	Acceptable			

Copper (Cu)

All data in blue were <0.001 (LOR)

Site name	Site number	Date	Cu (sol) (mg/L)	Hardness (tot) (CaCO3) {Ca+Mg} (mg/L)	Adjust factor	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.001	70	2.5	0.0035	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.004	69	2.5	0.0035	Guideline exceeded
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.002	72	2.5	0.0035	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.0005	81	2.5	0.0035	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.002	120	3.9	0.00546	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.002	100	2.5	0.0035	Acceptable
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.0005	100	2.5	0.0035	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.0005	94	2.5	0.0035	Acceptable
PATRICIA CLOSE	BBCSN15	07/10/2010	0.0005	100	2.5	0.0035	Acceptable
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.001	110	2.5	0.0035	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.001	72	2.5	0.0035	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.004	76	2.5	0.0035	Guideline exceeded
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.004	85	2.5	0.0035	Guideline exceeded
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.001	85	2.5	0.0035	Acceptable

Hardness (mg/L)	Cu	ANZECC trigger value*
0-59	1	0.0014
60-119	2.5	
120-179	3.9	
180-240	5.2	
400	9	

Lead (Pb)

All data in blue were <0.001 (LOR)

Site name	Site number	Date	Pb (sol) (mg/L)	Hardness (tot) (CaCO3) {Ca+Mg} (mg/L)	Adjust factor	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.001	70	4	0.0136	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.0005	69	4	0.0136	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.0005	72	4	0.0136	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.0005	81	4	0.0136	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.0005	120	7.6	0.02584	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.0005	100	4	0.0136	Acceptable
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.0005	100	4	0.0136	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.0005	94	4	0.0136	Acceptable
PATRICIA CLOSE	BBCSN15	07/10/2010	0.0005	100	4	0.0136	Acceptable
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.0005	110	4	0.0136	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.002	72	4	0.0136	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.0005	76	4	0.0136	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.0005	85	4	0.0136	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.0005	85	4	0.0136	Acceptable

Hardness (mg/L)	Pb	ANZECC trigger value*
0-59	1	0.0034
60-119	4	
120-179	7.6	
180-240	11.8	
400	26.7	

Nickel (Ni)

All data in blue were <0.001 (LOR)

Site name	Site number	Date	Ni (mg/L)	Hardness (tot) (CaCO3) {Ca+Mg} (mg/L)	Adjust factor	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value	Hardness (mg/L)	Ni	ANZECC trigger value*
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.0005	70	2.5	0.0275	Acceptable	0-59	1	0.011
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.004	69	2.5	0.0275	Acceptable	60-119	2.5	
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.001	72	2.5	0.0275	Acceptable	120-179	3.9	
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.0005	81	2.5	0.0275	Acceptable	180-240	5.2	
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.001	120	3.9	0.0429	Acceptable	400	9	
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.001	100	2.5	0.0275	Acceptable			
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.0005	100	2.5	0.0275	Acceptable			
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.0005	94	2.5	0.0275	Acceptable			
PATRICIA CLOSE	BBCSN15	07/10/2010	0.0005	100	2.5	0.0275	Acceptable			
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.001	110	2.5	0.0275	Acceptable			
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.002	72	2.5	0.0275	Acceptable			
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.005	76	2.5	0.0275	Acceptable			
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.002	85	2.5	0.0275	Acceptable			
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.0005	85	2.5	0.0275	Acceptable			

Zinc (Zn)

All data in blue were <0.001 (LOR)

Site name	Site number	Date	Zn (mg/L)	Water Hardness (mg/L)	Adjust factor	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value	Hardness (mg/L)	Zn	ANZECC trigger value*
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.023	70	2.5	0.02	Guideline exceeded	0-59	1	0.008
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.018	69	2.5	0.02	Acceptable	60-119	2.5	
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.018	72	2.5	0.02	Acceptable	120-179	3.9	
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.015	81	2.5	0.02	Acceptable	180-240	5.2	
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.01	120	3.9	0.0312	Acceptable	400	9	
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.021	100	2.5	0.02	Guideline exceeded			
WHITEMAN PARK - BALLAJURA	BBCSN08	06/10/2010	0.016	100	2.5	0.02	Acceptable			
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.011	94	2.5	0.02	Acceptable			
PATRICIA CLOSE	BBCSN15	07/10/2010	0.011	100	2.5	0.02	Acceptable			
CLARRY SMALL PARK	BBCSN16	07/10/2010	0.012	110	2.5	0.02	Acceptable			
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.014	72	2.5	0.02	Acceptable			
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.012	76	2.5	0.02	Acceptable			
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.017	85	2.5	0.02	Acceptable			
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.013	85	2.5	0.02	Acceptable			

Appendix 3 – Bennett Brook Catchment Sediment Quality Results

Aluminium (Al) (total sediment)

(mg/kg)

ANZECC trigger value: ND

Max (red) 3690 Min (blue) 270

Site name	Site number	Date	Al (tot)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	1000
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	1330
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	610
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	3690
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	660
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	490
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	920
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	270
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	530
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	1610
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	2100

Arsenic (As) (total sediment)

(mg/kg)

All data in blue were <0.5 (LOR)

ANZECC trigger value: 20 mg/kg

Max (red) 2.6 Min (blue) 0.25

Site name	Site number	Date	As (tot)	Comparison to ANZECC lower trigger value 20 mg/kg
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.25	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.25	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.25	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	2.6	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.25	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.25	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	1	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.25	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.25	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.25	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	1.9	Acceptable

Iron (Fe) (total sediment)

(mg/kg)

ANZECC trigger value: ND

Max (red) 5730 Min (blue) 150

Site name	Site number	Date	Fe (tot)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	1380
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	670
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	550
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	5730
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	1560
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	670
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	2450
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	150
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	240
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	430
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	1870

Mercury (Hg) (total sediments)

(mg/kg) All data in blue were <0.2 (LOR)

ANZECC lower trigger value: 0.15 mg/kg

Max (red) 0.1 Min (blue) 0.1

Site name	Site number	Date	Hg (tot)	Comparison to ANZECC lower trigger value 0.15 mg/kg
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.1	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.1	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.1	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.1	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.1	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.1	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.1	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.1	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.1	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.1	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.1	Acceptable

Cobalt (Co) (total sediments)

(mg/kg) All data in blue were <0.5 (LOR)

ANZECC trigger value: ND Max (red) 2.1 Min (blue) 0.25

Site name	Site number	Date	Co (tot)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.25
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.25
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.25
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	1.3
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.25
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.25
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.25
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.25
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.25
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.25
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	2.1

Manganese (Mn) (total sediments)

(mg/kg) All data in blue were <0.5 (LOR)

ANZECC trigger value: ND Max (red) 21 Min (blue) 3.1

Site name	Site number	Date	Mn (tot)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	8.8
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	20
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	16
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	21
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	3.2
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	3.2
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	5.2
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	9.9
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	3.1
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	4.4
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	18

Molybdenum (Mo) (total sediments)

(mg/kg) All data in blue were <0.5 (LOR)

ANZECC trigger value: ND Max (red) 0.71 Min (blue) 0.25

Site name	Site number	Date	Mo (tot)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.25
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.25
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.25
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.71
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.25
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.25
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.25
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.25
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.25
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.25
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.25

Selenium (Se) (total sediments)

(mg/L) All data in blue were <0.5 (LOR)

ANZECC trigger value: ND Max (red) 0.25 Min (blue) 0.25

Site name	Site number	Date	Se (tot)
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.25
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.25
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.25
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.25
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.25
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.25
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.25
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.25
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.25
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.25
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.25

Cadmium (Cd) (total sediments)

(mg/L) All data in blue were <0.2 and 0.5 (LOR)

ANZECC lower trigger value: 1.5 mg/kg Max (red) 0.25 Min (blue) 0.1

Site name	Site number	Date	Cd (mg/kg)	Comparison to ANZECC lower trigger value 1.5mg/kg
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.25	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	0.25	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	0.25	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	0.1	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.1	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.1	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.1	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.1	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	0.1	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	0.1	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	0.1	Acceptable

Chromium (Cr) (total sediments)

(mg/L) All data in blue were <0.5 (LOR)

ANZECC lower trigger value: 80 mg/kg Max (red) 17 Min (blue) 0.25

Site name	Site number	Date	Cr (mg/kg)	Comparison to ANZECC lower trigger value 80 mg/kg
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	2.4	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	2.7	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	1.8	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	7.9	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.82	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.25	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	1.6	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.25	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	1.8	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	8.1	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	17	Acceptable

Copper (Cu) (total sediments)

(mg/L) All data in blue were <0.5 (LOR)

ANZECC lower trigger value: 65 mg/kg Max (red) 18 Min (blue) 0.86

Site name	Site number	Date	Cu (mg/kg)	Comparison to ANZECC lower trigger value 65mg/kg
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	2.5	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	5	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	4.3	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	18	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	1.9	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.86	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.97	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	1.5	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	4.3	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	10	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	12	Acceptable

Nickel (Ni) (total sediments)

(mg/L) All data in blue were <0.5 (LOR)

ANZECC lower trigger value: 21 mg/kg Max (red) 53 Min (blue) 0.25

Site name	Site number	Date	Ni (mg/kg)	Comparison to ANZECC lower trigger value 21 mg/kg
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	0.61	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	1.1	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	1.8	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	3.6	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	0.5	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	0.25	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	0.25	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	0.25	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	3.7	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	2.4	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	53	Guideline exceeded

Lead (Pb) (total sediments)

(mg/L) All data in blue were <0.5 (LOR)

ANZECC lower trigger value: 50 mg/kg Max (red) 58 Min (blue) 1.3

Site name	Site number	Date	Pb (mg/kg)	Comparison to ANZECC lower trigger value 50 mg/kg
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	5.2	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	14	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	6.4	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	58	Guideline exceeded
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	4.7	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	1.3	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	1.7	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	2.6	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	2.3	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	4.7	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	5	Acceptable

Zinc (Zn) (total sediments)

(mg/L) All data in blue were <0.5 (LOR)

ANZECC lower trigger value: 200 mg/kg Max (red) 120 Min (blue) 5.5

Site name	Site number	Date	Zn (mg/kg)	Comparison to ANZECC lower trigger value 200 mg/kg
MALGA DRIVE - IVORY ST	BBCSN01	06/10/2010	19	Acceptable
LIGHTNING SWAMP - DRAIN DOWNSTREAM	BBCSN02	06/10/2010	32	Acceptable
LIGHTNING SWAMP - DRAIN UPSTREAM	BBCSN03	06/10/2010	30	Acceptable
MADEIRA AVE - ALTONE PARK	BBCSN04	06/10/2010	120	Acceptable
ALTONE ROAD - OPTUS	BBCSN05	06/10/2010	12	Acceptable
ALTONE PARK GOLF COURSE	BBCSN07	06/10/2010	5.5	Acceptable
EMU SWAMP DRAIN EXIT	BBCSN10	06/10/2010	9.7	Acceptable
RSPCA COMPENSATING BASIN	BBCSN24	06/10/2010	20	Acceptable
GLYDE COURT COMP BASIN OUTFALL	BBCSN26	06/10/2010	33	Acceptable
COMP BASIN OUTFALL AT VICTORIA RD AND COGLA ST	BBCSN27	06/10/2010	43	Acceptable
COMP BASIN OUTFALL AT COGLA ST AND MULGUL RD	BBCSN28	06/10/2010	47	Acceptable

Appendix 4 – Trigger Values and Guidelines

Table 10: Trigger values and guidelines for nutrient concentrations and physical properties in lowland rivers and freshwater.

Guideline	DO (% saturation)	pH	TN (mg/L)	NO_x-N (mg/L)	TP (mg/L)	FRP (mg/L)
ANZECC Water quality trigger value – lowland river (2000)	80-120	6.5 - 8.0	1.2	0.15	0.065	0.04
ANZECC Water quality trigger value – Recreational (2000)	>80	6.5 – 8.5	-	10	-	-
Swan Canning Cleanup Program Action Plan Targets (Bennett Brook)	-	-	2.0	-	0.1	-

Table 11: ANZECC trigger values and guidelines for heavy metals in freshwater

Guideline	Al (mg/L)	As (mg/L)	Cd* (mg/L)	Cr* (mg/L)	Co* (mg/L)	Cu* (mg/L)	Fe (mg/L)	Pb* (mg/L)	Hg (mg/L)	Mn (mg/L)	Mo (mg/L)	Ni* (mg/L)	Se (mg/L)	Zn* (mg/L)	Hardness (mg/L)
ANZECC Water quality trigger value – Recreational (2000)	0.2	0.05	0.005	0.05	-	1.0	0.3	0.05	0.001	0.1	-	0.01	0.010	5.0	500
ANZECC Water quality trigger value – Freshwater 95% (2000)	0.055	0.024	0.0002	0.001	0.0028	0.0014	-	0.0034	0.0006	1.9	0.034	0.011	0.011	0.008	-
NMI Limit of Reporting	0.005	0.001	0.0001	0.001	0.001	0.001	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	5

* Trigger values not adjusted for water hardness.

Table 12: ANZECC trigger values for toxicants in sediments

Guideline	Al (mg/kg)	As (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	Ni (mg/kg)	Se (mg/kg)	Zn (mg/kg)
ANZECC Sediment Quality Guideline (Interim) Low trigger value (2000)	-	20	1.5	-	80	65	-	50	0.15	500	-	21	-	200
ANZECC Sediment Quality guideline (Interim) High trigger value (2000)	-	70	10	-	370	270	-	220	1.0	-	-	52	-	410
NMI Limit of Reporting	0.5	0.5	0.2	0.5	0.5	0.5	0.5	0.5	0.2	0.5	0.5	0.5	0.5	0.5