www.hornsby.nsw.gov.au ☎ 9847 6666

Water Quality Monitoring Program

2010-2011 Annual Report
Water Catchments Team

creating a living environment

Catchments remediation rate

HORNSBY SHIRE COUNCIL

Photo 1: "Berowra Waters Ferry" by Francis Keogh
Award Winner in 2011 Hornsby Shire Photographic Competition.

Acknowledgements:

Data used in this 2010-2011 Annual Water Quality Monitoring Report was organised and collected by Paul Fredrickson under the supervision of David Beharrell, Team Leader Catchment Remediation and the direction of Dr Ross McPherson, Manager Water Catchments. Assistance with sampling and data gathering was provided by Elizabeth Bulley, with help from Ana Rubio, Ross McPherson, Kristy Guise, David Beharrell, Peter Coad, David Bolton, David Leggett and Katie Clarke. Assistance with statistics and mapping was provided by Peter Coad, Ana Rubio and David Leggett. This report was prepared by Paul Fredrickson. Laboratory testing of waters was carried out by Sydney Water Monitoring Services Laboratory; algal identifications by MicroAlgal Services.

A special mention needs to be made of the source of many of the photographs that appear in this report. These have been provided by members of the Community who responded to Council's call for submissions to its annual Photographic Competition. Hundred's of excellent photographs were submitted. This report contains some photos which relate to streams, estuary and water quality issues. The winners of the various photographic sections appear on Council's website at http://www.hornsby.nsw.gov.au/whats-on/photography-competition.

For further information contact:

PAUL FREDRICKSON
Environmental Scientist – Water Quality
Water Catchments Team
Environment Division

Tel: (02) 9847-6874
Fax: (02) 9847-6598
Email: pfredrickson@hornsby.nsw.gov.au

Table of Contents

1 Executive Summary

Hornsby Shire Council established a water quality monitoring program in 1994 to assess, through time, the impact of land use on waterways within the Shire and to monitor the performance of Council's Catchments Remediation Rate (CRR) program. The monitoring data is utilised by Council for prioritising catchment remediation works, for environmental assessments, catchment modelling and education programs, and is made available to the Community and interested Authorities through the Annual Reports and Council's web site. The program monitors algal blooms in the Estuary and the catchment activities that contribute to these blooms.

During 2010-2011 water quality was monitored at 60 sites. These included representative sites for assessment of (1) ecosystem health, over the long term, in estuary and creek sites located below different land use types, including urban, industrial, rural and bushland; and (2) performance of Council programs aimed at reducing stormwater impacts and improving water conservation and reuse. The water quality data is assessed against National Water Quality Guidelines, which reflect community expectations that creek ecosystems should be maintained in a good condition. Unfortunately, the upper sections of creeks close to intensive industrial, urban and rural developments have been historically highly disturbed, and much work remains to be done to return them to a healthier state.

Physical, Chemical, Bacterial and Biological Monitoring
At regular intervals, usually monthly, water quality measurements were recorded in-situ with a portable water quality analyser, and general observations, such as water appearance, odours and flows, were made. Water samples were simultaneously collected for laboratory analysis of chemical or microbial contaminants. As part of Council's algal bloom investigations samples are taken in the Berowra Estuary to assess the presence of harmful microalgae. In addition, during the summer swimming season, testing is carried out at Crosslands Reserve and Brooklyn baths as part of Council's recreational water quality monitoring program.

Water Quality Findings
Creeks located in areas with the least human disturbance, or located furthest downstream from land developments, usually had water quality which satisfied the National Water Quality Guidelines. Long term monitoring showed that two "Reference" freshwater creeks, located within undeveloped catchments in National Parks, were healthy according to Guideline criteria. These sites give a good baseline against which to compare other creeks in the Shire; they provide information on the condition of freshwater creeks before urban development and assist in identifying on any long-term changes.

Based on three key water quality parameters the measured water quality ratings for 36 selected sites in creeks and the estuary during 2010-2011 were "Good" at 36%, "Fair" at 8% of our sampling sites and "Poor" at 56% of sites (Compared with 39%:14%: 47% for 2009-2010). A reason that poor sites appear to dominate is that the monitoring program has tended to concentrate at locations in the upper sections of creeks close to intensive industrial, urban and rural developments, or the sewage treatment plants which have been historically highly disturbed.

Overall the trends and ranges of contaminant levels at most creek sites were similar to the last few years. Creeks close downstream of urban and rural areas did not satisfy the water quality Guideline for ecosystem values most of the time; they suffered during both wet and dry times from moderate levels of contaminants. Nitrogen nutrients in discharge water from West Hornsby and Hornsby Heights Sewage Treatment Plants (STPs) continues to dominate the receiving waters of Berowra Creek and the upper Berowra Estuary. High concentrations of nutrients and faecal bacteria contamination were present in sampling sites close downstream of industrial areas, particularly the Thornleigh Industrial areas and the rural Glenorie Village. These problems highlight the need for ongoing inspections, auditing and education. The conventional stormwater collection systems, which are directly connected to creeks in older urban and industrial areas, have removed the natural processes of stormwater filtration and flow reduction normally provided by vegetated soils. Now, in those areas with extensive hard surfaces, even the frequent small rain events can cause 'flash-flows' in creeks which creates additional chemical and physical stress to creek ecosystems. The CRR program and the incorporation of Water Sensitive Urban Design Principals are working towards reducing these undesirable flash-flow effects.

Bacterial contamination: Elevated bacterial counts were regularly found in most creeks, especially after rain. Occasionally this could be explained by the influence of animals (e.g. pets, ducks, horses and stock). However, the major sources of faecal bacteria were believed to be from leaking sewer systems. In urban areas untreated sewerage can enter creeks from numerous designed overflow points and from by-passes at the sewage treatment plants (STPs). In this reporting period Sydney Water reported two dry-weather STP by-passes and 21 wet-weather by-passes. These occurred during heavy rainstorms or due to equipment failures. In addition there were 82 dry weather overflows from sewerage infrastructure reported by Community members and investigated by Sydney Water; these were mainly caused by roots blocking pipes. The prime sources of faecal bacteria in the unsewered rural residential developments, particularly Glenorie Village, were considered to be illegal septic discharges, however animal husbandry, use of manures in market gardens and septic seepages probably also contributed. These problems remain despite the ongoing auditing of septic systems by Council officers and quick response repairs by Sydney Water when the Community reports sewer problems.

Nutrient contamination: Total nitrogen and oxidised nitrogen were regularly above Guideline values in all creeks draining urban and rural areas. Residual nitrogen nutrient concentrations were very high in the treated sewerage discharges from STPs into Waitara and Calna Creeks, and the plume of nutrient-rich waters was evident down Berowra Creek and out into Berowra Estuary. Sources of nutrients, other than STP outputs, in creeks below urban and unsewered rural areas, were considered to be from fertilisers, manurers, eroding soils, animal faeces or sewerage/septic seepages. High nitrogen and phosphorus levels in some rural creeks, particularly upper Glenorie Creek, continued to stand out. Using total nitrogen concentration alone as a key indicator of environmental health of the waterways, results from sampling freshwater creeks indicate that approximately 40% of sites are improving, 40% of sites are not changing and about 20% are degrading.

Estuarine Monitoring: Summer recreational water quality monitoring ranked the Hawkesbury River at Brooklyn Pool as Good (low risk) but Berowra Creek at Crosslands as Poor (moderate risk). Generally swimming at Crosslands is not recommended for 3 to 5 days after heavy rain due to the increased likelihood of bacterial contamination arising from sewer system overflows and from stormwater runoff from developed areas. Nitrogen nutrients and chlorophyll concentration were generally elevated in the Berowra Estuary. Algal activity was generally high and, on a number of occasions during the reporting period, elevated levels of potentially harmful algal species were detected during Council monitoring and reported to the Regional Algal Co-ordinating Committee, but on these occasions the Committee assessment did not require public notices to be issued.

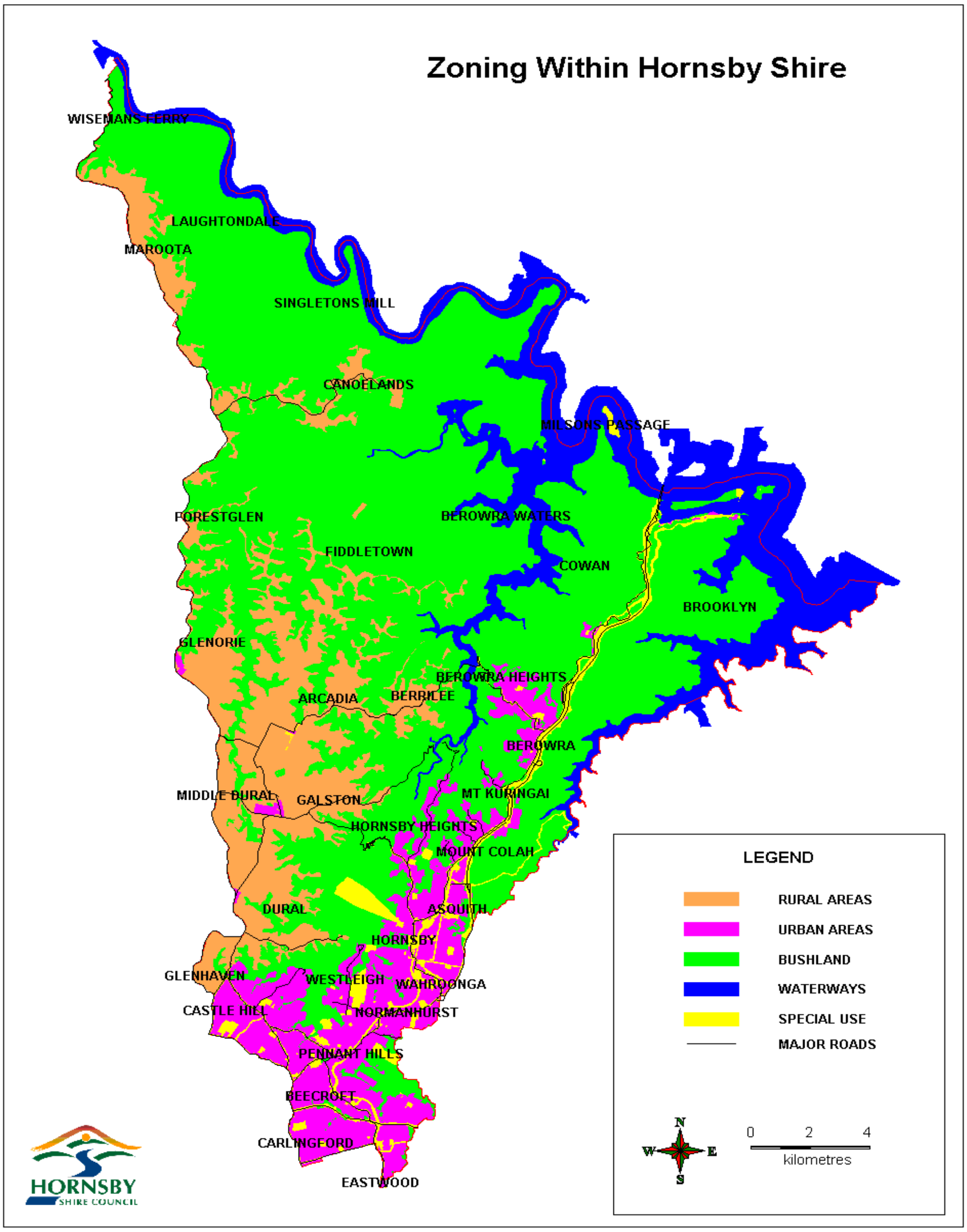
Water quality improvement and reuse projects: Water monitoring supported Council's CRR Capital Works Program and selected projects developed under Council's Total Water Cycle Management Strategy. Monitoring was used to confirm that stormwater, harvested at facilities near sports fields and at Council's nursery, provide irrigation water of suitable quality to replace potable water supplies. Groundwater leachate, collected and treated at rehabilitated landfill sites at Arcadia and Mount Colah, was assessed for its potential to be used to irrigate sports fields and gardens.

2 Hornsby Shire

The Hornsby Shire is situated approximately 25 km north west of Sydney and includes extensive areas of bushland and waterways. The main urban and rural developments are concentrated in the southern half of the Shire on the plateau areas. The aesthetic values of the bushland and waterways, including good quality water in the creeks and estuary, are important contributing factors towards attracting people to live within the Shire.

Hornsby Shire covers an area of 510km^2 of which 67% (342.9km^2) is bushland. Rural landuses constitute 20% (101.2km^2) whilst 13% (65.9km^2) is a mixture of urban and industrial uses. Water catchments within the Shire include Berowra Creek, Lane Cove River, Cowan Creek and the Hawkesbury River. The entire catchment of Berowra Creek and Estuary lies within the Shire.

Figure 1: Landuse zoning map of Hornsby Shire



2.1 Berowra Creek Catchment

The Berowra Creek catchment is bounded on the south by Castle Hill Road, to the west by Old Northern Road, to the north by the Canoelands Ridge and to the east by the Pacific Highway. All of the Berowra Creek Catchment is within the jurisdiction of Hornsby Shire Council.

This catchment contains significant bushland areas, including Marramarra National Park, Muogamarra Nature Reserve and Berowra Valley Regional Park. Landuses in this catchment include bushland, rural, developed and developing urban, light industrial and commercial. The main impacts on water quality in Berowra Creek arise from the discharge of tertiary treated sewage waters from the West Hornsby and Hornsby Heights sewage treatment plants (STPs) into Waitara and Calna Creeks, and from stormwater run-off from the developed urban and commercial areas concentrated in the south eastern parts of the Shire.

The rural and rural-residential areas are situated in the southern end of the Shire and drain to upper Berowra Creek, Tunks, Still and Calabash Creeks; while along the south-western edge similar areas drain to Colah and Fiddletown Creeks then via Marramarra Creek to lower Berowra Ck close to the Hawkesbury River.

2.2 Lane Cove River Catchment

Seven local government authorities have jurisdiction over the Lane Cove River Catchment. Only the upper reaches of the Lane Cove River Catchment are within Hornsby Shire; this includes Devlins Creek, and the subcatchment is bounded by the upper Lane Cove River and Terrys Creeks. This catchment is dominated by developed urban landuses and some commercial areas as well as bushland areas such as the upper parts of Lane Cove National Park. This is Council's only catchment that drains to Sydney Harbour.

2.3 Cowan Creek Catchment

Within the Cowan Creek catchment there are four Local Government Areas. The western boundary of Cowan Creek Catchment, defined by the Pacific Highway, lies within Hornsby Shire. Cockle Creek and Cowan Creek themselves form part of the Shire boundary. Land uses in the southern part of this area include extensive light industrial areas, large commercial shopping centres and developed urban areas. Kuring-gai Chase National Park also covers a large part of the catchment.

2.4 Hawkesbury River Catchment

The Hawkesbury River Catchment within Hornsby Shire is divided into two areas which include the Wisemans Ferry/Maroota region as well as the Brooklyn area. These areas drain directly to the Hawkesbury River. Landuses in this area include small farming ventures, market gardening, residential, marinas, boat ramps, aquaculture and fishing (commercial and recreational). A sewage treatment plant (STP) was recently commissioned by Sydney Water at Brooklyn to treat water from Brooklyn, Mooney Mooney, Cheerio Point and Dangar Island residences. The discharge of treated effluent from the STP started in late 2007 into the Hawkesbury River from the highway bridge into an area of strong tidal current.

Photo 1: Aerial view of Sandbrook Inlet at Brooklyn with rail bridge over the Hawkesbury River in the background

3 Water Quality Monitoring Program

The objectives of this program are to:

- Undertake long term monitoring of water catchments within Hornsby Shire to assess trends in water quality from both point and diffuse pollution sources, with emphasis on understanding causes and effects of algal blooms in the Berowra Estuary.
- Compare the observed water quality data with undisturbed catchments in nearby National Parks, and with nationally accepted Guidelines for fresh and marine waters; specifically for the water values associated with the *protection of aquatic ecosystems,* with *recreational water uses,* and for *stormwater reuse projects*.
- Use biological monitoring at representative sites to complement the water quality program. (Indicator species utilised are Macroinvertebrates, Diatoms and Planktonic Algae)
- Determine the effectiveness of Catchments Remediation assets in removing pollutants from the waterways.
- Support water savings programs, including water treatment and reuse projects at swimming pools and old landfill sites, and stormwater harvesting and reuse projects at sports ovals.
- Use water quality data to calibrate and support catchment/pollutant modelling and assist with environmental education programs.

The Hornsby Shire Council water quality monitoring program commenced in October 1994 in response to increasing concern about algal blooms in the Berowra Estuary and tightening of water pollution regulations. Council scientific staff has carried out inspections, on-site water testing and water sample collections at all sites since the program's inception. Collected waters are sent for more detailed analysis at specialist industry accredited laboratories.

Sampling site locations have generally remained unchanged since the program began. Additional sites have been progressively added in order to monitor the effectiveness of devices installed by Council to improve the quality of stormwater and landfill leachate entering local creeks, and to assess water quality in the Hawkesbury River prior to and after commissioning of the new sewage treatment plant at Brooklyn.

The water monitoring program involves systematic sampling to a predetermined regular, usually monthly, schedule over the year. Sampling is done during daylight hours (8am to 3pm) on weekdays, and covers all seasons and both wet and dry periods. This report does not include results from any additional specific targeted investigations, e.g. sampling a reported pollution incident carried out by Environmental Health Officers.

Annual water quality monitoring reports have been produced since 1996. This report addresses water quality investigations during the July 2010 – June 2011 sampling period.

Reports are available in printed format in local libraries. Reports for recent years can also be accessed on Council's web site at http://www.hornsby.nsw.gov.au/environment/ (choose subcategories "Water Catchments" then "Water Quality").

Diatom and Macroinvertebrate monitoring to assess the impacts of contaminated waters on the streams ecosystem health was recommenced. The focus of studies during 2010-2011 was to better characterise References sites.

An important project, initiated as part of the Council-lead Estuary Management Program, was the installation of a number of chlorophyll monitoring probes which report real-time data and provide an indication of any change in algal activity and salinity in estuarine waters. One probe has been operating since 2002 in the upper Berowra Estuary near Calabash Bay. Over the last few years, additional probes with temperature, salinity and chlorophyll sensors have been installed in the lower Berowra Estuary near Bar island and in the Hawkesbury River between Wisemans Ferry and Broken Bay (HSC, 2010a). If high chlorophyll-a readings occur Council officers respond by taking additional samples for algal identification. If harmful species are identified in high numbers Council then works in collaboration with the Regional Algal Co-ordinating Committee to monitor the bloom and inform the community of possible risks or estuary closures. The real-time data generated by these monitoring probes can be seen on Council's website for Calabash Bay at http://mhl.nsw.gov.au/projects/berowra/latest.php , and, for the Hawkesbury River, at http://mhl.nsw.gov.au/projects/hscsal/.

Autosamplers and stormwater flow gauging sensors were set up to better assess the effectiveness of selected CRR devices to clean up stormwater. An initial project, commenced in 2011, was aimed at representatively sampling stormwater run-off from the Pacific Highway into Hornsby Park. It is planned to send samples to the University of Queensland which is undertaking a detailed Australian-wide study of risks and health issues of using harvested stormwater.

4 Water Quality Guidelines

The water quality data obtained in Hornsby Council's monitoring of freshwater creeks and estuaries are compared with current National Guidelines for water quality; these are set down in the National Water Quality Management Strategy (NWQMS) and by the National Health and Medical Research Council (NHMRC). Specifically the water values of *aquatic ecosystem protection* and *recreational water use* within local creeks and estuaries are of most relevance to Council's water quality monitoring program. Council's long term monitoring is now being used to develop Regional Environmental Health Values (REHV) for local freshwater creeks.

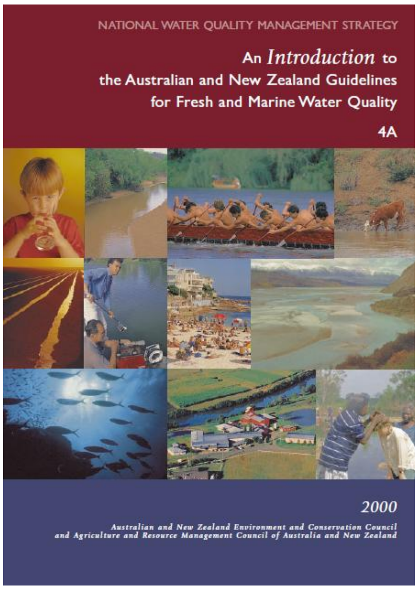
Algal bloom monitoring in the estuarine sections of Berowra Creek and Hawkesbury River involve regular sampling and identification of algal species; the results are compared with phytoplankton action levels set out in the NSW Food Authority Marine Biotoxin Management Plan. Council also operates a series of real-time chlorophyll monitoring probes in Berowra Creek and Hawkesbury River and has developed interim guidelines for management responses to high chlorophyll levels.

Stormwater harvesting systems are being increasingly used to irrigate Council assets. Based on draft National guidelines for stormwater harvesting and reuse, and on National guidelines for irrigation water quality, Council prepared an interim set of sampling and water quality Guidelines. These will be further developed over the next few years as research of risks and health aspects of stormwater harvesting, currently being conducted in collaboration with the Centre of Water Sensitive Cities, is published.

4.1 Aquatic Ecosystem Protection

The objective adopted for the *protection of aquatic ecosystems*, as defined by ANZECC/ARMCANZ (2000) in the NWQMS is to "maintain and enhance the 'ecological integrity' of freshwater and marine ecosystems, including biological diversity, relative abundance and ecological processes". Biological systems are extremely variable, and coupled with the marked differences in the sensitivity of different ecosystems and biological communities to particular pollutants and other stressors makes it important that management occurs on an ecosystem to ecosystem basis (ANZECC, 1992).

Consequently, this water quality monitoring program has included sampling sites located downstream of the various human activities and land uses throughout the Shire. In addition, *reference sites* are monitored which represent the water quality of typical local ecosystems which are essentially free of any anthropogenic impact and influences. These reference sites provide baseline data which, together with the ANZECC/ARMCANZ Guideline values, can be compared with creeks elsewhere in the Shire to determine the type and extent of impacts our activities and developments are having on our creeks and waterways.



Council's program involves measurement of a number of 'indicators' of ecosystem health; namely

- Physical and chemical quality of the water – physical-chemical parameters (e.g. pH, dissolved oxygen), suspended sediment, nutrients, biological oxygen demand, dissolved salts and trace metals
- Abundance of bacteria typically sourced from human faeces; faecal coliforms, E.Coli and/or enterococci, and
- Abundance and diversity of insect and algal indicator organisms. In the estuary the indicator organisms chosen are the planktonic algae and in the freshwater creeks they are the macroinvertebrates and diatoms.

The physical and chemical indicators of water quality have been chosen from the National Water Quality Guidelines. Prior to 2003 Hornsby Shire Council used the earlier, now superseded, ANZECC 1992 Guidelines as guidance for its monitoring program. After 2003 Council adopted the ANZECC/ARMCANZ (2000) Guidelines, specifically the values for "South-East Australia east flowing coastal rivers" (Freshwaters) and "Estuaries" (Marine Waters), with the default trigger values set for 'slightly to moderately disturbed' ecosystems. If water quality failed to comply with these criteria it indicates that the biological community in the waterway is under ecological stress.

The Guidelines (2000) recommend interim 'trigger' values for different regions around Australia, which, when sufficient data is available, should be replaced by Regional Environmental Health Values (REHVs) that should be developed after long term analysis of local reference sites. Hornsby Council now has sufficient data available from a number of local reference sites to develop its own Regional Environmental Health Values (REHV). The procedures used to develop the REHV by Council's Water Catchment Team will be detailed in a report to be finalised in early 2012. Table 1 below sets out these interim REHV and compares them with the ANZECC/ARMCANZ Guideline values that have been used for the annual reporting since 2003. The Guidelines (2000) will continue to be used for estuarine waters, as no suitable Reference Sites were available in local estuaries that enable us to better develop local estuarine REHVs.

The chosen water quality objectives reflect a Community expectation that creek ecosystems in the Shire's bushland areas should be maintained in a good condition. Unfortunately, the upper sections of creeks, fed by intensive industrial, urban and rural developments, have been historically highly disturbed, and much work remains to be done if those sites are to be returned to the 'slightly to moderately disturbed' category. In addition, major creeks and the estuary are downstream of the two major sewage treatment plants which continue to discharge waters containing nutrient concentrations well in excess of Guideline values.

Table 1: The Guidelines for the protection of aquatic ecosystem health: physical and chemical stressors.

Water Quality Parameter	Freshwaters	Freshwaters	Marine and Estuarine Waters
Guideline		ANZECC/ARMCANZ, 2000	ANZECC/ARMCANZ, 2000
	Interim Regional Environmental Health Values developed by Council based on Reference Creeks(3)	For slightly to moderately modified ecosystems	
pH	4.8 - 7.0	6.5 - 8.0	7.0 - 8.5
Conductivity	< 0.32 mS/cm	< 0.3 ms/cm	NR
Turbidity	< 8 NTU	< 6 NTU (1)	< 6 NTU (1)
Dissolved Oxygen	75 % to 118%	Between 85% and 110% saturation	Between 80% and 110% saturation
Temperature	-	Between 11.7 °C and 20.1 °C	NR
Salinity	-	NR	NR
Oxidised (NOx) nitrogen	< 0.05 mg/L	< 0.04 mg/L	< 0.015 mg/L
Ammonium Nitrogen	<0.02 mg/L	< 0.02 mg/L	< 0.015 mg/L
Total Nitrogen	< 0.32 mg/L	< 0.35 mg/L	< 0.3 mg/L
Total Phosphorus	< 0.01 mg/L	< 0.025 mg/L	< 0.03 mg/L
Soluble reactive Phosphorus	-	< 0.02 mg/L	< 0.005 mg/L
Suspended solids	<7 mg/L	< 6 mg/L(1)	< 6 mg/L((1)
Chlorophyll a	-	< 3 ug/L	< 4 ug/L (2)

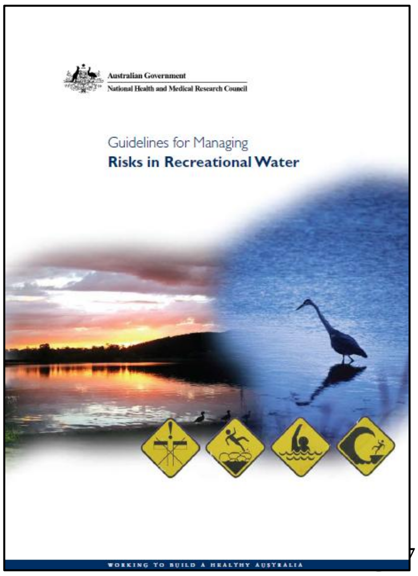
(1) ANZECC/ARMCANZ 2000. Vol 2 Section 8.2 NR – Guideline values have not been recommended

(2) Chlorophyll monitoring in Hornsby's estuaries is also being carried out through the Estuary Management Program using insitu probes (HSC, 2010a). Chlorophyll-a trigger values are being developed by Council specifically for Berowra Creek; current recommended values are <4 ug/L in Winter and <8 ug/L in Summer; if values exceed 16 ug/L further investigation is triggered to sample and identify the presence of potentially harmful algal species. (3) HSC (2011c). River Health Report Card – Hornsby Shire. Companion Technical Report. (draft only)

4.2 Recreational Water Quality

The National Health and Medical Research Council (NHMRC, 2008) have released Guidelines for Managing Risks in Recreational Water. The Guidelines represent a major revision of the previous Recreational Water Quality Guidelines (ANZECC, 2000) and concentrate on risk assessment and risk management in recreational waters. This approach requires information on the local influences on recreational water quality, as well as numerical information on the likely level of contaminants. The results can be used to:

- Classify beaches in order to support informed personal choice
- Provide on-site guidance to users on the relative safety of the water
- Assist in identifying and promoting effective management interventions
- Provide a basis for regulatory requirements, and an assessment of compliance with such requirements.



Relevant assessment parameters listed in the NHMRC Guidelines for recreational water quality are summarised in Tables 2 and 3. In addition to the parameters listed, Council measured a number of physical-chemical parameters (total phosphorus (TP), total nitrogen (TN), turbidity and electrical conductivity (EC)) which are related to the health of aquatic ecosystems and which impact on recreational water values, particularly aesthetic factors. The two sites monitored in Hornsby Shire for recreational water uses: are (1) Site 55 in the Hawkesbury River within Brooklyn Baths at McKell Park, Brooklyn and (2) Site 100 in Berowra Creek at Crosslands Reserve. As these are estuarine swimming sites they were assessed against those parameters listed in Table 1 under 'Marine and Estuarine Waters'.

Previous assessments by Council classified the recreational status of Site 55 Brooklyn Baths as "Low Risk" and of Site 100 Berowra Creek at Crosslands Reserve as "Moderate Risk" (HSC, 2010a). These classifications led to the summer 2010-2011 monitoring schedule described in this report.

Table 2: Summary of recreational water quality Guidelines (NHMRC, 2008)

Characteristic	Guideline	Comment
Microbial activity	Preventative risk management practices should be adopted to ensure that designated recreational waters are protected against direct contamination with fresh faecal material, particularly of human or domesticated animal origin.	The main health risks are from enteric viruses and protozoa. Bacterial indicators of faecal contamination monitored.
Cyanobacteria and algae	Coastal and estuarine recreational water bodies categories: **Surveillance Mode**: ≤ 1 cells/mL *Karenia brevis* and/or have history but no current presence of *Lyngbya majuscule* and/or *Pfiesteria* **Alert Mode**: 1-10 cells/mL *K.brevis* and/or have *L.majuscula* and/or Pfiesteria present in low numbers **Action Mode**: >10 cells/mL *K.brevis* and/or have *L.majuscula* and/or *Pfiesteria* present in high numbers	A situation assessment and alert levels framework for the management of alga/cyanobacteria in recreational waters has been developed that allows for a staged response to the presence and development of blooms
pH	6.5 – 8.5	A wider pH of 5 – 9 is acceptable for water with a very low buffering capacity
Dissolved Oxygen	> 80%	When considered with colour, odour and turbidity, dissolved oxygen is an indicator of the extent of eutrophication of the water body
Aesthetic aspects	Recreational water bodies should be aesthetically acceptable to recreational users. The water should be free of visible materials that may settle to form objectionable colour, odour, taste or turbidity; and substances and conditions that produce undesirable aquatic life.	Consumer complaints are useful guides to the suitability of water for recreational use.
Dangerous Aquatic Organisms	Direct contact with venomous or dangerous aquatic organisms should be avoided; Examples of species potentially in Hornsby estuarine recreational areas are sharks, stingrays and catfish.	Brooklyn Baths fenced to keep out larger fish.

Table 3: Classification of Recreation Water Environments (NHMRC, 2008)

<table>
<tr><th></th><th colspan="4">Microbial water quality assessment category (95^{th} percentiles – intestinal enterococci/100 mL)</th><th>Exceptional circumstances</th></tr>
<tr><td>Sanitary inspection category (susceptibility to faecal influence)</td><td>A
≤ 40</td><td>B
41-200</td><td>C
201-500</td><td>D
>500</td><td rowspan="7">ACTION</td></tr>
<tr><td>Very Low</td><td>Very Good</td><td>Very Good</td><td>Follow up</td><td>Follow up</td></tr>
<tr><td>Low</td><td>Very Good</td><td>Good</td><td>Follow up</td><td>Follow up</td></tr>
<tr><td>Moderate</td><td>Good</td><td>Good</td><td>Poor</td><td>Poor</td></tr>
<tr><td>High</td><td>Good</td><td>Fair</td><td>Poor</td><td>Very Poor</td></tr>
<tr><td>Very High</td><td>Follow up</td><td>Fair</td><td>Poor</td><td>Very Poor</td></tr>
<tr><td>Exceptional circumstances</td><td colspan="4">ACTION</td></tr>
</table>

There are a number of occasions in this report where the older, superseded Recreational Water Quality Guidelines in ANZECC/ARMCANZ (2000) are referenced. That Guideline recommended maximum concentration of Faecal coliforms for different contact activities as shown in Table 4.

Table 4: Bacterial levels for Recreational Water Uses (ANZECC/ARMCANZ, 2000)

Recreational Use	Guideline
Primary Contact – Direct water - contact sports , e.g. swimming	The median bacterial content in fresh and marine waters taken over a swimming season should not exceed: * 150 Faecal coliforms cfu/100mL (minimum of 5 samples per month, with 80% of samples less than 600 organisms/100mL)
Secondary Contact – Low contact sports, e.g. fishing, boating	The median bacterial content in fresh and marine waters taken over a swimming season should not exceed 1000 Faecal coliforms cfu/100mL (minimum of 5 samples taken per month, with 80% of samples less than 4000 organisms/100mL)

4.3 Estuarine Phytoplankton/Algal Bloom Hazards

The enormous productivity of marine waters is based on the variety and total mass of single celled microscopic algae collectively called phytoplankton. These organisms range in size from micrometres to millimetres and exist in their millions in the upper zone where sunlight is available for photosynthesis. They are a critical food source for bivalve shellfish and the larvae of commercially important crustaceans and fish. Through the process of photosynthesis primitive phytoplankton are thought to have generated the oxygen-rich atmosphere of Earth, and today phytoplankton help keep it replenished.

Algal "blooms" occur at times of optimum growth (light, warmth, nutrient availability) when the numbers of organisms may increase dramatically and can number in the millions of cells per litre. The blooms may turn the water green, brown, red or a milky colour, and the dead organisms may float to the surface causing oily scums, or can result in oxygen depletion at night or in deep underlying waters. Algal blooms are a natural phenomenon and occur at times in all our oceans and estuaries. It is generally believed, however, that algal blooms in The Berowra Estuary occur much more commonly now than they did prior to the intense urban and rural development in the catchment over the last 30 years and, in particular, before treated nutrient-rich sewage was discharged into Berowra Creek. Extra nutrients and ballast water releases have probably increased the variety of algal species. Some species, especially when they are in bloom proportions, have caused fish kills and affected shellfish harvesting. The increasing occurrence of blooms in the Berowra Estuary was the initial impetus for the introduction of the Catchments Remediation Rate by Hornsby Council in 1994.

Photo 2. Near Site 61 Berowra Creek at Calabash Bay.
Sampling an algal bloom using a net towed from a boat.

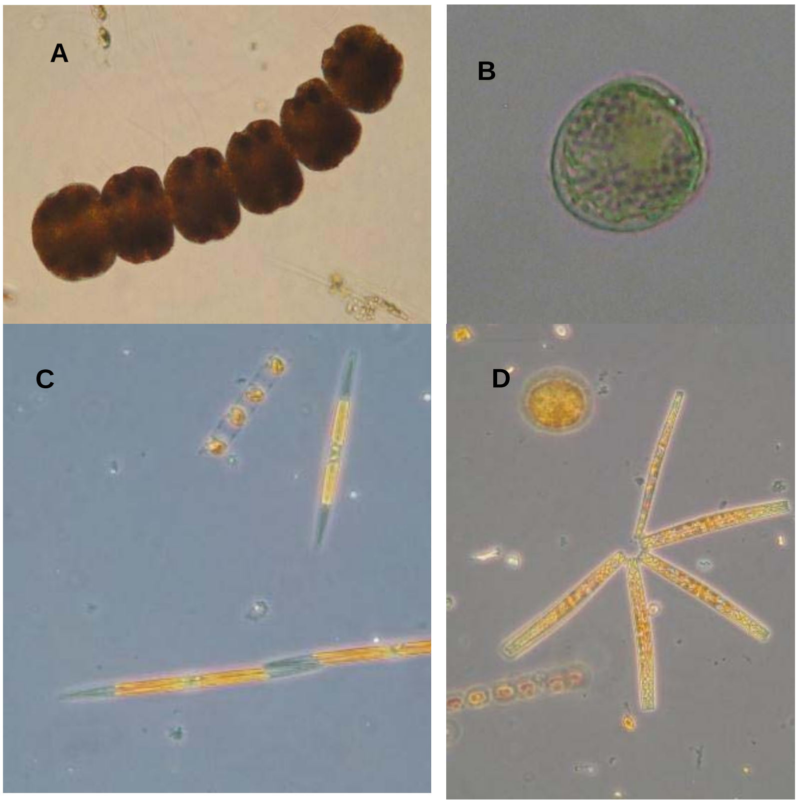


Photo 3. Phytoplanktonic algae as seen under a microscope.
A= Gymnodium sp; B = Prorocentrum sp; C= Pseudo-nitzschia sp
D = Thallasionema sp. Photos and identifications provided by S Brett of MicroAlgal Services Ormond, Victoria.

Most phytoplankton species are harmless to humans and marine life; however there are a small number of species that, especially when in high numbers, may be hazardous. Three types of problem microalgae are described by Hallagraeff (2002): (1) species that produce mostly harmless water discolorations (e.g. Noctiluca, Scrippsiella), (2) species that are non-toxic to humans, but harmful to fish or invertebrates by damaging or clogging their gills (e.g. Caetoceros, Heterosigma); and (3) species that potentially produce potent toxins that can find their way through the food chain to humans (e.g. Gymnodinium, Nitzschia, Prorocentrum). However, when they bloom, any algae, even "harmless species", can cause sudden severe reductions in dissolved oxygen resulting in fish deaths.

Hornsby Council's estuary monitoring program has included routine monthly sampling for the laboratory identification of phytoplankton species at Berowra Waters since 1999. In the earlier years, testing was restricted to the 6 most dominant species. In 2003, the program was improved to include identification of all abundant species as well as a specific search for potentially harmful species, even at low numbers.

The criteria against which the phytoplankton identifications are assessed in this program are based on those species which potentially cause harm to fish, invertebrates or humans. (NSW Food Authority, 2008; Brett, 2007; RACC, 2009). The NSW Food Authority (2008, Appendix 12) sets out recommended Phytoplankton Action Levels based on the concentrations of specific algal species that affect shellfish aquaculture. Whenever Council staff finds that these triggers are exceeded, the Regional Algal Co-ordinating Committee (RACC) is notified. This may result in closure of the estuary to fishing (by the Department of Primary Industries – Fisheries Division), or closure of shellfish harvesting (by the NSW Food Authority), and/or erection of public warning notices by Hornsby Council's Water Catchments Team. (see Note 1).[1]

Council's chlorophyll monitoring probes (section 5.4.1) enables real-time assessment of the development of algal blooms in The Berowra Estuary and assists managers in timely response. Council has developed preliminary guidelines for monitoring algal blooms based on Table 5 from Coad et al (2010). Recommended management actions are based on mean daily chlorophyll-a concentrations. Generally the initial response to elevated chlorophyll readings on the probes is to take water samples for laboratory algal identification and algal counts. The findings are compared with the Phytoplankton Action Levels of the NSW Food Authority (2008, Appendix 8) and actions taken as discussed in the previous paragraph.

Table 5. Management Response to Real-Time Chlorophyll Monitoring Probes from Coad et al (2010)

Threshold	CHLa Daily Mean Concentration (ug/L)	Example Bloom Management Response	Ecosystem Protection Risk	Management Mode: Summer	Management Mode: Autumn/ Spring	Management Mode: Winter	Management Mode Key
Extreme	64+	Estuary closure recommended	High >8ug/L				**Alert mode** **Bloom**= Seasonal Mean exceeded ≥ 3 consecutive days **Perturbation**= Seasonal Mean exceeded < 3 consecutive days
Very High	32 to 64	Secondary contact cautioned					
High	16 to 32	Primary contact cautioned					
Medium	8 to 16	Community alert					
Moderate	4 to 8	Agency alert	Moderate >4ug/L and < 8ug/L (HRC, 1998)	8ug/L	6ug/L		**Action mode** Increasing CHLa < Seasonal mean
Low	0 to 4	Estuary open	Low <4ug/L (ANZECC, 2000)			4ug/L	**Surveillance Mode** Decreasing or stable CHLa < Seasonal mean

[1] Note: The NSW Food Authority and the oyster growers frequently monitor water quality, including algal species, in the waters near the Oyster Leases in the Hawkesbury, Lower Berowra and Marramarra areas. Their monitoring results go through a similar review process. Council's chlorophyll and salinity monitoring probes provide valuable information to assist in the management of local aquaculture. However, Council's algal sampling program does not cover the same section of the Estuary.

4.4 Quality of Harvested Stormwater

In recent years, the need to conserve valuable drinking water and to reduce the impacts of urban stormwater on stream water quality and flows has led to increased harvesting of stormwater for reuse. Stormwater harvesting involves collecting storm runoff from parks, paved areas, drains and creeks. A number of such schemes have been constructed in Hornsby Shire in recent years mainly to provide irrigation water for sports ovals (HSW, 2010b). The catchment areas for harvesting are selected after a thorough investigation to ensure minimal risk to the downstream creeks or of capturing contaminated water.

A series of National Guideline documents on water reuse have been published under the National Water Quality Management Strategy. The most recent is Guideline for Stormwater Harvesting and Reuse (NRMMC, et al, 2009). The Guideline sets out processes to manage the risks of stormwater capture and reuse in terms of minimising health, environmental and operational risk. This Guideline has not yet been adopted by NSW State or Local Councils. An interim set of sampling and water quality parameters, based on the Guideline (NRMMC et al, 2009), together with the ANZECC/ARMCANZ (2000) Guidelines for irrigation waters is proposed within this Report for Hornsby Council purposes. The proposed parameters are set out in Tables 6 and 7 below.

Further development and research is underway through the Centre for Water Sensitive Cities (http://www.watersensitivecities.org.au/programs/cities-as-water-supply-catchments/about/program-outline/project-5/) which aims to resolve outstanding issues related to safe harvesting of general urban stormwater for both potable and non-potable use. Projects to better characterize risk will hopefully lead to improvement in water monitoring guidelines.

Table 7 proposes interim trigger values that, if exceeded, should lead to further investigations. Various strategies, such as irrigation scheduling or increased maintenance, may enable continued operation when parameters are above recommended trigger values.

Health risks are based on potential exposure of humans to pathogens and chemicals during reuse of water. Examples of types of exposure are: bodily contact with the harvested stormwater or inhalation of sprays/aerosols when water is reused for irrigation of playing fields, flushing toilets, in park fountains, or control of fires, etc.

Photo 4: Tanks at Epping Oval for holding stormwater harvested from nearby streets

Table 6: Interim Sampling Requirements for Stormwater Harvesting Projects

Pre-Development Sampling	As part of catchment surveillance water samples should be taken upstream of the proposed stormwater harvesting sites prior to the final design stage. Ideally samples should be taken at monthly intervals from end-of-pipe where the water will be harvested or from nearby downstream creeks. Presence of fluoride in the source water may indicate leaks from townwater supply; if such leaks are later repaired, the quantity and quality of collected 'storm' water could change.
Post-Development Sampling	Sampling points should be identified/installed to take water samples of (1) 'raw' (harvested) stormwater from storage tanks, (2) 'raw' water from the pipework immediately before it enters the sterilisation system, (3) 'treated' water as it exits the sterilisation system (e.g. immediately after the UV lamps), and (4) 'treated' water from the tanks used to hold the water prior to use. This enables measurement of raw and treated water quality, as well as the effectiveness of the sterilisation equipment.
Water testing Requirements	Testing can assess risks to soil structure, to infrastructure/irrigation equipment, the environment, and to human health. Where the stormwater includes runoff from urban or industrial areas, roads or sewered areas (with potential for sewer pipes to surcharge or septic seepages) or seepages from salt affected areas or landfill sites, water testing may need to be tailored to each situation.

Table 7: Interim Guidelines for Harvested Stormwater Reuse for Open Space Irrigation, giving Triggers for Further investigation

	Parameter	Trigger	Notes
Catchment issues	Fluoride[+#]	0.1 mg/L	Presence of fluoride may point to leaking fluoridated townwater. (e.g. Fluoride of 0.3 mg/L implies about 30% townwater)
Soil Structure Risks	Salinity/ Conductivity[+#]	2000 uS/cm (for very sensitive plants)	Irrigation of sensitive plants. Salt tolerance depends on sand/clay content of soils, and on plant species being grown.
	Sodicity[+#]	Na 114 mg/L	Acceptable SAR depends on value of conductivity. Waters with high SAR might induce degradation of soil structure by clay aggregate breakdown. Potential problems may be overcome by corrective management (e.g. application of lime or gypsum)
	Sodium Absorption Ratio (SAR)[+#]	SAR 2 (at EC=200 uS/cm) SAR 7 (at EC=2000 uS/cm)	
	Chloride[+#]	Cl 175 mg/L	
Infrastructure/irrigation equipment risks	Turbidity [O]	Turbidity 10 NTU	Effectiveness of UV treatment decreases as turbidity increases.
		20 yr life / **100 yr life**	
	Total suspended solids (mg/L)[# *]	50 / 20	Potential blockages of irrigation pipes and jets
	Hardness (mg CaCO3/L) [+#]	350 / 350	" "
	Total Iron [#]* (mg/L)	10 / 0.2	" "
	Total Phosphorus [#]* (mg/L)	0.8 / 0.05	" "
Health Risks (DEC, 2006. Table 6.4, Level 2)	**Reference** Bacteria *[+O] (Median Values)	Faecal coliforms 10 CFU/100mL[x] E. coli 10 CFU/100mL	Test initially fortnightly, then reduce to monthly if median <10. But increase back to fortnightly after any result > 100.

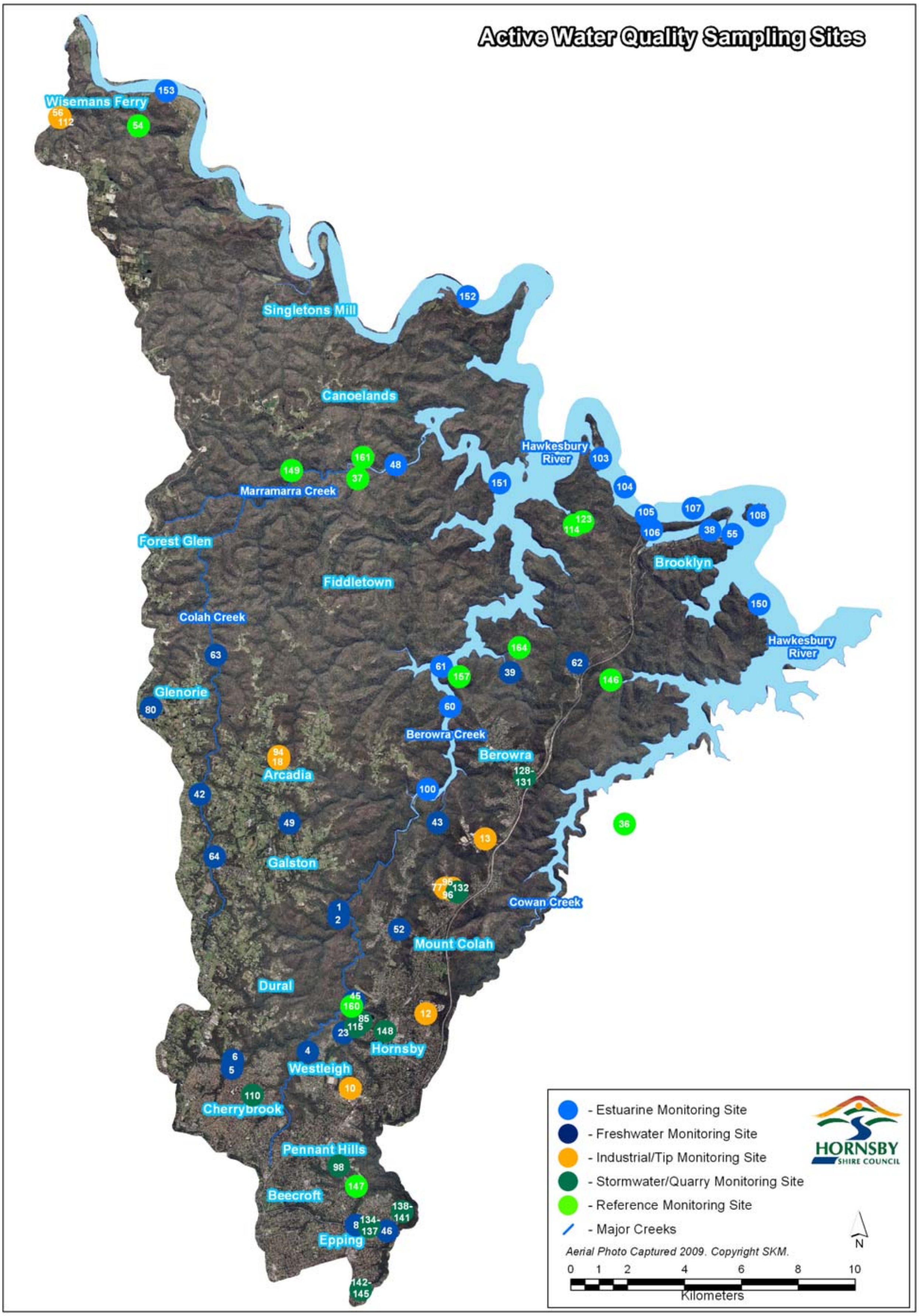
Notes: + Testing of raw harvested water; o Testing of raw water feed to sterilisation unit

* Testing of 'final' treated water before use; # Predevelopment and occasional operational testing (e.g. Biannual)

x Faecal coliforms measured as a more conservative indicator than the E.coli (which is recommended in NRMMC Guideline)

5 Water Sampling Sites

Figure 2: Aerial view of Hornsby Shire showing Location of Water Quality Monitoring Sites (2010-2011)



5.1 Freshwater Sites

Freshwater streams and creeks were selected according to the catchment landuse type. The sampling site on each waterway was chosen based on reliability of stream flow, accessibility and ability to monitor during stormwater flows.

Sites shown in Table 8 were monitored for physical, chemical and bacterial parameters. Water sampling occurs each month at the majority of the freshwater sites. Three of the freshwater sites are located close below industrial/commercial areas and are therefore considered to be under more intense landuse pressure and subsequently require a more frequent sampling regime to detect the full range (extremes) of water quality. Thus, they were monitored at fortnightly intervals.

Table 8: Location of Monitoring Sites on Freshwater Streams sampled in 2010-2011

Site	Location and Access	Sampling Frequency	Catchment
1	Berowra Creek, 200m downstream of concrete road bridge at Galston Gorge	Monthly	B
2	Tunks Creek, Galston Gorge under wooden truss bridge	Monthly	B
4	Berowra Creek, Westleigh 500m S along Great North Walk off end of Barkala Pl	Monthly	B
5	Pyes Creek, Cherrybrook, end of Kristine Place	Monthly	B
6	Georges Creek, Dural, off Fallon Drive on Sydney Water land	Monthly	B
8	Devlins Creek, Sutherland Rd, Cheltenham, 200m downstream of M2	Monthly	LC
10	Larool Creek, Sefton Rd, Thornleigh behind playground	Fortnightly	B
12	Hornsby Creek, upstream of Leighton Pl road bridge, Hornsby	Fortnightly	C
13	Sams Creek, Hamley Rd, Mt Kuring-gai 25m downstream of trash rack	Fortnightly	B
23	Waitara Creek, at fire trail causeway 100m upstream from WHSTP outfall, Hornsby	Monthly	B
36	Murray Anderson Creek, by boat off Smiths Creek (Reference)	Monthly	C
37	Smugglers Creek, by boat/walk off Marramarra Creek (Reference)	Monthly	B
39	Joe Crafts Creek, above confluence with Berowra Creek	Monthly	B
42	Colah Creek, near of Wylds Road bridge, Glenorie	Monthly	B
43	Calna Creek, above confluence with Berowra Creek. Walk in from Crosslands	Monthly	B
45	Berowra Creek, at upper end Fishponds Waterhole, Hornsby at stepping stones	Monthly	B
46	Unnamed tributary of Terrys Creek, track from eastern end Somerset St, Nth Epping	Monthly	LC
49	Still Creek, end of Mansfield Road downstream tennis court	Monthly	B
52	Calna Creek, down Pikes Road Hornsby, 300m upstream of HHSTP outfall	Monthly	B
54	Laughtondale Ck, off Laughtondale Rd, Marramarra Nat Pk (reference)	Monthly	H
62	Cowan Township drainage, upper Kimmerikong CK, walk from Alberta Ave	Monthly	B
63	Colah Creek, at end of fire trail off Ben Bullen Road Glenorie	Monthly	B
64	Galston Village drainage, unnamed creek, tributary of Colah Ck near Salaway Place	Monthly	B
77	Gleeson Creek, causeway crossing at end of Oxley Dr, Mt Colah	Monthly	B
80	Glenorie Creek, Tekopa Ave, Glenorie. Pipe inlet upstream of GPT	Monthly	B
85	Hornsby Quarry – pumped water (discharged from Quarry site into Old Mans Ck)	Monthly +	B
114	Muogamarra Ck, at walking track crossing, flowing to Peats Bight (Reference)	Bimonthly	B
115	Old Mans Creek, at fire trail crossing off Rosemead Rd	Monthly +	B
122	Upper Calabash Ck below Arcadia Tip, Arcadia	Quarterly	B
123	Creek draining Peats Crater in Muogamarra Nature Reserve (Reference)	Bimonthly	B
146	Yatala Ck flowing into Jerusalem Bay, access by boat at high tide(Reference)	Bimonthly	C
147	Unnamed creek in Lane Cove Nat Pk, flowing into Byles Ck (Reference)	Bimonthly	LC
149	Unnamed creek end Duckpond Ridge Trail in Marramarra National Pk (Reference)	Bimonthly	B
157	Unnamed Ck flowing into Deep Bay Berowra Waters. (Reference)	Quarterly	B
160	Unnamed creek flowing from Joes Mt Saddle to Fishponds (Reference	Quarterly	B
161	Unnamed Ck flowing from Canoelands into Marramarra Ck (Reference)	Quarterly	B
164	Unnamed creek flowing into north arm of Joe Crafts Ck; at Djarra Crossing (Ref)	Bimonthly	B

KEY: B – Berowra catchment LC – Lane Cove catchment C – Cowan catchment H – Hawkesbury R

+ - Hornsby Quarry Discharge monitoring. Sampling in response to pump operations.

Table 9: Land Use Classifications and Associated Freshwater Creek Sample Sites

Land Use	Sample Sites
Undisturbed Land (Reference Sites)	36, 37, 54, 114, 123, 146, 147, 149, 157, 160, 161, 164
Urban area	4, 5, 6, 8, 39, 46
Discharge of Sewage Treatment Plants	1, 23, 52, 53, 45
Commercial / Industrial	10, 13, 12, 77
Rural	2, 40, 42, 49, 62,63, 64, 80
Estuary	38, 48, 55, 60,61, 100, 103, 104, 105, 106, 107, 108
Recreation - swimming	55, 100

5.2 Estuarine sites

Estuarine sites are sampled to assess algal blooms, ecosystem health (EH), recreational water quality (REC) and impacts of Brooklyn STP outfall. The sites monitored on a regular basis are described below.

Table 10: Location of Estuarine water quality monitoring sites – ecosystem health. Sampled in 2010-2011

Site	Location	Monitoring Status	Freq
38	Sandbrook Inlet, Brooklyn, Hawkesbury River	EH	M
48	Marramarra Creek in Marramarra NP near old orange orchard	EH	M
55	Hawkesbury River at Brooklyn Baths	REC	W
60	Berowra Creek, 50m downstream of Berowra Waters Ferry	EH	M
61	Berowra Creek, mid stream at Calabash Point	EH, Real-time Probe	M
100	Berowra Creek at Crosslands Reserve (north beach)	REC, EH	W, M
103	Mouth of Milsons Passage (Eastern end)	STP	M
104	Middle of Hawkesbury River off Peat island	STP	M
105	Under old Hawkesbury River Bridge; 2nd pylon Southern end	STP	M
106	Middle Sandbrook Inlet, off Fenwick's Marina	STP	M
107	Middle Hawkesbury River north off centre of Long Island	STP	M
108	Hawkesbury off Bradleys Beach Dangar Island	STP	M
150	Hawkesbury River off Gunyah Point	Real-time Probe	~M
151	Mouth of Marramarra Ck mouth, junction with Berowra Ck	Real-time Probe	~M
152	Hawkesbury River off Courangra Point	Real-time Probe	~M
153	Hawkesbury River, near Laughtondale	Real-time Probe	~M

M = monthly throughout the year
EH= Long term environmental health
STP = Brooklyn STP monitoring program
W = weekly over summer for recreational monitoring.
REC = Summer recreational Monitoring

Photo 5: canoe-fishing on Berowra Creek at Crosslands Reserve

5.3 Water Treatment Sites

In addition to routine water quality monitoring of fresh and estuarine waters, the Water Catchments Team monitors water quality associated with selected CRR projects. Table 11 shows the sites routinely sampled in conjunction with the projects. The project sites include:

- Constructed wetlands to treat stormwater
- Leachate collection and treatment devices at old landfill sites
- Harvested stormwater used for irrigation of sports ovals and plants at Pennant Hills Nursery
- Stormwater event sampling

Table 11: Location of CRR Devices, leachate treatment devices and stormwater harvesting sites sampled in 2010-2011

Site	Location	Frequency	Catchment
18	Arcadia Tip Leachate Pond	Quarterly	Berowra
56	Wisemans Ferry Tip Leachate Pond	Quarterly	Hawkesbury
94	Arcadia Tip Treated Water Tank	Quarterly	Berowra
95	Foxglove Oval – collected landfill leachate	Monthly	Berowra
96A, 96A2	Foxglove Oval – bioreactor output water	Monthly	Berowra
96	Foxglove Oval – treated leachate, after wetland	Monthly	Berowra
132	Foxglove Oval - Treated Water – in storage tank for oval irrigation	Monthly	Berowra
98	Council Nursery – Treated stormwater - reuse water	Monthly	Lane Cove
110F	Lakes of Cherrybrook – lower Lake at observation platform	Monthly	Berowra
112	Wisemans Ferry Tip, Riser 'C' below wall	Quarterly	Hawkesbury
120	Greenway Park Cherrybrook, raw harvested stormwater	Monthly	Berowra
121	Greenway Park Cherrybrook, treated harvested stormwater	Monthly	Berowra
128	Berowra Park Oval - Raw harvested stormwater in underground tank	Monthly	Berowra
129	Berowra Park Oval - Raw stormwater – input to UV treatment	Quarterly	Berowra
130	Berowra Park Oval – Treated stormwater – output from UV	Quarterly	Berowra
131	Berowra Park Oval – treated stormwater - in storage tank	Monthly	Berowra
134	Epping Oval – Raw stormwater in underground tanks	Monthly	Lane Cove
137	Epping Oval – Treated stormwater in above ground tank	Monthly	Lane Cove
138	North Epping Oval – Raw stormwater in underground tank	Monthly	Lane Cove
141	North Epping Oval – Treated stormwater in underground tank	Monthly	Lane Cove
142	Somerville Oval - Raw stormwater in underground tank	Monthly	Lane Cove
145	Somerville Oval - Treated stormwater in underground tank	Monthly	Lane Cove
148	Stormwater outlet from Pacific Highway into Hornsby Park	Storm Events	Berowra

Photo 6: Site 98 Council's Nursery at Pennant Hills. Stormwater is captured, treated and stored for use on site for nursery irrigation and toilet flushing. The mauve pipes differentiate the stormwater and potable townwater supply.

5.4 Other Water Quality Test Programs

5.4.1 Chlorophyll and Salinity Monitoring Probes in Estuarine Waters

Council operates water quality monitoring probes in The Berowra Estuary and Hawkesbury River to support the Estuary Management Program. The probes capture continuous real time data on temperature, salinity and chlorophyll which is used by state and local government to assist in managing algal blooms and to assess and improve current management practices within the estuary. Council joined with Manly Hydraulics Laboratory (MHL) in 2002 to deploy a remote monitoring probe (YSI 6820 Sonde) at Calabash Bay. In the last 3 years additional probes have been installed in the Hawkesbury River at Laughtondale, Courangra Pt and Gunyah Pt and at the mouth of Marramarra Creek. Data collected by the probes are supplemented by regular (each time the probes are serviced at 3 to 4 weekly intervals) testing and sampling for physical-chemical parameters and identification of species density and diversity of planktonic algae.

Results of the program are described elsewhere (see the Estuary Management Program Annual Reports e.g. HSC, 2011a). All data from the probes is available and displayed (updated every 6 hours) on Council's estuary website (http://www.hornsby.nsw.gov.au/environment/water-catchments/hawkesbury-estuary/environmental-monitoring-in-the-hawkesbury-river) .

5.4.2 Storm Event Sampling and Stormwater Quality Investigations

The Water Catchments Team plan to set up water monitoring around a number of the recently installed CRR devices. The aim will be to study the improvement in the quality of stormwater as it passes through selected treatment devices. For example, the bioremediation basins are claimed to reduce suspended sediment and nutrients. However, it is not a simple matter to monitor the effectiveness of the basins. Water only flows through the basins during storms, so it is necessary to set up auto samplers at the inlet and outlet of the basins, in order to take representative water samples throughout the storm events. To achieve this two ISCO 6712 Autosamplers and flow gauging equipment were purchased. During this reporting period only preliminary studies, mainly to gain experience with the auto samplers, have been carried out with the equipment set up at a stormwater outlet pipe in Hornsby Park. Stormwater flowing from a section of Pacific Highway outside Council Chambers has been sampled on a number of occasions.

Council's CRR team is a partner in an Australian-wide program, co-ordinated by the Centre for Water Sensitive Cities, Monash University, which aims in part to improve understanding of stormwater, its treatment and use. One of the programs is assessment of risk and health issues in stormwater harvesting. (e.g. see http://www.watersensitivecities.org.au/programs/cities-as-water-supply-catchments/about/program-outline/project-5/). This program, funded by the Centre for Water Sensitive Cities, is being carried out at the University of Queensland. To assist that program Hornsby's CRR Team has been asked to provide representative samples of stormwater collected from a stormwater outlet in Hornsby Park for detailed chemical, microbial and toxicity testing.

Photo 7. Site 148. Autosampler set up in Hornsby Park near a stormwater outlet to collect representative samples of running off Pacific Highway during storms.

5.4.3 Hornsby Quarry Discharge Program

Hornsby Quarry, close to the central business district of Hornsby, was a source of hard rock for various uses but mainly road base and gravel. Mining commenced in the early 1900s but the operation became increasingly unviable in recent years. Council was obliged to purchase the area from CSR Limited in 2001.Since mining ceased the quarry excavation has been slowly filling with rainfall and groundwater seepages. For further information see: http://www.hornsby.nsw.gov.au/planning-and-building/hornsby-quarry

Geotechnical investigations predicted that rising waters in the quarry could increase the instability of the steep walls. In order to keep the water level below the recommended maximum depth Council commenced a pumping operation in late 2009 to discharge quarry water into Old Mans Creek. The pumping operates under a Dewatering Groundwater Licence issued by the (then) Department of Water and Energy and with agreement of the (then) Environment Protection Authority.

In 2009 Council's Water Catchments Team commissioned to review of impacts and environmental risks of dewatering Hornsby Quarry (Ecowise, 2010). Out of this report a monitoring program was developed to assess impacts of the quarry discharge. This involves monitoring the water quality in the quarry water body, the discharged water, and downstream receiving creeks. The results of this monitoring are to be reported separately to the Works Division, and are not included in this report.

Photo 8: Panorama of Hornsby Quarry showing the water-filled pit. The white walls just above the water surface show where the water level has been lowered by pumping.

5.4.4 Berowra Waters Drinking Water Supply

The town water supply to Berowra Waters is managed by Hornsby Council's Works Division. Council takes the water from Sydney Water's main at Berowra and pipes the water down to Berowra Waters for distribution to residences and public areas. The water quality is sampled and tested regularly under contract by a specialist laboratory, which reports monthly to the Works Division. The quality must satisfy the requirements of the Australian Drinking Water Guidelines (NHMRC et al. 2004). Results of the program are not included in this report.

6 Sampling and Testing Procedures

6.1 Physical-chemical Parameters

Water quality parameters routinely measured include temperature, pH, conductivity, salinity, dissolved oxygen and turbidity. In-situ measurements are made using a YEOKAL 615 Water Quality Analyser. The instrument is calibrated in accordance with manufacturer's specifications at the commencement of each sampling day, and checked at the end of the day to identify and correct for any instrumental drift.

At each water testing site general observations are made on weather conditions, rain, tide, nuisance organisms, oily films, froth, odours, stream flow, water clarity, colour and sample site details. These observations and portable analyser measurements are recorded in the field on a pocket PC for later download into Council's database.

6.2 Chemical, Bacterial and Algal Parameters

A number of different sample bottles, provided by the contract laboratories, are used to collect samples at each site. Water samples are taken directly into the plastic bottles with the bottle mouth directed into the flowing water. At freshwater sites the sampling depth is 5 -10cm below the water surface, and at saltwater sites about 50cm. Samples for microbial testing (for faecal coliforms and/or enterococci) are taken in sterile 250mL containers which contain a trace of thiosulphate. The sample for suspended solids is collected in a 1 litre HDPE bottle. Water samples for chlorophyll-a analysis are taken at selected sites in 1.25 litre clear PET bottles. Water samples for trace metal analysis are collected in 200mL PET bottles without preservative. Samples for nutrient analysis are taken on 200mL PET bottle without preservative. Samples for major cation and anions are taken in a 200mL PET bottle. In all the above sample bottles an air gap (~ 5%) is left. Samples for bicarbonate/alkalinity are taken in a 600mL PET bottle filled completely to remove all air. Immediately after collection all the water bottles are placed in cooler box with ice bricks.

At each site, after all water samples have been collected, the Yeokal data and general observations are recorded as described in section 6.1 above. At the end of each sampling day the bottles are repacked in coolers with crushed ice and dispatched by Courier to arrive at the Laboratory by 4pm.

Algal identification at the estuarine sites involves sampling from the top one metre using a 1m long plastic bailer tube and transferring the sample to a 600mL PET bottle containing Lugols preserving solution. In addition, a concentrated algal sample is collected using a 30 micron mesh net. The net is towed behind the boat for about 5 minutes at slow speed. The contents of the net's collection vessel are washed to a 200mL PET bottle containing Lugols solution. These samples are packaged safely in bubble wrap and sealed in double plastic bags then sent by overnight postal express to the testing laboratory in Victoria for identification and abundance of major and nuisance phytoplankton species.

Photo 9. Equipment used for collecting water samples and recording in-situ water quality information

Laboratory Chemical and Bacterial Testing

Chemical and bacterial analyses were carried out by the contract laboratory Sydney Water Monitoring Services, West Ryde. Table 12 sets out the parameters measured, detection limits and testing methods:

Table 12: Laboratory Parameters: Reporting Limits and Test Methods

Water Quality Parameter	Units of reporting	FRESHWATER Reporting limit	ESTUARINE WATERS Reporting limit	Test Methods
Suspended solids	mg/L	2	2	APHA 2540 D. Filtration, gravimetric
Chlorophyll a	ug/L	2	2	APHA 10200 H Filtration, extraction, spectrometry
Faecal coliforms	CFU/100 mL	1	1	APHA 9222 D. Membrane filtration, culture
Enterococci	CFU/100 mL	1	1	AS 4276.9 (2007) by Membrane filtration, culture
Oxidised nitrogen (NOX-N)	mg/L	0.01	0.01	APHA 4500 NO3 I, by FIA
Ammonium Nitrogen (NH3-N)	mg/L	0.01	0.01	APHA 4500 NH3 H, by FIA
Total Nitrogen and Total Phosphorus	mg/L	0.05 0.002	0.05 0.002	APHA 4500 PH and NO3 I, by FIA
Soluble Reactive Phosphorus	mg/L	0.002	0.002	APHA 4500 P G. Colorimetric by FIA
Trace metals, Cations	ug/L or mg/L	various	-	USEPA 6010 by ICP-AES, USEPA 6020 by ICP-MS, APHA 3112 B by FIMS
Major anions and Bicarbonate	mg/L	various	-	APHA 4110 B (mod) by IC and APHA 2320 B by Titrator
Biological Oxygen Demand (CBOD5)	mg/L	2	-	APHA 5210 B by DO probe
Total Organic Carbon	mg/L	0.2	0.2	APHA 5310B combustion
Fluoride	mg/L	0.01	-	APHA 4110B (mod) by IC
Hardness	mg/L	0.5	-	APHA 2340C titration

6.3 Quality Assurance/Quality Control

To ensure accurate *in-situ* measurements, the Yeokal probe sensors are calibrated in the morning prior to each sampling run using commercially available standard solutions and check tests as shown in Table 13. Calibration is checked in the afternoon after each sampling run; correction factors are applied to probe data if sensor calibration drifted by more than accepted daily variation listed in Table 13.

At each sample site the information on date, time, site details, visual observations and probe readings are typed into a hand-held computer, and later downloaded to desktop PC for entering into Council's database. In the field, the probe readings are also stored in the probe memory for later downloading as 'back-up' data.

The contract laboratory supplies new bottles for taking water samples. The date and unique sample identification number is printed on adhesive labels immediately before sampling. After the water samples are taken the sample bottles are immediately placed in cooler boxes with freezer blocks. After returning from the field the bottles are repacked in ice, a Chain-of-Custody form is completed and attached to the cooler, and couriered to the laboratory by 4 pm on the day.

In addition, each month a duplicate field sample is taken at a random site. This effectively provides two samples of the same water which are labelled differently. The results from laboratory analysis provide an indication of the combined variability of water quality at a site and of variability of the laboratory testing procedures.

Further, every month "field blanks" are sent to the laboratory for analysis. Field blanks are sample bottles filled with high purity deionised water before the run, packaged and sent to the laboratory with the river water samples for analysis of all parameters. The results provide an indication of the contamination from the sample bottles or due to transportation and field handling, and provides a check of the lab's handling, analysis and detection limits.

The contract laboratory also has its own comprehensive quality control program. With each daily batch of samples for each test parameter the laboratory includes extra QA/QC samples including replicate tests, lab blanks, spiked samples and lab check samples, which must all pass in-house QC standards before results are released. Test reports provided to Council included all QA/QC test results. This information was assessed and stored by the Council's Water Catchments Team.

Table 13: Sampling and Probe Calibration Quality Assurance and Quality Control Procedures

Sampling	Only use new bottles supplied by lab. Store empty bottles with lid fitted in sealed bag in boxes to keep dust free.	Attach unique label identifers on all bottles before sampling	Sample with bottle opening into moving water. Upstream water not disturbed. Hands held away from bottle opening.	Sample bottles cooled immediately in Esky with ice bricks	Chain of custody form. Rapid courier to Lab
Observation and field probe results	On-site entry of all data. Type into hand-held PC.	Probe data entries checked by second operator	Download hand held PC to desktop PC for review and direct entry into database spreadsheet	Store probe data in PC as backup.	Carry paper forms for hand recording of field observations in case of probe or PC failure
OHS in Field	Follow SWMS procedures	Minimum 2 officers. Senior First Aid	Sampling run planned and notified to office before run.	Mobile phone or satellite phone. Communication with office.	
Laboratory results	Receive results by email.	Check data and QA/QC sample results and add data to master database	Store raw lab results files as backup files if needed to later trace anomolous results	Query Lab re unusual or suspect results immediately	
Probe Tests	**Low Value Calibration**	**High Value Calibration**	**Check Solution. Tested immediately after calibration**	**Daily Calibration check before and after each day's sampling**	**Accepted daily variation (low/high). If exceeded recalibrate sensor, or correct data for drift. (Low/High)**
Temperature	Quarterly in range 3 to 7oC	Quarterly in range 40 to 45oC		One point check against standardised thermometer in water bath	0.2/0.2 oC
EC	Daily 0 uS/cm (DI water)	Daily 1413 uS/cm (commercial)	Sydney tap water	Low and high cal check before and after probe use	1/15uS/cm
Salinity	Daily 0 ppt (DI water)	Daily 35 ppt (commercial)		"	0.01/0.5ppt
DO	Monthly 0% sat (zero DO sensor insert)	Daily 100 % sat (air bubbled in tank of tap water)		"	0.5/5%
pH	Daily pH7 (commercial)	Daily pH10 (commercial)	Daily pH 4 and diluted pH 7 (commercial)	"	0.1/0.1 pH units. Correct pH for temperature variation.

7 Water Quality Monitoring Results

7.1 Introduction

The program of monitoring freshwater creeks and estuary has been designed to obtain data suitable for assessing water quality according to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/AMRCANZ, 2000) and the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008). The test results can be used to identify trends in the quality of water at sites and to highlight the impact of land use on receiving water quality. Since the commencement of the water quality monitoring program in 1994, Hornsby Shire has experienced considerable population growth. Rapid increases in population intensify the pressure on nearby waterways. Hornsby Council has endeavoured to alleviate the stress placed on waterways by undertaking catchment remediation works throughout the Shire, by imposing strict development construction procedures and consent conditions, auditing environmental aspects of industrial and commercial businesses and on-site septic systems, and by carrying out community education programs.

7.2 Presentation of monitoring data

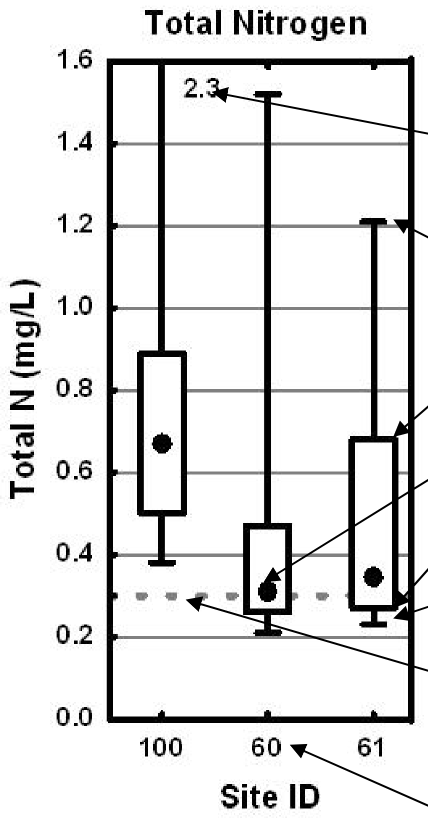
Water quality monitoring has occurred at many sites at numerous times throughout the year for many parameters, generating a large database. Presentation of such large amounts of data is not the role of this Annual Report. Rather, the aim of this report is to provide summaries and trends. To do this the data is presented to show the averages and distribution of each parameter using basic statistical terms as described in Table 14 and Figure 3.

Table 14: Terminology for water quality data presentation (see tables in Appendix for each sample site)

Term	Meaning
Parameter	A water quality variable or component which is subjected to analysis (e.g. Temperature, phosphorus, etc)
Valid N	The number of water samples taken or tests conducted at the site during the reporting period for each parameter
Mean	The numerical average of the values for the parameter for the samples taken or tested during the reporting period. The 'mean' value often appears high as it is easily biased high by one or two extreme values.
Median	The 'middle' value of the parameter at a site for all the samples taken or tested during the reporting period. When all the values are sorted into increasing magnitude from lowest to highest, the median is the magnitude of the middle number if there are an uneven number of values, or it is the average of the central two numbers when there is an even number of values.
Minimum	The lowest value of the parameter at a site for all the samples taken or tested during the reporting period. The numerical difference between the 'minimum' and 'maximum' value for the parameter is the 'range' of values for that parameter during the reporting period.
Maximum	The highest value of the parameter at a site for all the samples taken or tested during the reporting period
20^{th} Percentile or $20^{th\%ile}$	The statistically calculated value of the parameter above which 80% of all test results lie. Values below the 20^{th}% might be considered significantly lower than the average.
80^{th} Percentile or $80^{th\%ile}$	The statistically calculated value of the parameter below which 80% of all tests lay. Values above the 80^{th}% might be considered significantly higher than the average.
Std Dev.	The statistical standard deviation of the values for a parameter for the samples taken or tested during the reporting period. If the Std Dev is high relative to the mean (e.g. Turbidity, Faecal coliforms) it means the parameter varies a lot throughout the year. If the Std Dev is low relative to the mean (e.g. pH) it means there is low variability of that parameter over the year.

Water quality data has been presented using 'whisker-box-plots' which enables ready comparison of water quality at various sites and, in particular, comparison with the reference sites. Figure 3 shows how to interpret the graphs used in this report. The graphs present the minimum, maximum, $20^{th\%ile}$ and $80^{th\%ile}$ data value for each parameter at a site. This gives a visual presentation of the magnitude, scatter and most usual range of a water quality parameter, and can also readily present the data in a form more easily compared with existing Guideline values or reference sites.

Figure 3: Interpretation of water quality data using Whisker-Box Plots



Interpretation of the Whisker-Box Plots

Shows whisker-box plots for 3 sites for Total Nitrogen concentrations in milligrams per Litre

- Sometimes the maximum concentration value of some parameters is so high it is necessary to draw the whisker 'off scale'. In this case the value of the maximum concentration ('2.3') is typed here for this site.
- Maximum value of the test data at this site for the year is the top value of the 'whisker' line.
- 80^{th} percentile value of test data for the year is the top of the 'box'
- Median value of test date for the year is the 'dot' inside the box
- 20th percentile value of test data for the year is the bottom of the box.
- Minimum value of test data for the year is the bottom value of the 'whisker' line (Note; often the reported minimum value is equal to half the laboratory detection limit)
- Dashed Line showing Guideline/REHV concentration. In this case the guideline for ecosystem protection of estuarine waters is 0.3 mg/L for this parameter. Concentrations above this value are considered to be undesirable in estuarine waters
- Sampling Site Number. The whisker-box symbol directly above the site number shows the distribution of data for the selected parameter for the year at that sample site.

7.3 Wet Weather Event Sampling

Rainfall events have a major effect on water quality in waterways by increasing turbidity and suspended solids in stormwaters, washing rubbish and contaminants into streams and creeks and increasing the likelihood in developed areas of overflows of sewage systems into waterways. Large areas of impervious surfaces (e.g. roofs, roads, pavements), particularly when connected directly to creeks by stormwater pipes, result in larger, faster flows within the creeklines following rain. The magnitude of the contamination at a sampling site is related to the quantity and to the intensity of the rainfall, and to how recently a rainfall event occurred prior to sampling.

Council's water monitoring program involves systematic sampling to a set monthly schedule which over the year will by chance usually include representative dry and wet times. For the purposes of this program a "wet weather" sampling event is considered to be one for which a total of over 10mm of rain fell during the day prior to the sampling. It is recognised that stream flow rates at some sites are heavily affected by small rain events (e.g. sites close downstream of industrial and urban areas with high impervious surface areas), while others far downstream (e.g. estuarine sites) may hardly be affected except after heavy rainfall or extended wet periods.

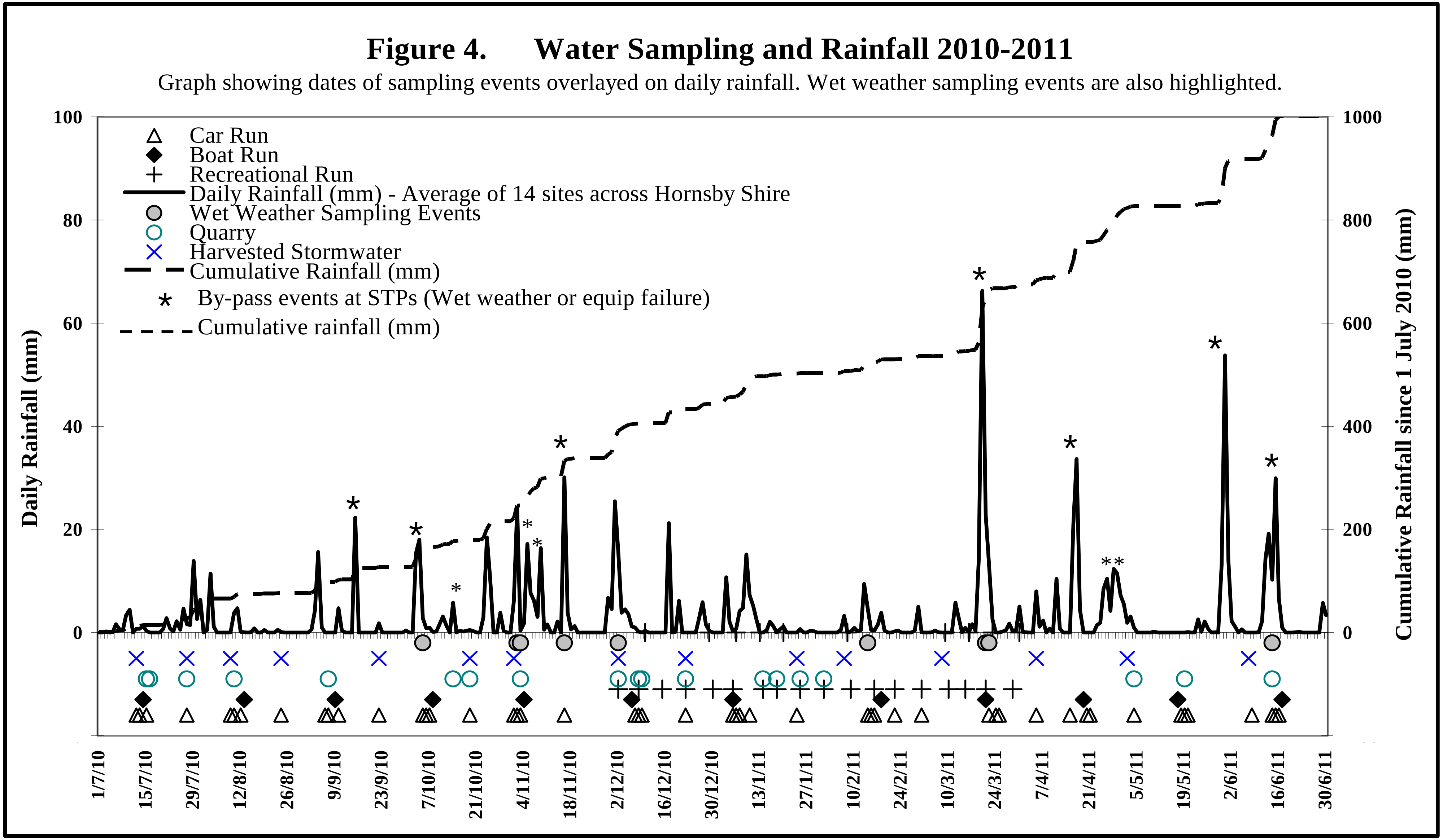
Figure 4 shows the daily rainfall and cumulative rainfall for the 2010-2011 year obtained from the Bureau of Meteorology averaged over 14 gauging stations throughout the Shire. Along the bottom is given information on the annual sampling program for the year 2010-2011 showing the days when routine sampling by car or boat was undertaken, wet weather sampling days and also the times of the summer recreational water sampling.

The wet weather sampling events are highlighted as grey dots along the bottom of Figure 4. During the reporting year there was a total of 77 sampling days which included 9 "wet weather" days. Also highlighted by an asterisk * on Figure 4 are the rainfall events which caused 'by-passes' at West Hornsby and Hornsby Heights STPs resulting in the release of partially treated sewage into creeks. The total annual rainfall was similar to the previous 2 years, however, there were more smaller storms in 2010-2011.

Even though there were less sampling days classified as "wet weather " days during 2010-2011, stream flows on sampling days were on average greater in 2010-2011 than the previous 2 years doe to more frequent storms. This resulted in generally higher turbidity , suspended solids, nutrients and bacteria at sites in catchments with human developments during this reporting period.

Photo 10: Site 43 showing flow of turbid water in Calna Creek after a rainstorm.

Figure 4. Water Sampling Events and Rainfall 2010-2011



.

7.4 Reference Creeks.

Data from these sites show natural variation of water parameters in creeks with minimal human impact. Thus the sites provide ‘control’ or ‘reference’ data useful for comparison with water quality in streams in developed areas. These creeks are considered to more closely reflect the water quality that existed before modern man developed the land area now known as Hornsby Shire.

Within Hornsby Shire there are limited choices for suitable reference sites. Ideally such sites should have similar geography, geology, soils and vegetation to other creeks under investigation. However, development within the Shire historically concentrated first in areas with good quality soils suitable for farming in some valleys and on ridgetops with shaly soils. Subsequent urban development concentrated around the ridgetop areas. As a result there is now a paucity of unimpacted creeks draining such types of soils and geology. For the purposes of this study reference creeks therefore had to be sought in nearby National Parks (NP) which are dominated by large areas of exposed sandstone and poorer soils. Two sites chosen for long term monitoring were Murray Anderson Ck in Ku-ring-gai NP and Smugglers Creek in Marramarra NP. These sites have been monitored monthly since January 1995. During the last two years a number of additional reference sites have been sampled to more fully assess the diversity of water quality and aquatic biota occurring in unimpacted creeks.

7.4.1 Site 36: Murray Anderson Creek, Kuring-gai National Park

Site 36 is located in Murray Anderson Creek, which is a tributary draining to Smiths Creek within the Cowan Creek catchment. Access is via boat from Cowan Creek with a short walk to the site. The catchment above this site is approximately 250 hectares in size all within Ku-ring-gai Chase National Park. This site is used as a reference site and has been sampled since January 1995. As with Site 37 this site has had minimal changes in water quality both through time and between wet and dry weather periods. See tabulated summary of results in Appendix A.36.

7.4.2 Site 37: Smugglers Creek, Marramarra National Park

Site 37 is located in Smugglers Creek, a tributary of Marramarra Creek. The site is accessed by boat up Marramarra Ck and then on foot through the bush about 500m up Smugglers Creek. The site is defined as a reference creek within this program as the catchment is located wholly within the boundary of Marramarra NP and there is no development within the catchment above the site. The catchment area is approximately 533 hectares all of which is undisturbed bushland. See tabulated summary of results in Appendix A.37

7.4.3 Other Reference Sites

During the reporting year a number of additional potential Reference Creeks were sampled a number of times as listed in Tables 8 and 9. These sites were investigated to obtain additional data to assess how representative sites 37 and 37 are as reference sites, and as part of a survey of macroinvertebrates and diatoms in reference creeks described as in Section 7.15. Based on sampling these sites for another year of two the decision will be made on whether to retain any of the sites in the long term.

Site 54: Laughtondale Creek. This creek is on the northern boundary of Marramarra National Park and drains a catchment of approximately 312Ha which has about 10% cleared land under horticulture. There is a gravel road running beside the creek for much of its length which means the site is easily accessed, but during wet weather the creek can contain fresh course sediment washed off the road. The creek flows through a narrow gully with a series of shallow pools of sandstone bedrock. This site has previously been used as a reference site and tested monthly from 1996-2002). Even in dry times there appears to be a clear base flow. See tabulated summary of test results in table A.54.

Site 114: Muogamarra Creek. This creek is within Muogamarra Nature Reserve and drains about 305 Ha of an undisturbed bushland valley with sandstone geology. Access was by 4WD down Peats Trail from the Pacific Highway then walking on a bush track for about one kilometre to access the narrow, shady, freshwater section of the creek about 100m upstream of the flat saltwater tidal marsh of Peats Bight. This creek has a crystal clear base flow, but surface flow may cease in drought conditions, leaving pools. See tabulated summary of results in Appendix A.114.

Site 123: An unnamed creek draining Peats Crater, here referred to as "**Peats Crater Creek**" in Muogamarra Nature Reserve. Although its catchment size, at about 90 Ha, is not large this site was chosen because of its differing geology. The catchment includes exposure of igneous rock in a diatreme. The central part of the valley (crater) was cleared for farming in the late 1800s, but since the area was declared a nature reserve has been undergoing natural revegetation. Access was by 4WD down Peats Trail from Pacific Highway then walking on a bush track for about 200m to access the narrow, shady, freshwater section of the creek. Near the sample site the creek flows through a heavily shaded gully and does not have permanent base flow, drying out occasionally during droughts. See tabulated summary of results in Appendix A.123.

Site 146: Yatala Creek. This creek drains an area of 335 Ha of sandstone geology in Kuring-gai National Park. The catchment is over 95% bushland, however the F3 motorway, in the upper part of the catchment contributes some runoff (but this passes through road-side vegetated sediment traps). Access to site 146 is down a walking track from Cowan Station, or by boat up Jerusalem Bay (off Cowan Creek) at high tide. It is necessary to walk through the thick bush up the creek to a point upstream of its junction with an unnamed creek flowing from Cowan Station. At the sample site the creek is partly shaded by tall trees and flows through bedrock exposures of sandstone in a series of permanent pools. See tabulated summary of results in Appendix A.146.

Site 147: An unnamed creek, here referred to as "**PH Oval Creek**", which flows into Byles Creek from a small bushland catchment of about 33 Ha adjacent to the Pennant Hills Ovals complex. This small creek has low flows after rainy periods but periodically dries out in dry times. It is in sandstone geology and the sample site has wide shallow pools on bare sandstone bedrock, It is believed to be the only remaining subcatchment of Lane Cove River that has not been subjected to the degradation by urban development. Access to site 147 is along a walking track about 200m from Day/Malton Road Cheltenham. See tabulated summary of results in Appendix A.147.

Site 149: An unnamed creek in Canoelands, here referred to as "**Duckpond Ridge Creek**", which flows in predominantly undisturbed bushland in sandstone country in Marramarra National Park. The catchment is bounded by Duckpond Ridge, the Old Northern Road and Canoelands Ridge. The catchment area is about 760 Ha but includes some relatively small areas (about 10%) of the catchment in its headwaters along Old Northern Road and Canoelands Road that have been cleared for sand extraction and horticulture. The creek at the sample site is in a deep rocky gully, heavily shaded and with broken sandstone boulders covered in brown diatom growths. Access to Site 149 is by 4WD to the very NE end of fire trail along Duckpond Ridge. See tabulated summary of results in Appendix A.149.

Photo 11: Site 147- an unnamed creek intermittently flows from a small undisturbed catchment near Pennant Hills Park in Lane Cove National Park.

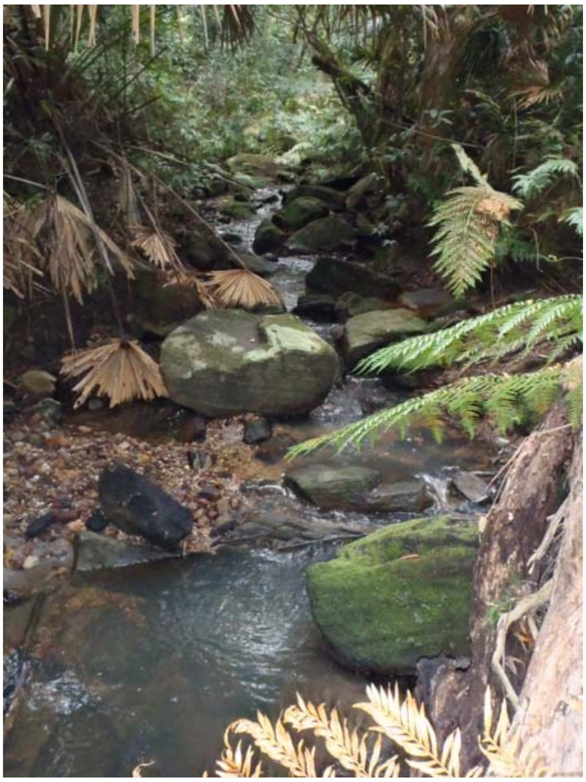


Photo 12: Site 123 - creek flowing from Peats Crater in Muogamarra Nature Reserve

Site 157: An unnamed creek, here referred to as "**Deep Creek**", which flows from its headwaters at Alston and Turner Roads in Berowra Heights to Deep Bay on Berowra Estuary. The catchment is Crown Land bushland with an area of 90 Ha. Access is either on foot for about one kilometre down a steep part of the Great North Walk off the fire trail at the northern end of Turner Road, or, by boat at high tide into Deep Bay, then by scrambling up the creek through the bush up to pools. See tabulated summary of results in Appendix A.157.

Site 160: An unnamed creek, here referred to as "**Joes Saddle Creek**", which flows out of a small bushland catchment of about 16Ha next to Joes Mountain in Hornsby. This small creek only runs for a few weeks after rain and dries up regularly, however it is not impacted by urban development. Access is with 4WD for about one kilometre along a fire trail which starts at the northern end of Rosemead Road. Thence by foot about 400m along a feeder track towards the Great North Walk. The sample site is under a small wooden foot bridge, about 100m before the creek joins Berowra Creek at Fishponds. See tabulated summary of results in Appendix A.160.

Site 161: An unnamed creek, here referred to as "**Canoelands Creek**", which flows from a bushland valley in Marramarra National Park. Its catchment is about 505 Ha and is bounded by Canoelands Road and Blakes Ridge. It does include some small areas of private property used for horticulture in the headwaters that have been partly cleared. Access to Site 161 is by boat at high tide from Marramarra Creek, with a short walk through the bush to access the freshwater flow above the creeks tidal limit. The creek at this site is thickly vegetated and in deep shade, with the creek line filled with small algal covered sandstone boulders. See tabulated summary of results in Appendix A.161.

Site 164: Djarra Crossing on the north arm of **Joe Crafts Creek** in Muogamarra Nature Reserve. The catchment of 90 Ha is in undisturbed bushland in sandstone geology. Access is by 4WD off Glendale Road Cowan and down the Western Fire trail to the creek crossing. The creek at the sample site is predominately bare sandstone bedrock open to midday sunlight. It is expected that during droughts that water flows will cease, although that situation has not occurred since monitoring started in May 2011. See tabulated summary of results in Appendix A.164.

7.4.4 Choice of Regional Environmental Health Trigger Values (REHV)

Monitoring results collected at Sites 36 and 37 through time suggest that the water quality at these sites has remained constant and satisfied the Guidelines for Aquatic Ecosystem Protection more than 95% of the time (HSC, 2009a), with relatively few fluctuations except in very wet weather or prolonged drought. Based on the results for these sites a set of Interim Regional Environmental Health Values (REHV) have been developed which are considered to provide guidance to the water quality condition of unimpacted sites in Hornsby Shire. The values are listed in table 1. On the graphs shown in this report are dotted lines showing these Interim Regional Environmental Health Values (REHV). The procedures used to develop these REHVs are documented in a report in preparation (HSC, 2011c).

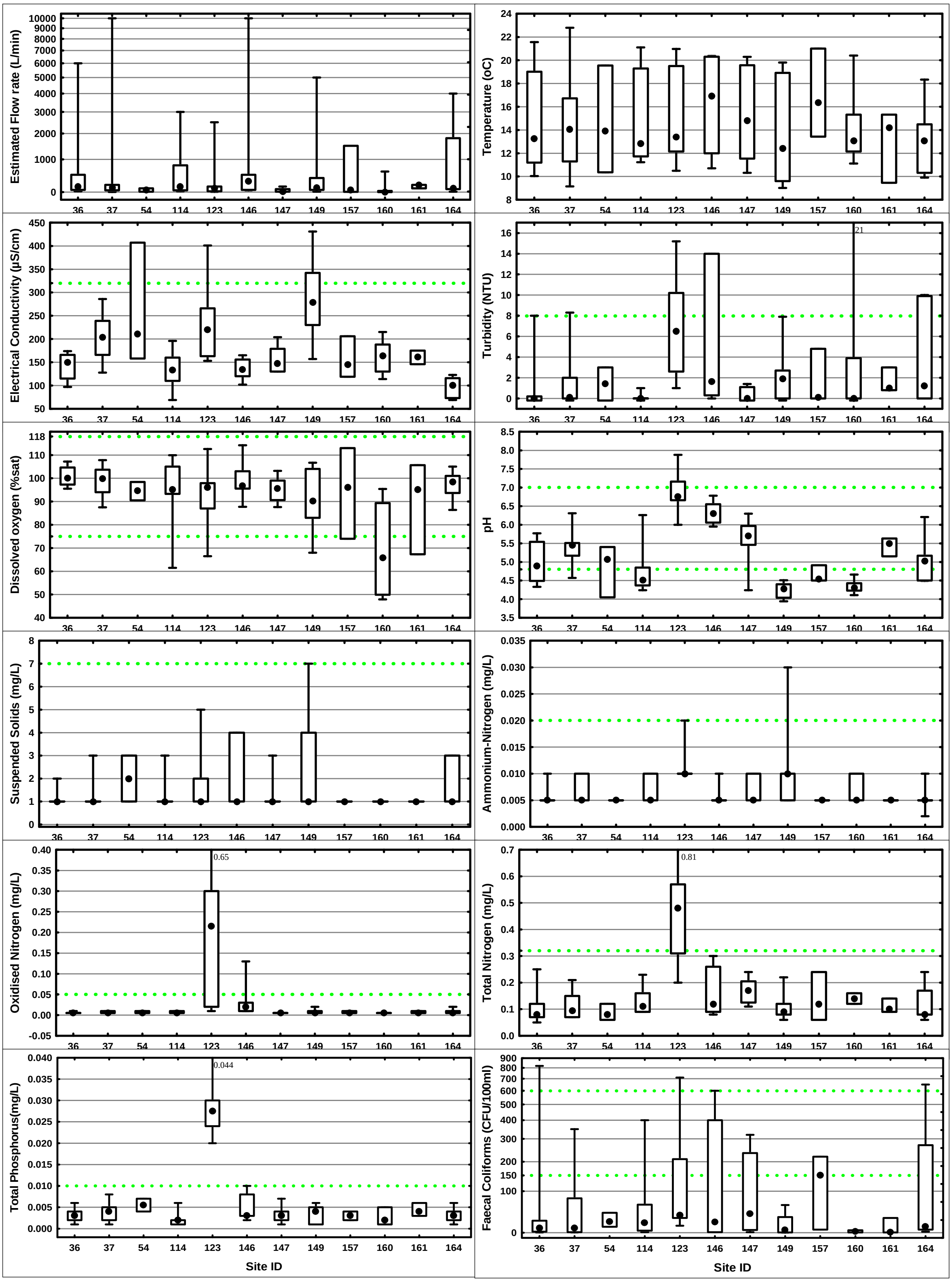
7.4.5 Summary of Water Quality at Reference Sites

Test results for the Reference Sites for the period July 2010 to November 2011 are presented in Appendices A.36, A..37, A.54, A.114, A.123, A.146, A.147, A.149, A.157, A.160, A.161 and A.164. Box plots for selected water quality parameters measured at the reference sites are shown in Figure 5. The Reference Sites are characterised by low values of dissolved salts, pH, suspended solids, nutrients, and bacteria.

The pH values at the reference sites are more acidic (i.e. lower pH) than the pH range generally recommended by ANZECC/ARMCANZ Guidelines for aquatic ecosystem protection. However, these pH levels are not unusual for unbuffered waters in wholly sandstone catchments and are not considered to indicate poor water quality at these reference sites. Creeks in the many **developed** sandstone catchment areas in Hornsby Shire and elsewhere in the Sydney region have pH in the range 7-7.5 - considerably higher than the natural background. One interpretation of this data is that man's influence, particularly the widespread use of alkaline concretes and soaps, has permanently changed the natural acid nature of most streams in urban areas in Sydney.

Site 123 draining Peats Crater shows some major differences when compared with other reference Sites. Site 123 was found to have consistently the highest turbidity, oxidised nitrogen, total nitrogen, total phosphorus and pH. This is not unexpected given the catchment contains known igneous influence (accounting for higher TP and pH), and, in addition, that the land was once cleared and probably fertilised (maybe leading to the high TN and NOx) and is frequented by numerous grey kangaroos (leading to elevated faecal bacteria).

Figure 5. Water Quality in Reference Creeks: Annual distribution of selected parameters June 2010- Nov 2011.



7.5 Urban Areas. Sites 4, 5, 6, 8, 39, 46

Urban catchments consist of representative residential and commercial areas throughout the Shire. They are characterised by reticulated water and sewerage systems. Urban developments have a large percentage of impervious surfaces (e.g. roads, driveways, roofs) and a complex stormwater collection infrastructure; together this results in stormwater running quickly into local streams.

Six streams are currently monitored downstream of urban areas have not changed since the pervious reporting period (HSC, 2010a). A detailed description of the sample sites and catchments associated with the urban sites is given in the previous annual report (HSC, 2010a).

Figure 6 gives a graphical comparison of selected water quality parameters in 2010-2011 at the six creeks in draining the urban areas. The corresponding results at the two reference sites are also included to enable comparison between the urban-affected and the unimpacted reference creeks. Although the total rainfall for the year was similar to the previous two years (~1000mm) there were more rain events in 2010-2011. This resulted In sampling on more days with higher stream flow rates, resulting in apparent poor water quality this reporting period.

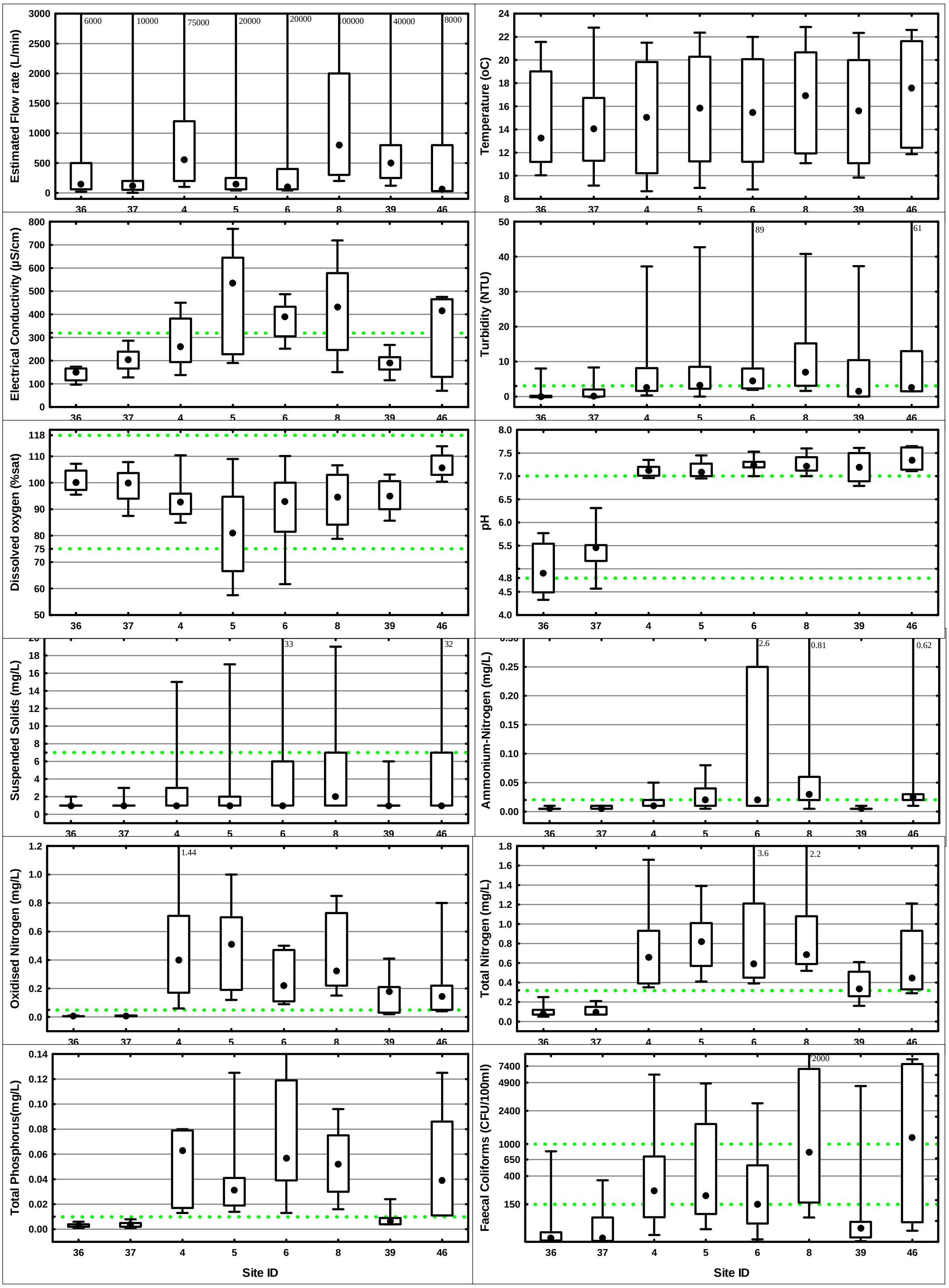
The levels of turbidity and suspended solids at urban sites were generally higher than the 2 previous years, as were the maximum and 80^{th}%ile values for Faecal coliforms. The source of elevated Faecal coliforms in creek waters is usually difficult to trace as they may be diffuse or point sources. The urban sites are always sampled on the same day, yet the highest levels recorded during 2010-2011 at Berowra Ck (site 4, 6000 cfu/100mL), Devlins Ck (site 8 72000 cfu/100mL) and the unnamed tributary of Terrys Ck (site 46, 8800 cfu/100mL) all occurred on different days confirming widespread and random faecal contamination of streams via stormwater runoff and/or sewer pipe overflows. During dry weather and low flow conditions the bacterial levels however were usually lowest. More than half the sampling times faecal contamination at Devlins Ck and the tributary of Terrys Ck were above 1000 units; the worst for many years.

Concentrations of total phosphorus (TP), total nitrogen (TN), oxidised (NOx) nitrogen and ammonium-nitrogen in urban creeks, except Joe Crafts Ck site 39, were always higher than the REHV levels. High nitrogen and phosphorus levels could be sourced from overuse of garden fertilisers and manures, eroding soils, road runoff and sewage overflows. The high maximum values for TN and NOx at all sites occurred immediately after heavy flooding rains (e.g. 15 June 2011).

Levels of pH within urban areas are, as noted, in Section 7.4.4, significantly higher than the Reference Creeks. Conductivity levels are similar to previous years and are typical of creeks in other disturbed areas, although Pyes Creek Site 5, Devlins Creek Site 8 and the tributary of Terrys Ck Site 46, were consistently elevated. Dissolved oxygen levels within the urban areas in 2010-2011 were within REHV levels , and were generally higher than the previous 2 years, probably resulting from extra turbulence at the higher flow rates this year.

Photo 13: Site 5 Pyes Creek on 14 Feb 2011 **Photo 14: Site 8 Devlins Ck on 14 Feb 2011.**
Water in urban creeks can sometimes appear black. In this instance about 10mm of rain fell on the previous day after a dry spell of about 3 weeks. Stormwater flowing from streets and urban areas carried dark-coloured waters into nearby creeks.

Figure 6: Water Quality in Urban Creeks: 2010-2011 Annual distribution of parameters compared with Reference Creeks



7.6 Impacts of Sewage Collection and Treatment in Hornsby Shire

The Shire's sewerage systems include pipes, pumping stations, overflow points and Sewage Treatment Plants (STPs) which are designed to transport and treat sewage. Property owners are responsible for the maintenance of sewerage systems in private land as far as the connection to the sewer main, while Sydney Water Corporation maintains the remaining facilities and STPs. Within Hornsby Shire there are three Sewage Treatment Plants (STPs) operated by Sydney Water Corporation. The two larger established plants are at Hornsby Heights and West Hornsby. These plants provide tertiary treatment to sewage collected in the more densely settled urban suburbs and industrial areas in the southern half of the Shire. Treated effluent from the STPs is discharged to upper creeks in the Berowra Creek catchment, and flows to the Berowra Estuary. A new, smaller plant is now operating at Brooklyn and the treated waters are discharged to the Hawkesbury River under the old Peats Ferry Bridge (see Section 7.10)

The STPs are operated under Licences to Pollute, issued by the NSW Office of Environment and Heritage, which require Sydney Water to operate and maintain the sewer pipe collection system and the treatment plant to certain standards. The Licences specify monitoring requirements and pollution reduction programs. Nevertheless, even with these controls in place, untreated sewage entering local creeks in sewered areas is not uncommon. A number of ways this can happen are:

- During wet weather, stormwater may infiltrate sewer pipes from illegal connections or fractured pipes, thereby greatly increasing flows in the sewer pipe network. This can cause an overload of the system's capacity resulting in by-passes at the STPs (when untreated or partially treated sewage is discharged to creeks at the STPs) or overflows from designed discharge points adjacent to sewer mains or pumping stations throughout the network. For example, within the catchment of West Hornsby STP, there are about 30 designed overflow points near creeks. Sydney Water had been running a SewerFix Program to investigate these surcharges,
- During dry weather, overflows of sewage can occur at designed relief points as a result of blockage in a pipe (e.g. by tree roots). Blockages reduce the capacity of the pipe to carry its design flow causing sewage to back up along the pipes and escape via safety overflow points.

There is little published information on how often the designed surcharge points discharge during wet weather or what volumes of raw sewage discharge from them into creeks. Sydney Water, however, publishes information on by-pass events occurring at STPs and incidents of reported sewage discharges resulted from, for example, blockages by tree roots. During this reporting period Sydney Water had reported that there were two dry-weather STP by-passes, 21 wet-weather STP by-passes, which occurred during heavy rainstorms or due to equipment failures. In addition there were 82 dry weather overflows from sewerage infrastructure reported and investigated; mainly due to roots blocking pipes.

Due to the significant impact of the STP effluent on creeks within the Shire, Council includes a number of water monitoring sites to assess the combined impacts of urban stormwater runoff and STP effluent on creeks. These sites are discussed below.

The five streams currently monitored near STPs have not changed since the previous reporting period. A detailed description of the sample sites and catchments associated with these sites is given in the previous annual report (HSC, 2010a).

7.6.1 Hornsby Heights Sewage Treatment Plant. Sites 52 and 43

Hornsby Heights Sewage Treatment Plant (HHSTP) discharges on average 6.7 megalitres of tertiary treated effluent per day to Calna Creek in Walls Gully. Calna Creek enters Berowra Creek in the tidal reach about 1km downstream of Crosslands Reserve. The STP discharge point into Calna Creek is about four kilometres upstream of its confluence with Berowra Creek.

Summaries of water quality data for the period 2010-2011 are presented in Tables A.52 and A.43.

Figure 7 gives graphical comparison of water quality in 2010-2011 between selected parameters at the sites on creeks near the STP - site 52 upstream and Site 43 downstream. Also included in Figure 7 are the corresponding results for the two reference creeks at sites 36 and 37 to show what the water quality would have been like before urban development.

Turbidity and suspended solids upstream and downstream of the STP were generally low and below the REHVs. Levels of faecal coliforms downstream of HHSTP at Site 43 were about the same as the upstream site (site 52), except on 12 Aug 2010 at site 52 (FC= 22000) which was a 'dry weather day" when the flow was relatively quite low.

Concentrations of total nitrogen, comprising mostly oxidised nitrogen, were consistently higher downstream of the STP at site 43 than at site 52, demonstrating the influence of the treated effluent from HHSTP. The REHV for total nitrogen (TN) and oxidised nitrogen were exceeded on all sampling occasions during 2010-2011 at site 43.

The concentrations of total phosphorus downstream of the STP exceeded the REHV on all sampling occasions during 2010-2011, whereas upstream values were lower, but still above the REHV.

The electrical conductivity at the downstream site 43 was significantly greater than site 52 upstream of the outfall. This difference is due to the influence of effluent which is contributing greater concentrations of salts from dissolved nutrients and domestic chemicals (e.g. washing powders). This pattern is consistent with previous years reporting.

The dissolved oxygen was considerably higher downstream of the outfall (site 43) due to the turbulence of flow down Calna Creek providing good contact with air.

Photo 15: discharge point for treated sewage into Calna Creek below Hornsby Heights STP

Photo 16: Waitara Creek flowing through a concrete culvert past West Hornsby STP. The discharge point for treated sewage is seen on the right side underneath the overhead sewer main.

7.6.2 West Hornsby Sewage Treatment Plant (WHSTP). Sites 1, 23, 45

West Hornsby Sewage Treatment Plant (WHSTP) discharges on average 11.9 megalitres per day of tertiary treated effluent to Waitara Creek. The discharge point is about 700 metres upstream of the confluence of Waitara Creek with Berowra Creek, and approximately 12 km upstream of the tidal reach of the Berowra Estuary at Crosslands Reserve.

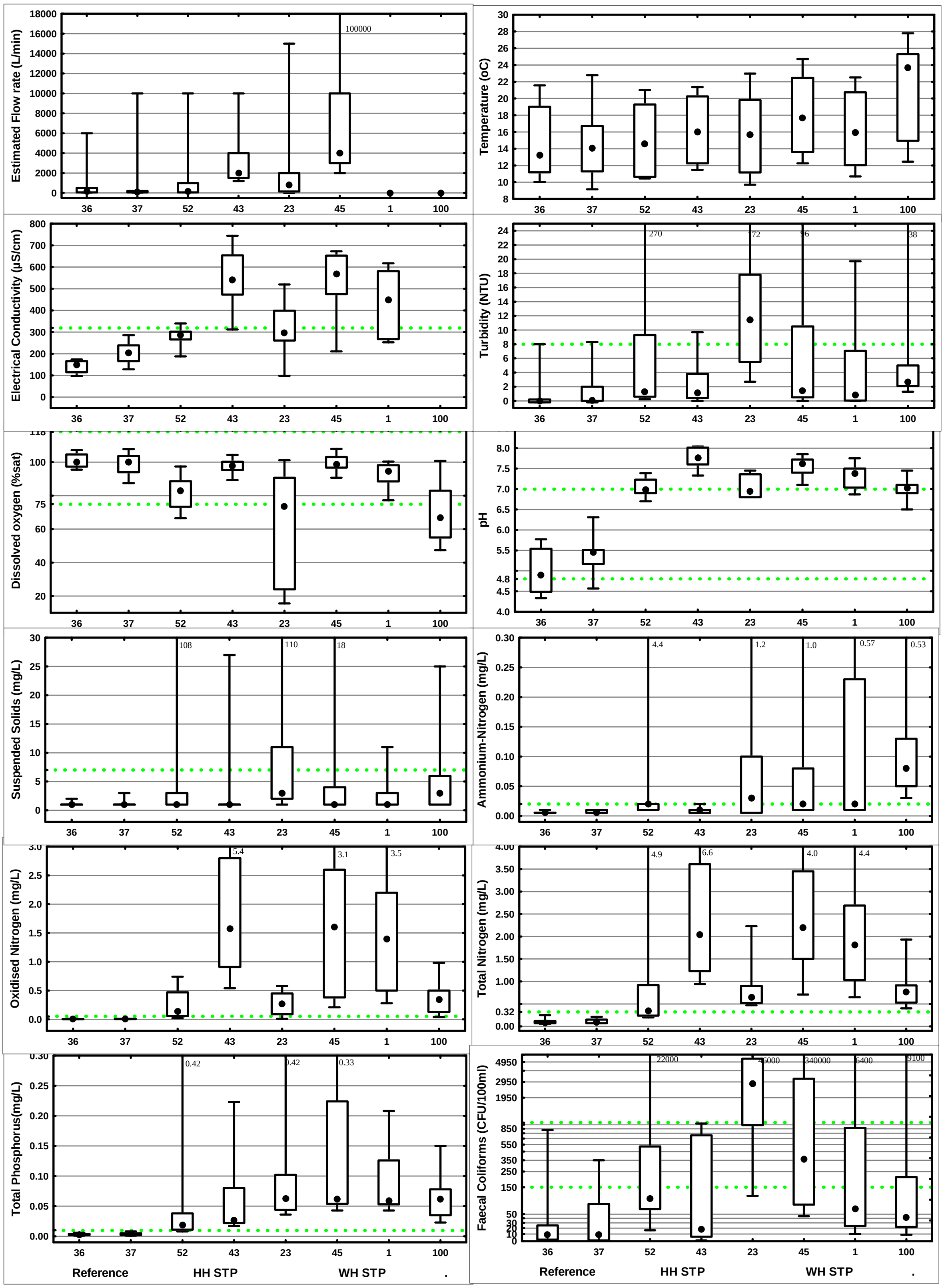
Summaries of water quality data for the period 2010-2011 are presented in Tables A.1, A.23 and A.45, and show on Figure 7.

Summaries of water quality data are given in tables A.23, A.45, A.1 and A.100

Figure 7 gives a graphical comparison of water quality in 2010-2011 for selected parameters in creeks upstream (site 23) and increasing distances downstream (sites 45, 1, 100) of the STP together with comparative information from the reference creeks

In winter the water temperature was significantly higher downstream of the WHSTP outfall (usually about 3^{o}C higher at site 45 than site 23) due to the elevated temperatures of the STP effluent. The impact of higher temperatures extended a number of kilometres downstream, but did not extend as far as site 1 at Galston Gorge, where water temperature was similar to other urban sites.

Figure 7: Water Quality in Creeks near STPs: Annual distribution of parameters compared with Reference Creeks



Note 1: Sites 52 and 43 help monitor effects of Hornsby Heights (HH) STP discharge. The sites are on Calna Creek immediately upstream of Hornsby Heights STP discharge point and 4km downstream of the STP, respectively.

Note 2: Sites 23, 45, 1 and 100 help monitor effects of West Hornsby (WH) STP discharge. Site 23 is on Waitara Ck 100m upstream of the STP discharge point. Sites 45 and 1 are freshwater sample sites downstream of West Hornsby STP on Berowra Creek at Fishponds and at Galston Gorge, respectively, and Site 100 is in the tidal estuary at Crosslands Reserve.

Site 23 located upstream of WHSTP had the highest mean level of faecal coliforms. This site received run-off from a large and diverse urban catchment, including the Thornleigh industrial area on Larool Creek, which often showed faecal contamination (see section 7.7). During sampling it was noted that the creek upstream of Site 23 was frequented by ducks, which probably added to faecal contamination. In addition Waitara Creek catchment has many sewer pipes buried next to feeder creeks; and some serious blockages and leaks from these pipes were reported during the period. So the question remains whether the source of faecal contamination upstream of the STP is predominantly from aging sewer pipe infrastructure, poor stormwater management in the industrial area, or wildlife near the sample site. It is planned to conduct a catchment combing exercise to attempt to identify the major source of faecal contamination in the next reporting period.
Downstream of the WHSTP, in Berowra Creek at Fishponds Site 45 the Faecal coliforms levels were generally lower than Site 23. Nevertheless, on most occasions at Fishponds, the bacterial levels failed to satisfy the older, ANZECC Primary Contact guideline (Table 4: 150 cfu/100mL), but only about 60% the time was the Secondary Contact Guideline (1000 cfu/100ml) satisfied. Further downstream at Galston Gorge and Crosslands the Faecal coliforms levels were lower but still failed the ANZECC Primary Contact Guideline for many occasions. Wet weather by-passes at the WH STP occurred on 9 occasions for durations from 1 to 6 days; and during 3 of these the disinfection process was reported to have failed. Council sampling rarely coincided with the STP by-passes; however, the highest faecal bacteria readings at both Fishponds (FC=340000 on 22 March and FC=10000 on 14 June) and at Crosslands (FC=9100 on 22 March) did coincide with STP bypasses when the disinfection process was operating. It would be interesting to target sampling at these sites when the disinfection processes is not working!

Ammonium nitrogen levels at site 23 in Waitara Creek (upstream on the WHSTP) mostly failed the REHV and generally followed the trends seen for faecal coliforms. Site 23 often receives contaminated discharges from the Thornleigh industrial area via Larool Creek Site 10 (with its faecal and high ammonium levels - see section 7.7). This trend suggests that sewerage infrastructure upstream from site 23 is often failing in the Waitara Creek catchment. Ammonium levels downstream at Fishponds Site 45 and Galston Gorge Site 1 also exceeded the REHV on more than 50% of the time, and failed 100% of the time at Crosslands Site 100.

The total nitrogen and oxidised nitrogen concentration showed similar trends to last year with values failing the REHV on all occasions downstream of the STP at Fishponds Site 45, Galston Gorge Site 1 and Crosslands Site 100. The concentrations of these nitrogen species in the freshwater section of Berowra Ck below the STP outlet averaged about 25 times higher than found in the Reference creeks.

Concentration values of total phosphorus exceeded REHV on all occasions in Waitara Ck at site 23, and all the way down Berowra Creek through Fishponds site 45, Galston Gorge Site 1, to Crosslands (Site 100). Levels of pH were consistently within Guidelines and are not considered to be problematic. Conductivity at site 45 (Fishponds) was greater than the upstream site, with the greater conductivity levels being directly attributed to the presence of effluent with associated nutrients and dissolved salts from residential use of chemicals (e.g. detergent powder) which are not removed by the STP process. Turbidity and suspended solids were generally low except after heavy rain when high maximums occurred at Waitara Creek Site 23, Berowra Creek at Fishponds site 45 and at Crosslands Site 100.

Levels of dissolved oxygen (DO) below the STP were generally within REHVs down Berowra Creek as far as Galston Gorge. However, DO concentrations in Berowra Creek at Crosslands Reserve (Site 100) or at the site upstream of the STP on Waitara Creek (Site 23) were mostly less than 80% saturation, indicating eutrophication issues.

7.6.3 Brooklyn Sewage Treatment Plant. Sites 103 to 108

See discussion section 7.10.

Photo 17. Site 1. Stepping stones across Berowra Creek at Fishponds

7.7 Industrial Areas. Sites 10, 12, 13 and 77

The major industrial areas in Hornsby Shire are located at Sefton Rd, Thornleigh; Leighton Pl, Hornsby; and Beaumont Rd, Mt Kuring-gai. These three areas drain into Larool Ck (site 10), Hornsby Ck (site 12) and Sams Creek (site 13), respectively. The Ku-ring-gai industrial area has only recently been sewered and connected to Hornsby Heights STP. Hornsby Council's Environment Protection Officers have an ongoing program to investigate contaminant sources within these industrial areas, and often get called out to investigate water pollution incidents. Gleeson Creek Site 77, downstream of a rehabilitated landfill site at Mt Colah receives some groundwater leachate from the landfill site, so has added to the industrial classification.

A detailed description of the sample sites and catchments associated with the industrial areas is given in the previous annual report (HSC, 2010a)

Photo 18: Sams Ck Site 13 normally.

Photo 19: Sams Ck Site 13 polluted with sediment

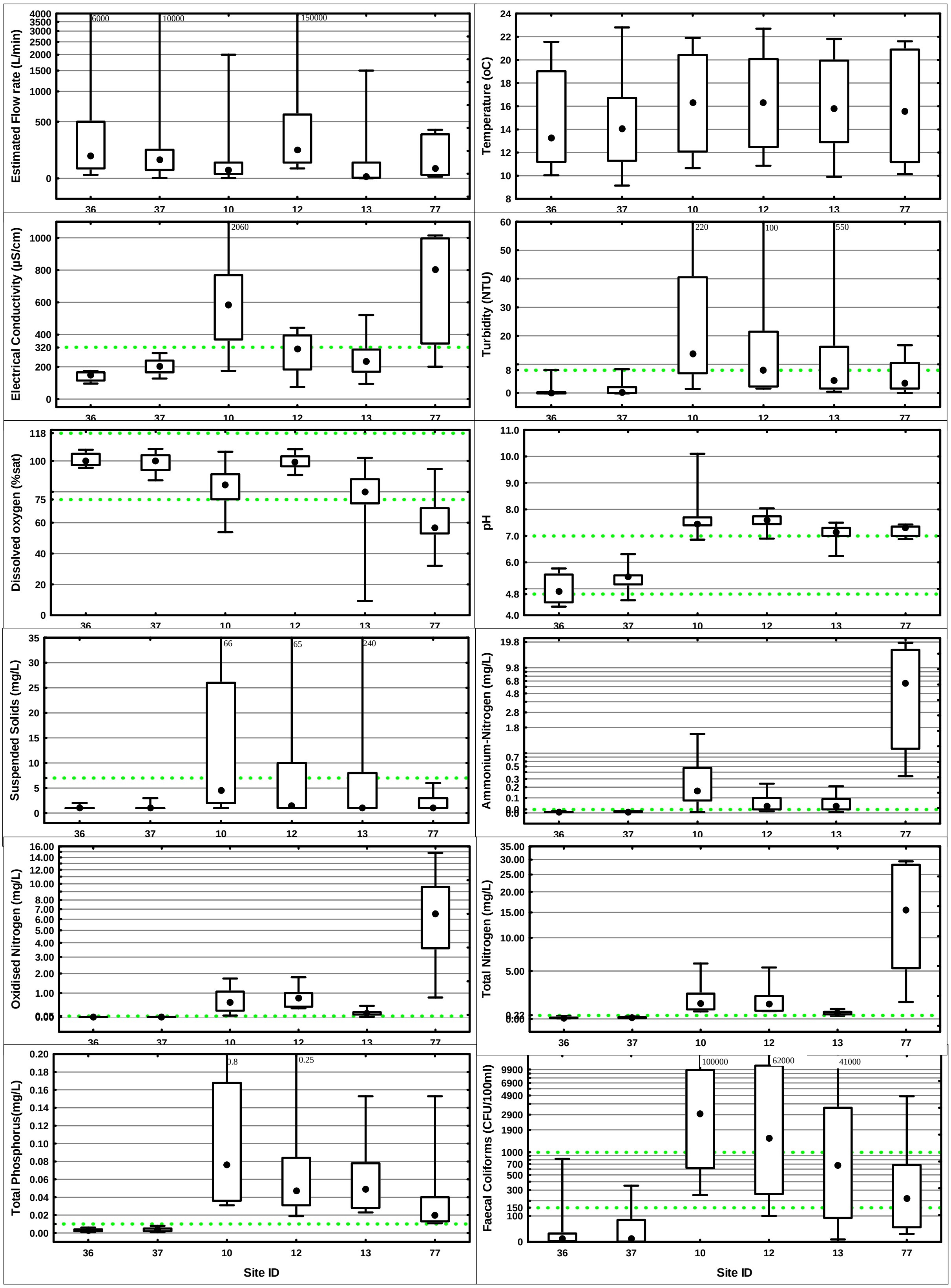
Summaries of water quality data for the industrial sites are presented in tables A.10, A.12, A.13 and A.77. Figure 8 gives graphical comparison of water quality in 2010-2011 of selected parameters at the sites on creeks draining the industrial areas and, for comparison, the two reference creeks sites 36 and 37.

Suspended solids, Faecal coliforms and turbidity levels in creeks close downstream of the industrial areas were consistently the highest found in freshwater creeks within the Shire, and the Thornleigh industrial area in Larool Creek at Site 10 was the worst of them. Sams Creek (Site 10), downstream of the industrial and commercial area at Mt Kuring-gai, however, suffered from an extreme incident of sediment pollution on 7 September 2010, when very high suspended solids (244 mg./L) and turbidity (550 NTU) were detected. These sorts of pollution incidents are no doubt extremely harmful to the aquatic ecosystem. Gleeson Creek Site 77 downstream of Foxglove Oval mostly satisfied the REHVs for turbidity and suspended solids, and the Secondary Contact Guide for faecal bacteria.

Concentration values of total nitrogen, ammonium nitrogen, oxidised nitrogen and total phosphorus were all above REHVs below the Thornleigh, Hornsby and Mt Kuring-gai industrial areas on all sampling days. The highest levels of phosphorus and ammonia were found in Larool Creek below the Thornleigh (Site 10) industrial/commercial area. The source of these nutrients is often not known, however, poor management of chemicals, sewer overflows, illegal discharges and hard surface runoff during rain periods are likely major sources. Gleeson Creek site && below the old landfill site had by far the highest nitrogen nutrient levels, with TN, NOx and NH3 concentrations averaging over 50 times the REHVs.

Generally, levels of pH below the industrial areas were within Guidelines, except on a number of occasions when the pH in Larool Creek at Site 10 exceeded pH of 9; this is a very high pH arising from strongly alkaline chemicals or cement. Salinity and electrical conductivity levels were also consistently high particularly below the Thornleigh industrial area. Council's Environment Officers investigated the sources of contamination and high pH in Larool Creek but found it difficult to identify the exact sources. In 2010-2011 Environmental officers carried out inspections and education programs to assist the owners and employees in the industrial businesses to improve their operations and stormwater management practices.

Figure 8: Water Quality in Creeks draining Industrial/Commercial areas: Annual distribution of parameters compared with Reference Creeks



The contamination of the creeks below these Industrial areas is frequent, serious and ongoing. Urgent follow-up of reported incidents has occasionally uncovered the source of contamination in the past. No doubt, however, most releases of contaminated water go unreported and untested as the polluted plumes are flushed down the creeks quickly in wet weather. It is therefore important that ongoing unannounced inspections and auditing of the industrial areas continue to be carried out.

Reduction of contamination of Gleeson Creek in Mount Colah by nitrogen nutrients in landfill leachate has been the subject of a major CRR program for a number of years. The leachate is intercepted, collected and transferred to a treatment plant with the intent to use the treated leachate as part of the sports field irrigation. (see Sections 7.13 and 7.14)

7.8 Rural Areas. Sites 2, 42, 49, 62, 63, 64 and 80

Rural areas are classified as those areas with a majority of their catchment area under rural zoning or townships which still rely on onsite or pump out disposal of their effluent. Seven sites were monitored in 2009 -2010.

A detailed description of the sample sites and catchments associated with the industrial areas is given in the previous annual report (HSC, 2010a)

Summaries of the water quality data are presented in tables A.2, A.42, A.49, A.62, A.63, A.64 and A.80.

Figure 9 shows box plots of selected results at the rural sites. The corresponding results for the Reference sites 36 and 37 are shown for comparison.

Levels of Faecal coliforms recorded at most rural sites were greater than last year. Faecal coliforms in Glenorie Creek Site 80 and below Galston Village Site 64 exceeded Primary Contact Guidelines on most sampling days, and Cowan Village Site 62 and Colah Creek at Wylds Rd Site 42 exceeded the guideline about half the time. The estimated average creek flow rates were greater than last year and this would have increased the rate of washing of animal manurers and seepages of septic systems. Tunks Creek Site 2 and Colah Creek Site 63 furthest downstream of the rural areas, and the less intensely developed catchment sampled at Still Creek Site 49, had the lowest faecal coliforms levels.

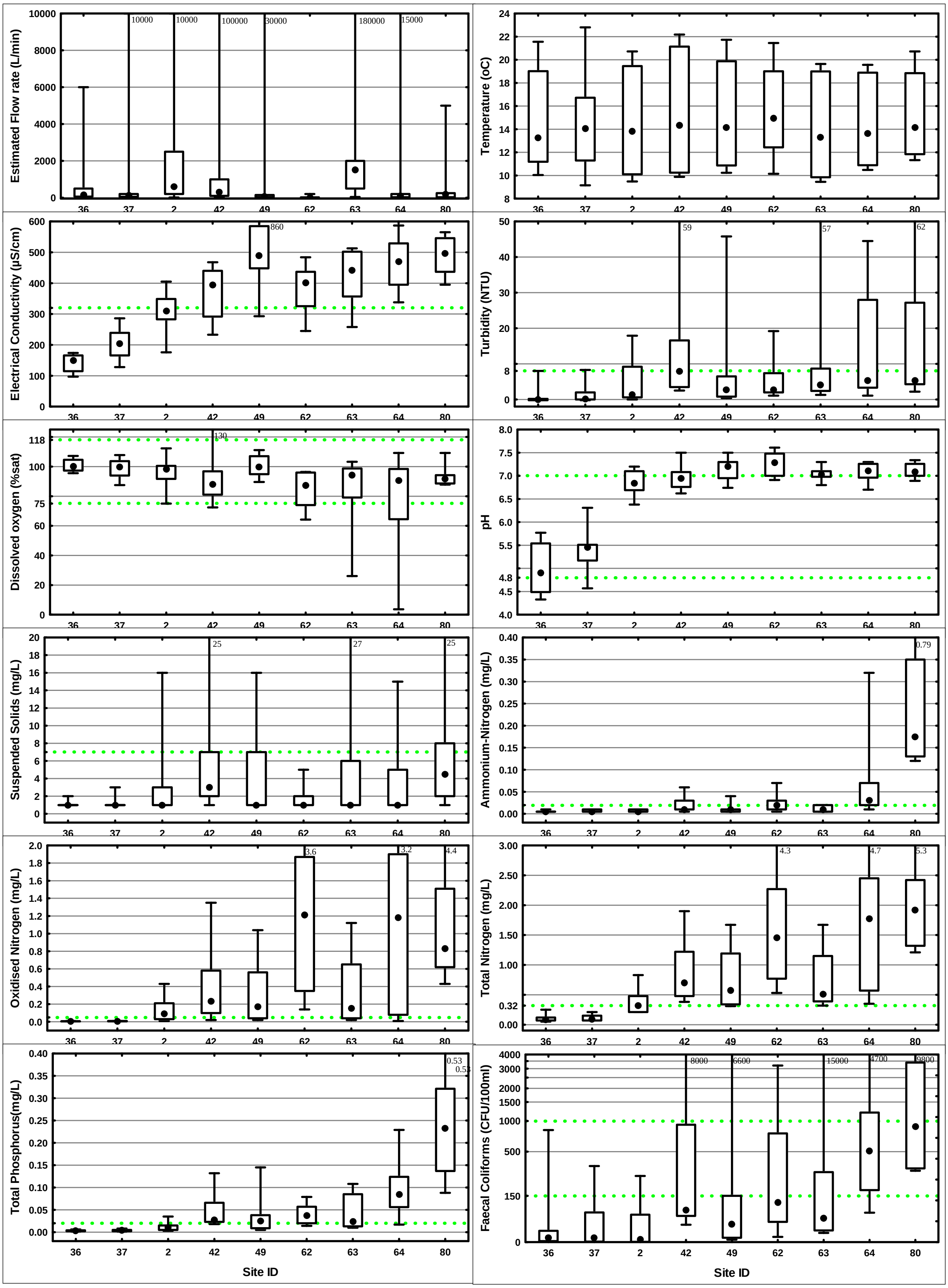
Most monitoring sites continued to show elevated total nitrogen, oxidised nitrogen and phosphorus with concentration values exceeding REHVs on most occasions. On every sampling occasion levels of nitrogen and phosphorus still remained exceedingly high at Glenorie (site 80). Total nitrogen and oxidised nitrogen were also very high at sites 62 and 64 below Cowan and Galston Villages, respectively. Sources of these nutrients are most probably from septic seepages, fertilisers, domestic uses of washing powders, incorrect disposal of greywater or illegal septic tank discharges in the upper catchment.

Turbidity values at the rural sites exceeded the REHV on about half the time at Colah Creek at Wylds Rd Site 42, below Galston Village at Site 64 and at Glenorie Creek Site 80. The high suspended solids and turbidity at Glenorie Creek Site 80 coincided with high faecal coliforms and high nitrogen concentrations. These factors imply that landowner(s) upstream are regularly discharging waste water possibly associated with animal farming. This catchment should continue to be investigated by on-site inspections as a matter of priority.

Photo 20: Site 42 Colah Creek under Wylds Rd near Glenorie

Photo 21: Site 64 on a small creek draining Galston Village area

Figure 9: Water Quality in Creeks draining Rural areas: Distribution of parameters compared with Reference Creeks



7.9 Estuarine Sites. Sites 60, 61, 38, 48, 55 and 100.

Monitoring of water quality has occurred monthly at four estuarine sites, 60, 61, 38 and 48, since the mid 1990s to assess environmental health of the estuaries which are the receiving waters for the majority of the Shire. In 2005 recreational water monitoring commenced over the summer swimming period (December to March) at two sites Hawkesbury River at Brooklyn Baths Site 55 and Berowra Creek at Crosslands Reserve site 100 (see Section 7.11). In 2006 six new sites in the Hawkesbury River were also added to the sampling program to obtain data upstream and downstream of the discharge site of the Brooklyn STP outlet (see Section 7.10.)

Routine monthly sampling at these sites is carried out from a boat, except Crosslands which is sampled from the shore. Probe tests and sample collection is in the top 0.5 m depth. Probe testing at the deeper sections of Berowra Waters Site 60 and Calabash Bay Site 61 are often also carried out to assess salinity and dissolved oxygen gradients.

A detailed description of the sample sites and catchments associated with the estuary areas is given in the previous annual report (HSC, 2010a)

Summaries of the water quality data are presented in tables A.60, A.61, A.38, A.48, A.55 and A.100.

Selected results for water testing of surface waters (sampled at 0.5m depth) at the estuarine sites are shown in Figure 10. (Results obtained for the Hawkesbury River are included for comparison – see discussion section 7.10).

Turbidity and suspended solids concentrations were highest at those sites located in downstream sections of the Estuary or located in the Hawkesbury River (Sites 48, 38, 55, 103-108). These sites are either relatively shallow, narrow channels, with a bed load of predominately fine sediment, or in or adjacent to areas of strong tidal flow. These turbidity levels are considered to be indicative of a tidal dominated estuary with sediment that is easily resuspended by the turbulence created by wind and tidal fluctuations. However, these levels are now considered typical of the lower Hawkesbury system.

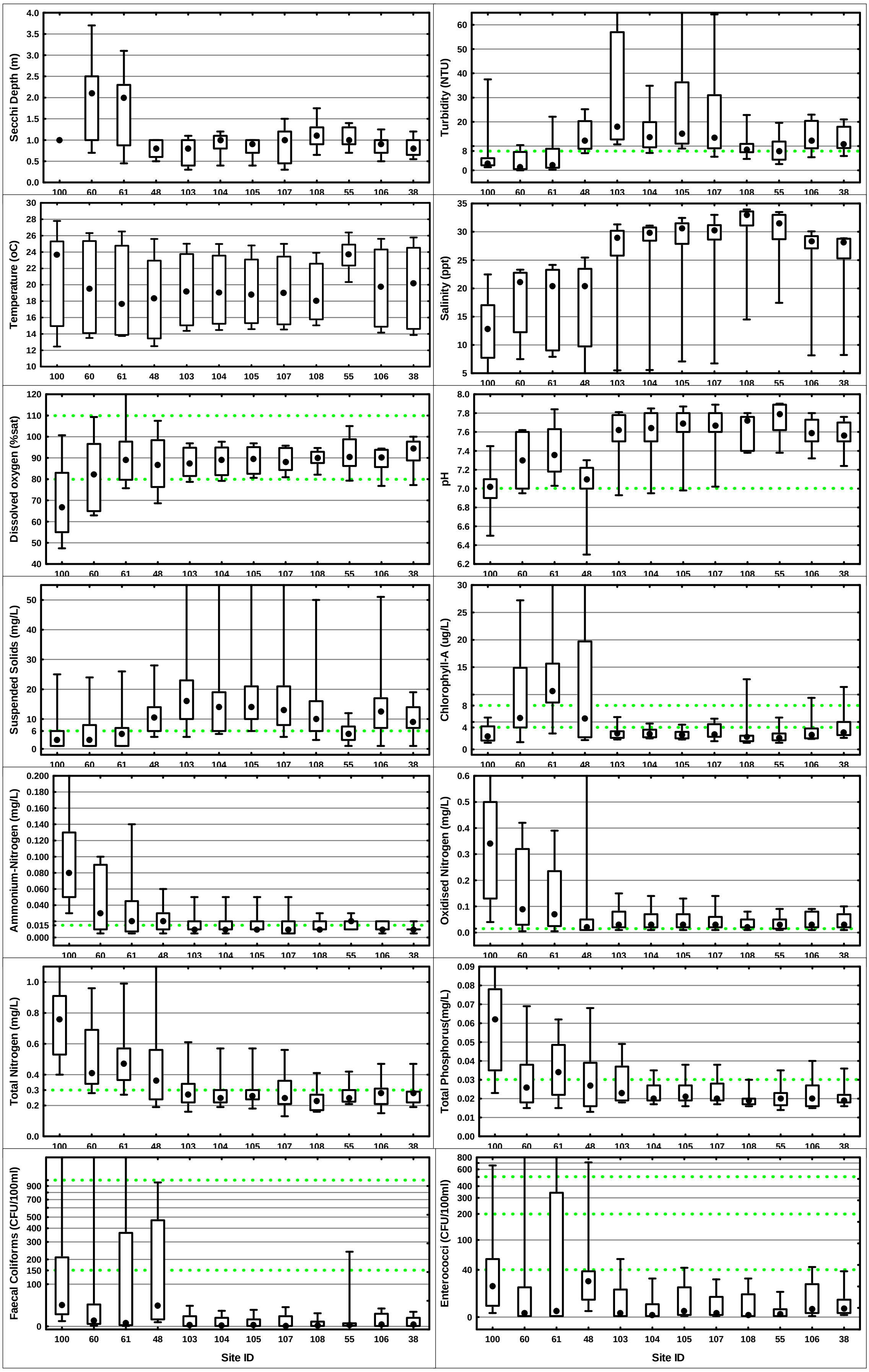
During 2010-2011 Faecal coliforms concentrations at the estuarine sites 60, 61, 48 often (~25% of times) exceeded the Primary Contact guide of 150 units. Samples from the Hawkesbury River sites were well below the Guide on all occasions.

As found during previous years concentrations of nitrogen-containing nutrients were often above the REHVs in the estuary. Total nitrogen, ammonia and oxidised nitrogen exceeded REHVs at Crosslands on all sampling occasions, while at sites 60 and 61 the REHVs were exceeded about half the time for oxidised nitrogen, ammonia and total nitrogen. The high nitrogen concentration in the estuary is sourced mainly from the discharges of West Hornsby and Hornsby Heights STPs, plus lesser quantities in runoff from the urban and industrial areas. The tidal section of Marramarra Creek at Site 48 exceeded REHVs for ammonia, total nitrogen and oxidised nitrogen about half the time, pointing to sources of nutrients from the rural residential and farming areas in upstream catchments of the rural areas in the Shire.

Dissolved phosphorus measured within the Berowra Estuary and Marramarra Creek satisfied the REHV about half of the time, but at Crosslands Site 100 where phosphorus satisfied the REHV less than 20% of the tests.

Monthly sampling for dissolved oxygen (DO) in the surface (at 0.5m depth) at Crosslands Site 100 found concentrations were lower than the REHV range in about 70% of tests. At Berowra Waters Site 60 DO concentrations were low 40% of times.

Figure 10: Water Quality at Estuarine and Recreational Sites: Annual distribution of Concentration Values



Notes: Site 100 at Crosslands and Site 55 at Brooklyn were monitored weekly during summer months December to March as part of the Recreational Water Monitoring Program. Sites 103 to 106 were monitored monthly as part of the Brooklyn STP impact assessment in the Hawkesbury River. Site 100 at Crosslands, Sites 60 and 61 at Berowra Waters, Site 48 in Marramarra Ck and Site 38 in Sandbrook Inlet were monitored monthly as part of Council's routine, long term estuary water quality program.

Compared with 2009-2001, the upper sections of The Berowra Estuary at Crosslands site 100, Berowra Waters Site 60 and Calabash bay Site 61, as well as upper tidal section of Marramarra Creek Site 48, showed evidence of greater (or more regular) freshwater influence during 2010-2011; median salinity values were lower by about 5 ppt and pH values lower by 0.1-0.2 units due to dilution with freshwater. At the same time the additional fresh stormwater and greater numbers of STP by-passes added to higher average levels of bacteria, nutrients, turbidity and suspended solids, and higher resulting growth of chlorophyll-a during this reporting period.

Chlorophyll-a concentrations are indicative of phytoplankton abundance and biomass. Within the upper estuary at sites 60 and 61, where waters are deeper and usually clearer and tidal currents relatively gentle, chlorophyll concentrations are often highest. During 2010-2011 the chlorophyll concentrations detected in the monthly samples exceeded the REHV (4ug/L) on most of occasions during summer and early autumn. High levels of chlorophyll-a are not always indicative of poor estuarine health, however in the Berowra Estuary it is the long term persistence of elevated average levels and occasional bloom levels exceeding 30 ug/L that is of concern.

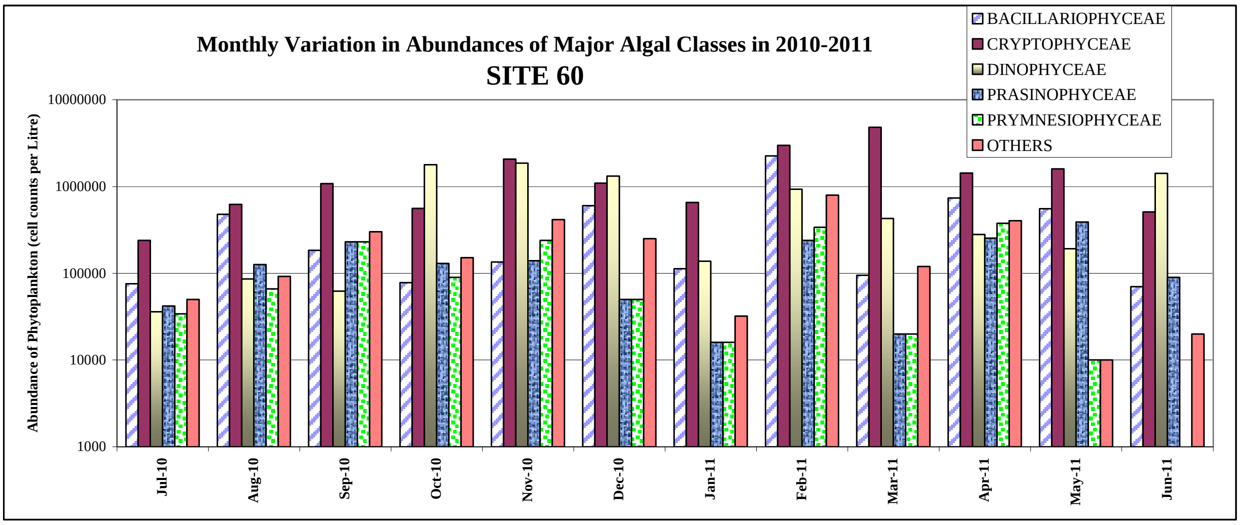
Chlorophyll was also measured continuously at the 5 probe sites 61, 150, 151, 152 and 152 stationed throughout the estuary system. Results of chlorophyll-a concentrations are recorded automatically and displayed in real time on the web at http://mhl.nsw.gov.au/projects/berowra/latest.php and http://mhl.nsw.gov.au/projects/hscsal/

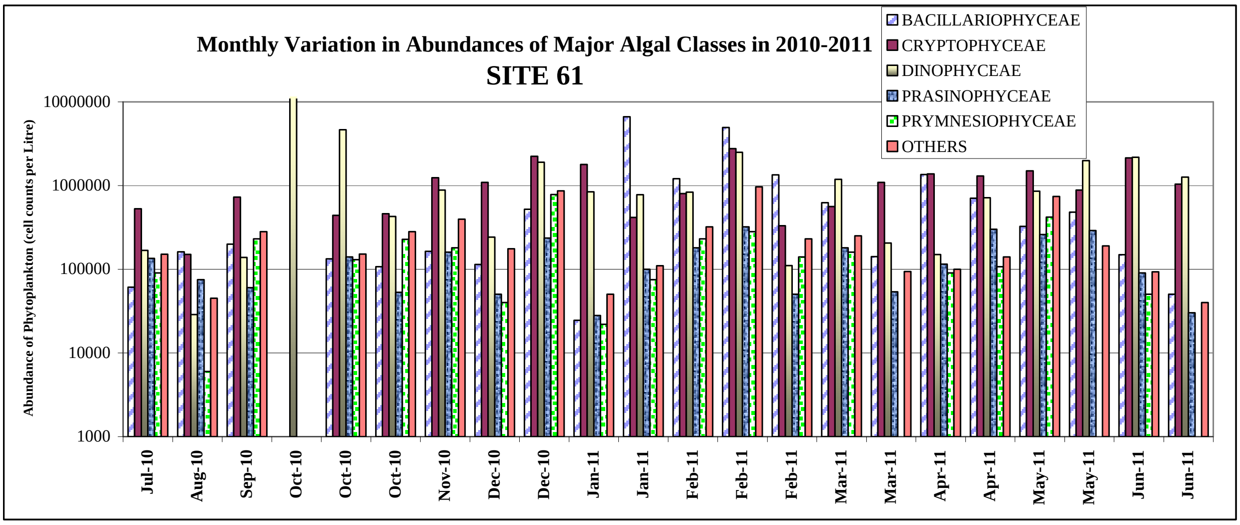
Analysis of phytoplanktonic samples collected during 2010-2011 showed a diverse range of species. The dominant algal Classes collected in the Berowra Estuary at sites 60 and 61 are shown in Figure 11. Major phytoplankton types were similar at both sampling sites throughout the year, and generally similar to previous years. Figure 12 shows the major algal Classes of samples collected near the probes along the Hawkesbury River; there are significant variations in the algal Classes as a result of decreasing salinity further up the river system. Table 15 sets out the details of identification and abundance specifically of potentially harmful algal species, and compares the numbers against the Action Trigger Levels (NSWFA, 2008, Brett, 2007). Most times the counts were well below levels that trigger the need for further investigations; however, in October 2010 the algal species *Prorocentrum cordatum*, a potential toxin producer that has caused fish kills elsewhere, bloomed to very high concentrations for a short time in Berowra Waters at Sites 60 and 61. On another one occasion in June 2011 at Site 61 the potentially harmful species *Dinophysis caudata* exceeded to trigger level. These test results were reported immediately to the NSW Food Authority and RACC which assessed the situation and concluded that Public Notices or Closures were not necessary on these occasions. At those times visible algal blooms were not significant and fish kills were not reported.

Photo 22: Site 48. Taking water samples from a boat in upper tidal area of Marramarra Creek

Photo 23: Site 105. Manoeuvring a boat in a strong tidal current on the Hawkesbury River to take a sample near the Brooklyn STP discharge pipe

Figure 11: Dominant Algal classes for 2010-2011 at sites 60 and 61 in Berowra Creek Estuary





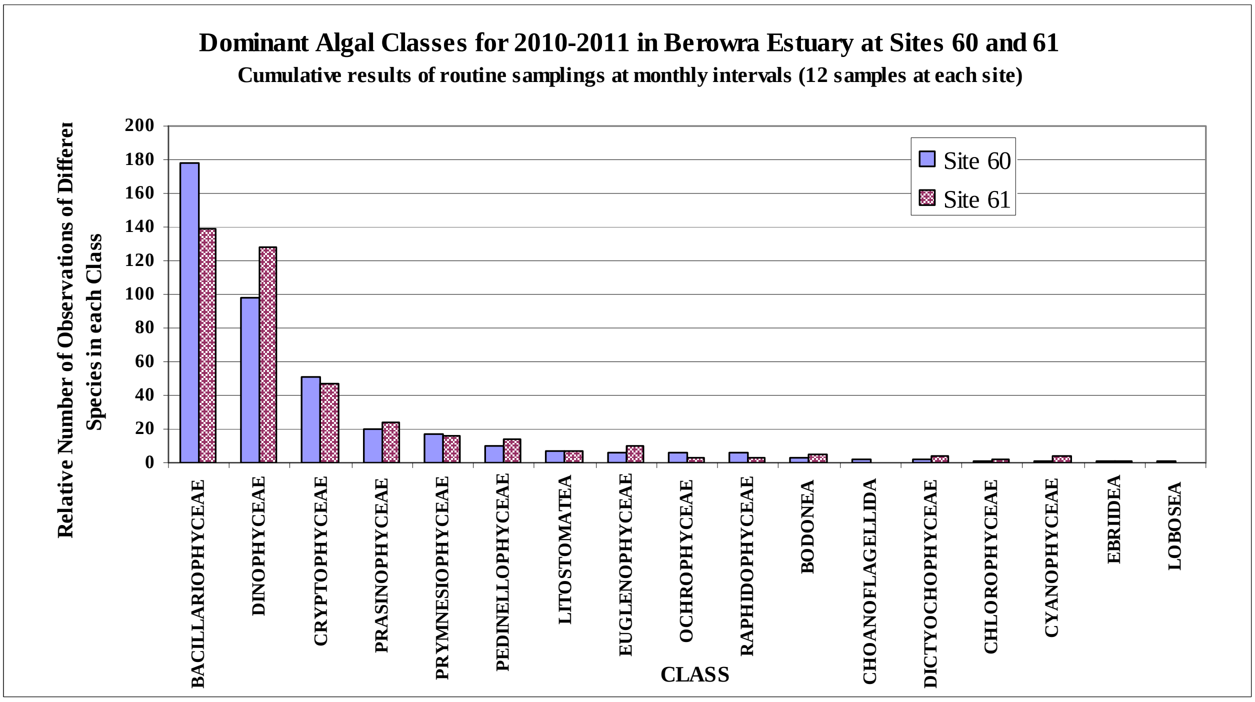


Table 15:

Phytoplankton in the Berowra Estuary at Sites 60 and 61: Summary breakdown listing occurrences of potentially harmful species July 2010 to June 2011.

Site 60. Berowra Creek near the Car Ferry at Berowra Waters

Hazard grouping and Toxicity	Genus - Species	Action Trigger Level (Cells/L)	Month Sampled Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
A	Chattonella sp.						0.5							
Amnesic/Paralytic/Diarrhetic/	Dinophysis acuminata	1000			0.5									
Shellfish Poisoning	Dinophysis caudata	500							50	0.5	200			
	Phalachroma/Dinophysis rotundata	500							0.5					
	Pseudo-nitzschia pungens/multiseries	50000		350					1000					
B. Toxicity Unclear	Alexandrium pseudogonyaulax	-		0.5										
C. Potential	Prorocentrum cordatum/minimum	-		2000	12000	1600000	4000	1000	6000	32000	140000	1000	2000	90000
Toxin Producer		-												
D. Toxicity	Alexandrium margalefi	-		0.5	150	50								
Unlikely	Prorocentrum dentatum	-									6700			
Blue-Green Algae	Oscillatoria sp	-						0.5						

SITE 61. BEROWRA ESTUARY NEAR MOUTH OF CALABASH BAY

Hazard grouping and Toxicity	Potentially Harmful Genus-Species	Action Trigger Level (Cells/L)	Jul-10	Aug-10	Sep-10	Oct-10	Oct-10	Oct-10	Nov-10	Dec-10	Dec-10	Jan-11	Jan-11	Feb-11	Feb-11	Feb-11	Mar-11	Mar-11	Apr-11	Apr-11	May-11	May-11	Jun-11	Jun-11
A	Alexandrium catenella	-	50	0.5																				
Amnesic/Paralytic/	Alexandrium cf. minutum	-						0.5																
Diarrhetic	Alexandrium sp.	-								50														
Shellfish Poisoning	Alexandrium tamarense	-				50		50																
	Dinophysis acuminata	1000			0.5	0.5	0.5																	
	Dinophysis caudata	500	0.5									700	150		75		100	400		100	0.5	0.5	1000	
	Phalachroma/Dinophysis rotunda	500										0.5	350								0.5			
	Pseudo-nitzschia delicatissima g	500000											2000			0.5	5500			1000				
	Pseudo-nitzschia pungens/multis	50000		900								1500	3000											
	Pseudo-nitzschia turgidula	50000															8500							
B	Alexandrium pseudogonyaulax	-		100									50											
Toxicity unclear	Chattonella sp.	-	0.5																					
	Heterosigma akashiwo	-					2000	500	5000							500	500							
C	Karenia mikimotoi	-													4000					4000	1000			
Potential Toxin	Karenia sp.	-															50					1000		
Producer	Prorocentrum cordatum/	-	2000	3500	5000	3320000	4540000	1500	2000		5000	76000	65000	125000	242000		1000	33000	12400	40000	283000	10000	110000	130000
	minimum	-																						
D	Alexandrium cf. ostenfeldii cyst	-	50																					
Toxicity unlikely	Alexandrium margalefi	-	50	100	550	1000	300																	
	Prorocentrum dentatum	-																			1000			
Blue-Green Algae	Anabaena spp.	-								0.5*														
	Microcystis weisenbergii	-								5000													0.5	
	Oscillatoria sp.	-			0.5					0.5														

Figure 12: Dominant Algal classes for 2010-2011 on Hawkesbury River at Remote Chlorophyll Probes

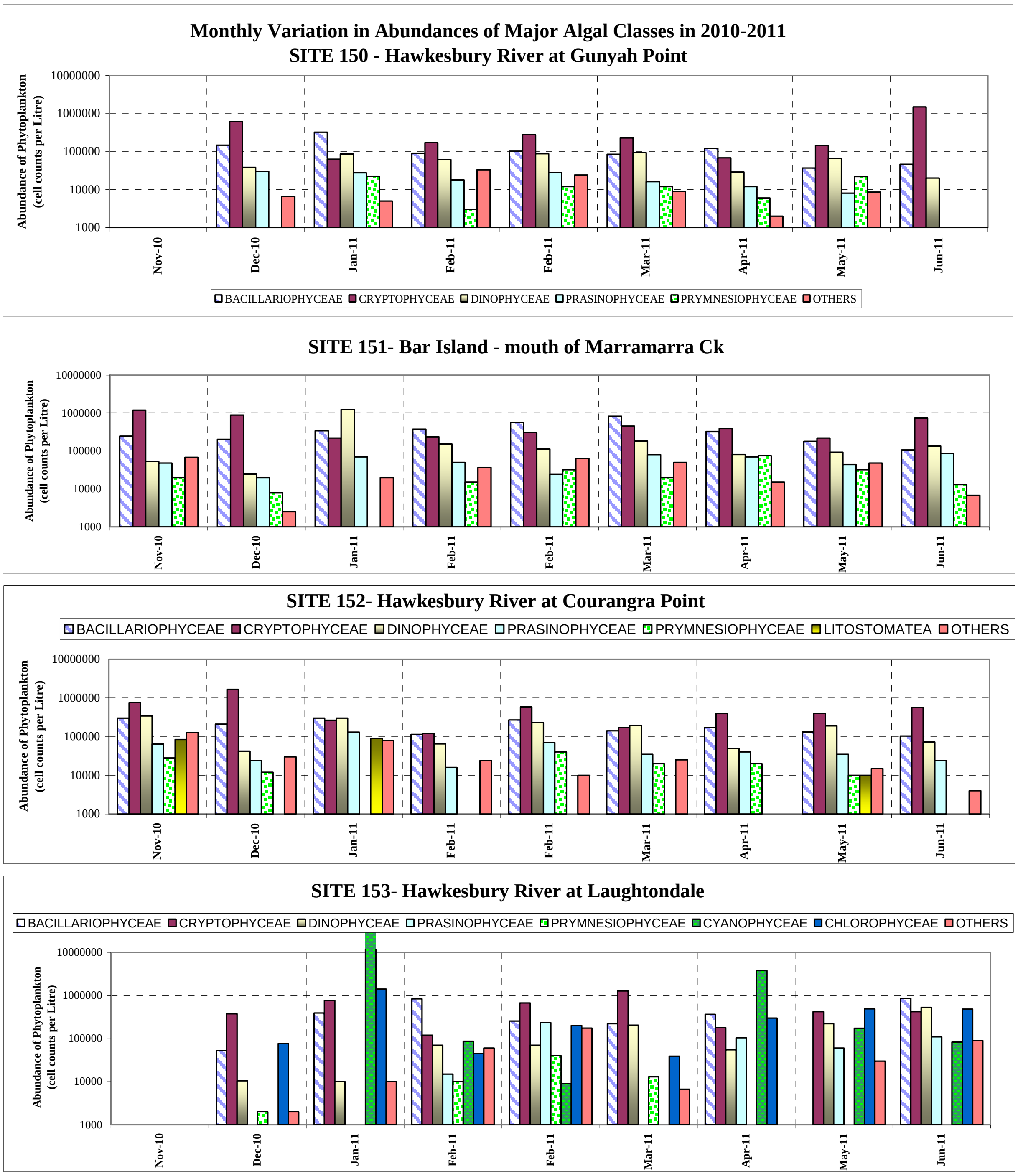


Photo 24: Near Site 38 on Sandbrook Inlet at Brooklyn

7.10 Hawkesbury River STP Monitoring Sites:

7.10.1 Sites 103, 104, 105, 106, 107 and 108

Sydney Water has constructed a sewage treatment plant (STP) at Brooklyn to treat household sewage and wastewaters from Brooklyn, Mooney Mooney and Dangar Island residences. The tertiary treated waters from the STP are discharged under the Peats Ferry bridge into the strong tidal flows of the Hawkesbury River.

A sampling program was initiated in June 2006 under the Estuary Management Program to study potential environmental effects pre and post commissioning of the STP outfall. The STP was commissioned in late 2007 and residences are progressively being connected to the sewer over the next few years.

The summary results tables (A.103 to A108) are presented in the Appendix to give information on the current condition of the river. Results for selected parameters are shown in Figure 10. However, until the STP is at full operational load it is still too premature to assess meaningful trends over the limited time that the sampling program has been undertaken.

Photo 25: "After a Swim", Photograph by Claire Miles - Entry in 2011 Hornsby Council Photo Competition

7.11 Recreational Monitoring Sites.

7.11.1 Site 55 Hawkesbury River at Brooklyn Baths and Site 100 at Berowra Ck at Crosslands

Water-based recreational activities have always been popular in Australia and are highly valued by the community. There are, however, limited opportunities for shore-based swimming in the Shire's estuaries due to the predominantly rocky nature of the foreshores in the tidal estuary. Hornsby Shire Council undertakes water quality monitoring at two recreational sites during the months of December, January, February and March. Recreational monitoring tests were carried out on a weekly basis at Brooklyn Baths Site 55 and Crosslands Reserve Site 100 and results compared to the Guidelines (see Section 4.2). In addition environmental health monitoring is carried out monthly at Crosslands throughout the year. Costly algal identifications were not carried out in samples from the recreational monitoring sites during the summer season 2010-2011; this change was based on the negative results during the previous 6 years for the specific harmful species listed in Table 2.

Results for on-site probe testing and laboratory analysis of samples taken at Sites 55 and 100 during 2010-2011 are summarised in Appendices A.55 and A.100. Selected results of analysis are also presented in Figure 9 to enable comparison with other estuarine sites which are monitored for the whole year.

Tables 16 and 17 summarise the monthly compliance with the Recreational Water Quality Guidelines. Data in the tables are placed on Council's website as they become available (see www.hornsby.nsw.gov.au/environment/ - Water Catchments – Water Quality – Recreational Water Quality)

Table 16: Site 55 Hawkesbury River at Brooklyn Baths for December 2009 to March 2010 – Summary Compliance with Recreational Water Guidelines

Month	Temp Range °C	Chlorophyll-a	pH	Dissolved Oxygen (%sat)	Oily Films or surface scums	Aesthetic aspects, clarity	Microbial Category (Enterococci)	Aquatic Ecosystem Protection parameters
NHMRC Recomm'n	-	*See table 1 and 2*	*6.5 – 8.5*	*>80 % sat*	*Free*	*Not Bothersome*	*See Table 3*	*See table 1 for TN, TP*
December 2010	20 - 23	Pass&	7.4 - 7.9 Pass	87 - 105 Pass	Pass*	Fair+	A. Good	Pass@
January 2011	22 - 25	Pass&	7.7 - 7.9 Pass	89 - 99 Pass	Pass	Fair+	A. Good	Pass@
February 2011	24 - 26	Pass	7.6 - 7.90 Pass	80 - 98 Pass	Pass	Fair+	A. Good	Pass@
March 2011	23 - 24	Pass	7.5 - 7.8 Pass	86 - 91 Pass	Pass	Fair+	A. Good	Pass@

:Chlorophyll slightly elevated on one occasion
+:Visibility affected by turbidity and suspended matter on 1 to 2 occasions
* Minor oily algal slick on one occasion
@ Oxidised nitrogen often slightly elevated

Based on the matrix in Table 16 Brooklyn Baths maintained the classification of GOOD or LOW-RISK as it satisfied the Guidelines during the 2010-2011 summer swimming season in terms of low microbial contamination, absence of excessive chlorophyll-a, satisfactory pH and low nutrient status. In addition the Baths are surrounded by a fence which protects swimmers from certain hazards (e.g. Boats, dangerous fish). Aesthetic aspects, however, were ranked FAIR due to the moderate suspended matter and turbidity levels of the water and fine silty sediment causing decreased water clarity – this is typical of the tidal areas of the Hawkesbury River.

Table 17 shows that Berowra Creek at Crosslands Reserve continues to be classified as generally POOR or MODERATE RISK for recreational swimming in 2010-2011 summer season. The POOR rating is based on occasional moderate levels of microbial organisms which are indicators of faecal material and are associated with increased disease risk for swimmers. The Crosslands site was ranked FAIR to POOR for aesthetic aspects based on observations (e.g. scums, low clarity, surface films, fine silt, smelly muds) and test parameters (e.g. Elevated suspended matter and nutrients; low dissolved oxygen).

Table 17: Site 100 Berowra Creek at Crosslands Reserve for December 2009 to March 2010 – Summary Compliance with Recreational Water Guidelines

Month	Temp Range °C	Chlorophyll-a	pH	Dissolved Oxygen (%sat)	Oily Films or surface scums	Aesthetic aspects, clarity	Microbial Category (Enterococci)	Aquatic Ecosystem Protection parameters
NHMRC Recomm'n	-	*See table 1 and 2@*	*6.5 - 8.5*	*>80 % sat*	*Free*	*Not Bothersome*	*See Table 3*	*See table 1 for TN, TP*
December 2010	21 - 25	Pass#	6.8 - 7.1 Pass	49 - 72 Poor	Fair*	Fair+*%	C. Poor	Poor@
January 2011	24 - 28	Pass#	6.5 - 7.1 Pass	51 - 69 Poor	Pass	Fair+*%	C Poor	Poor@
February 2011	24 - 28	Pass#	6.8-7.1 Pass	47 - 56 Poor	Poor0	Fair+*	B. Fair	Poor@
March 2011	23 - 25	Fair$	6.6 - 7.1 Pass	58 - 72 Poor	Fair*	Fair+*%	D. Poor	Poor@

:Chlorophyll slightly elevated on one occasion
$: Chlorophyll slightly elevated on most occasions
* : Mild oily algal surface scum on one occasion
0: Mild oily film or surface scum on most occasions
+: Water clarity occasionally affected by turbidity, suspended matter and dark colouration
% "Nuisance" organisms - Ducks and associated faeces noted.
@ : Poor – excessive nutrients

It is generally known that there is increased risk of pollution affecting recreational water quality for a few days after rain. Authorities, such as Beachwatch (http://www.environment.nsw.gov.au/beach/) generally recommend avoidance of swimming after heavy rain for at least 1 day at ocean beaches, and for 3 days at harbour and estuary sites. In the Berowra Creek catchment after heavy rainfall it may take days for bacterial contamination, flushing from far up the catchment, to reach Crosslands and an additional few days for waters at Crosslands to clear and be flushed by tides. Microbial monitoring data collected during the last six years of Council's bacterial monitoring at Crosslands is starting to indicate that a more appropriate avoidance period may be longer depending on the intensity and duration of rainfall in the Catchment.

Based on a known relationship between elevated microbial contamination and rainfall events, it is planned to integrate the bacterial data, gathered in Council's estuarine and recreational monitoring programs, into a modelling study of estuarine salinity being conducted under the Estuary Management Program (HSC, 2010a). It is anticipated that salinity measurement, together with modelling of salinity and bacterial contamination response to rainfall, will be able to provide a rapid bacterial risk rating for swimming in the estuary. This modelling study is at an advanced stage and it is envisaged that by the end of 2011 Council's website will include a link to real time monitoring of salinity and assessment of swimming risk. (see HSC 2011a, section 4.6).

7.12 CRR Water Treatment Devices – Constructed Wetlands

Council's Catchments Remediation Rate (CRR) Capital Works Program is described in regular annual reports (e.g. HSC, 2011b). The major program aim is to mitigate the influence of stormwater pollution on creeks and bushland. The program involves the construction and maintenance of catchment remediation devices, such as wetlands, bioretention systems, sediment basins and gross pollutant traps, as well as pollution preventative strategies such as landfill leachate treatment and community education. In the 2010-2011 reporting period, as part of the CRR program, water monitoring was carried out at one constructed wetland site, three landfill sites and seven stormwater harvesting sites.

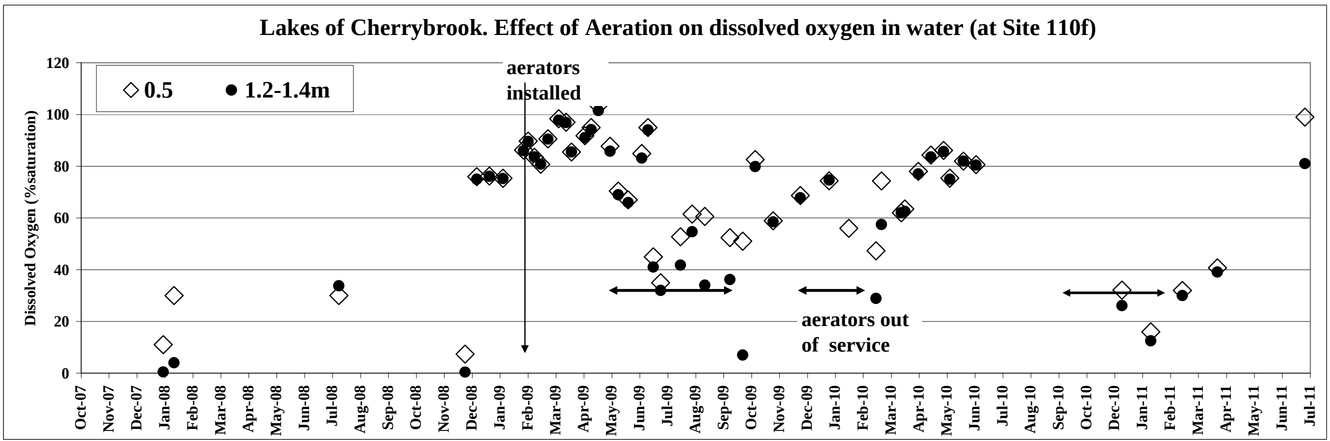
Photo 26. Site 110f. Lakes of Cherrybrook showing an aerator fountain.

7.12.1 Lakes of Cherrybrook.

In previous years, the dissolved oxygen (DO) concentration in outlet waters from the Lakes were depressed due to removal of DO by microbial and vegetative materials in the deeper still waters. At times, especially when the dissolved oxygen levels were very low in the centre of the Lakes, the water turned almost black and there was increased risk of water borne diseases harmful to water birds.

To improve the appearance and health of the Lakes of Cherrybrook an aeration system was installed in late 2008. The results of measurements of DO levels from the observation platform in the lower Lake (Site 110F) are shown in Figure 13. Very low DO levels were observed in 2008, but when the aerator system was operating, DO increased significantly, stratification did not occur and the visual appearance of the Lakes improved. On a number of occasions when the aerators were out of service testing showed that dissolved oxygen levels dropped and stratification occurred.

Figure 13: Graphs of Dissolved Oxygen concentrations in the centre of the lower Lakes of Cherrybrook



7.13 Stormwater Harvesting Projects – Catchment Remediation and Water Reuse

Council operates a number of stormwater harvesting projects to collect, treat and use rainwater harvested from the land or from nearby stormwater systems. The primary use of the harvested water is for irrigation of grassed sports fields. New stormwater harvesting schemes were commissioned during the 2010-2011 at three sports fields in the Epping area: Somerville Park; Epping Oval and North Epping Oval. The recent projects are described in annual reports of the Water Catchment Team's Sustainable Total Water Cycle Management Strategy (e.g. HSC 2011d).

Six stormwater harvesting schemes sampled during the 2010-2011 year are discussed below.

7.13.1 Council Nursery and Parks Depot, Pennant Hills: Site 98

Stormwater is collected from the nursery and depot areas and directed through filter-beds to a biological filter and then stored in large tanks. The harvested water does not undergo UV sterilisation. Water is used for hosing and spray irrigation of nursery plants to replace expensive town water. The system uses Town Water as back-up during dry times or for special watering requirements. Samples are taken near the nursery glasshouses from a tap fed by pump from the large storage tanks.

- Results of regular testing of the water are shown in Appendix A.98 and summarised in Figure 14.
- In table 18 the test results are compared with Council's Interim Guidelines. Further investigation of two parameters is recommended: turbidity and bacterial levels.
- Turbidity levels are high in irrigation water used at the nursery. This is probably due to the activities carried out in the stormwater catchments, which include chipping and mulching trees, and regular driving of large trucks on muddy soils. It is possible that these activities have overloaded the water treatment processes of settling and filtration. A low turbidity level is recommended for most stormwater harvesting systems because it can have detrimental affects on UV sterilisation processes. At the nursery this may not be a significant issue because UV is currently not used. However, if UV filtration is proposed (to reduce the bacterial levels) then it is recommended that turbidity will need to be reduced before UV sterilisation is expected to effectively.
- Faecal coliforms levels exceeded the irrigation guideline value of median=10 cfu/100ml on a number of sampling occasions. It is noted that spray irrigation of plants at the Nursery is only carried out after hours using an automatic timer, so the risk to staff and volunteer workers of inhaling the irrigation water is reduced. It is recommended that investigations in the catchment be undertaken to eliminate possible sources of faecal bacteria.

7.13.2 Greenway Park Sports Ovals, Cherrybrook:. Sites 120 and 121.

An enlarged and upgraded stormwater harvesting system was installed at Greenway Park, Cherrybrook during 2009-2010 (see description in HSC, 2009b). The system uses Town Water as automatic back-up during water shortages. As a result, the storage tank containing the 'UV-treated' stormwater can at times contain varying amounts of Town Water.

Two sampling taps were set up to collect 'raw' harvested water at Site 120 and 'UV treated' water at Site 121; the taps were placed to allow water to flow from the storage tanks under gravity, without the need to switch on pumps. Analysis results are shown in Tables A.120 and A.121, and summarised in Figure 14.

Testing shows that the raw stormwater at Site 120 contained faecal bacteria at levels greater than the Interim Guideline of 10 cfu/100mL for about 30% of tests. Table 18 shows that the irrigation water (site 121) complies with the Interim Guidelines for each parameter. One issue, however, is the high fluoride concentration (although only two tests were conducted). This implies that, on those occasions the irrigation water was, in fact, mainly town water, not stormwater. Therefore, there is possibly the need at Greenway Park to better monitor the source of irrigation water used, and to ensure that stormwater is used if available.

Photo 27: Stormwater harvesting collection point near Berowra Oval. After passing through a trashrack the stormwater is filtered through permeable pavers and collected in an underground concrete tank from which it is pumped on demand to the UV treatment system at the nearby oval.

Photo 28: Site 132. Foxglove Oval at Mount Colah. Sampling tap on the header tank where irrigation water is stored.

7.13.3 Berowra Oval, Berowra. Sites 128 to 131.

A stormwater harvesting project at Berowra collects stormwater near the Community Centre for use on Berowra Sports Oval. Stormwater is harvested from the end-of-pipe near upper Gully Rd, Berowra. The water is filtered (see Photo 27) and collected in an underground 90 kL tank, then pumped on demand up to a Control Room near the Oval where it is further filtered and UV-treated then stored in an above-ground concrete tank until use. The system is designed with a back-up system to use Town Water only if necessary during dry times. The sample sites associated with this project are:

- Site 128 - raw water from the underground storage tank.
- Site 129 is raw water taken (while pumping) at a sampling point immediately before the UV sterilisation;
- Site 130 is treated water taken immediately after UV sterilisation; and
- Site 131 is treated water taken from the above-ground storage tank near the Control Room.

Results of testing of the water are tabulated in Tables A.128, A129, A130 and A.131 and selected parameters are summarised in Figure 14.

Results available to date indicate that the concentrations of faecal bacteria in the source stormwater (Site 128) are reduced progressively through the collection and treatment train to a low level in the water used for irrigation (Site 131). Table 18 shows that the irrigation water (Site 131) satisfies all the Interim Guidelines.

7.13.4 Foxglove Oval, Mount Colah Site 132

Foxglove Oval irrigation system was set up a few years ago to water the sports field using Town Water which is stored in an above-ground concrete tank. Over recent years the plumbing and control systems have been modified to enable transfer of water from a nearby facility that collects and treats the leachate from the old Foxglove Landfill (see Section 7.14). It is anticipated that the system will be operating during 2012. In the meantime monitoring of the irrigation system has been carried out by sampling from a tap in the side of the water storage tank (Photo 28).

The results of monitoring is presented in table A.132 and shown on Figure 14. Table 18 shows that the irrigation water (Site 131) satisfies all the Interim Guidelines, but the fluoride content of ~ 1 mg/L is highlighted to flag that 100% town water is used.

Figure 14: Summary Selected Water Quality Parameters at Stormwater Harvesting Projects 2010-2011

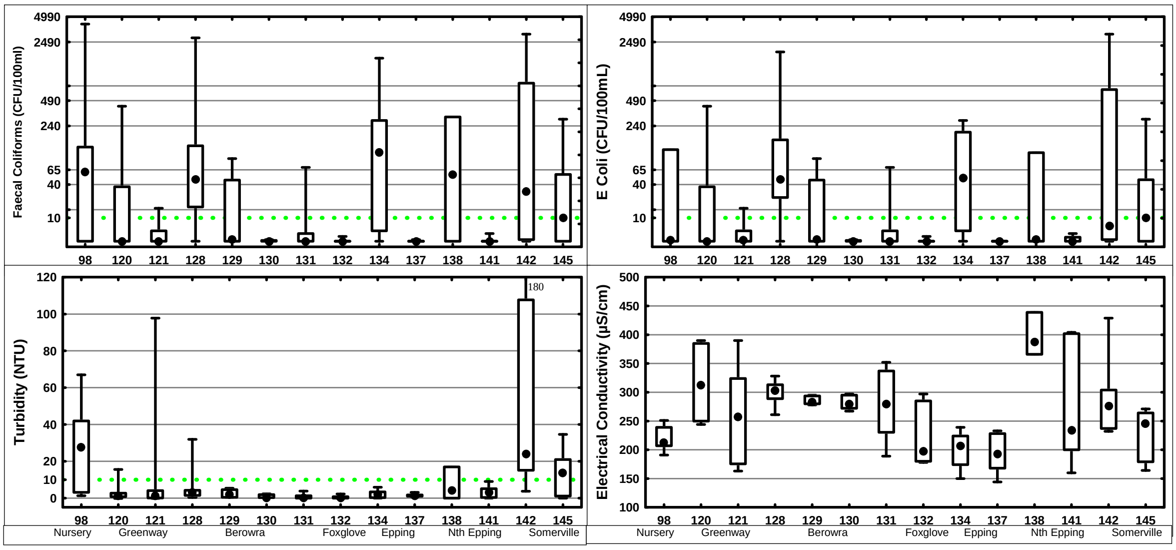


Table 18. Stormwater Harvesting Projects 2010-2011. Summary of Compliance with Interim Guidelines (Section 4.4)

Test Parameter	Units	Trigger	Nursery 98	Greenway 121	Berowra 131	Foxglove 132	Epping 137	North Epping 140+141	Somerville 145
Fluoride (mg/L)	mg/L	>0.1	0.4	0.6	0.1	1.0	*	*	*
EC (uS/cm)	uS/cm	>2000	220	250	280	220	190	330	250
Sodicity (mg Na/L)	mg Na/L	>114	11	18	17	16	9	44	22
SAR		>2	0.8	1.1	1.3	1.4	0.8	2.4	1.8
Cl (mg/L	mg/L	>175	20	27	31	34	13	83	33
Turbidity NTU	NTU	>10	28	8	1	0.5	2	3	13
Suspended Solids	mg/L	>50	1	2	2	1	1	6	1
Hardness	mg CaCO3/L	>350	88	124	66	*	49	36	57
Total Fe	mg/L	>10	0.4	0.35	0.06	0.01	0.08	0.4	0.4
Total P	mg/L	>0.8	0.2	0.1	0.02	0.01	0.2	0.2	0.04
Bacteria	Faecal coliform cfu/100mL	>10	61	1	1	1	1	1	10
Bacteria	E. coli cfu/100mL	>10	1	1	1	1	1	1	10

Mean values given, except for Bacteria where median value is listed
* = not tested
= Acceptable
= Potential Issue
= Problematic. Investigate further

7.13.5 Epping Oval, Epping. Sites 134 to 137.

The Epping Oval stormwater harvesting and re-use project was completed in 2011. The scheme has two below-ground storage tanks with combined capacity of 400 kLs of stormwater and an above-ground tank holding about 20 kL of treated water ready for irrigation use. There is a back up system to enable use of Town Water if necessary during droughts.

The sample sites associated with this project are:

- Site 134 - raw water from the underground storage tank.
- Site 135 - raw water taken while pumping from a tap immediately before the UV treatment system
- Site 136 - UV treated water taken from a tap immediately after the UV treatment system
- Site 137 - treated water taken from the above-ground storage tank near the Control Room.

Sites 139 and 140 have not yet been sampled yet due to issues with the logistics of disrupting the programmed irrigation timetable to turn on the pumps to take the samples.

Results of testing of the water are tabulated in Tables A.134 and A137. Selected data are summarised in Figure 14, which shows that the raw stormwater (Site 134) usually contained moderate levels of faecal bacteria, but that the filtration and UV process reduced bacterial numbers significantly in the treated water (Site 137).

Table 18 shows that the irrigation water (Site 137) satisfies all the Interim Guidelines.

7.13.6 North Epping Oval, North Epping

The North Epping Oval stormwater harvesting and re-use project was completed in 2011. The scheme has below-ground storage capacity of 300 kLs of raw stormwater and a below-ground tank holding 100 kLs of treated water ready for irrigation use.
The sample sites associated with this project are:

- Site 138 - raw water from the larger underground storage tank.
- Site 139 - raw water taken while pumping from a tap immediately before the UV treatment system
- Site 140 - UV treated water taken from a tap immediately after the UV treatment system
- Site 141 - treated water taken the smaller underground storage tank.

Photo 29: Epping Oval filtration and UV system

Selected data are summarised in Figure 14, which shows that the raw stormwater occasionally contained moderate levels of faecal bacteria, but that the filtration and UV process reduced bacterial numbers significantly in the treated water.

Results of testing of the water are tabulated in Appendices A.138 and A141 and are summarised in Figure 14.

Table 18 shows that the irrigation water (Site 140 and 141) satisfies all the Interim Guidelines.

7.13.7 Somerville Oval, Epping

The Somerville Oval stormwater harvesting and re-use project was upgraded in 2011. The scheme now has below-ground storage capacity of 300 L's and a below-ground treated water tank of 100 L.
The sample sites associated with this project are:

- Site 142 - raw water from the underground storage tank.
- Site 143 - raw water taken while pumping from a tap immediately before the UV treatment system
- Site 144 - UV treated water taken from a tap immediately after the UV treatment system
- Site 145 - treated water taken from the above-ground storage tank near the Control Room.

Sites 143 and 144 have not yet been sampled due to issues with the logistics of turning on the pumps to take the samples

Results of testing of the water are tabulated in Appendices A.142 and A145 and are summarised in Figure 14 which shows that the raw stormwater often contained very high turbidity levels, and moderate levels of faecal bacteria. The box-plots also show that for half the time the filtration and UV process did not reduce the faecal bacteria levels below 10 cfu/100mL in the treated water.

Table 18 shows that the irrigation water (Site 145) at Somerville Oval passed most of the Interim Guidelines, however, turbidity failed and Faecal bacteria only just passed. Further investigation is recommended to assess the efficacy of the filtration and sterilisation systems because these initial results suggest that the high turbidity of raw stormwater at this site could be reducing the effectiveness of the treatment system.

7.14 Landfill Sites Leachate Collection and Treatment

The rehabilitation of former municipal landfill sites has been in annual reports of the Catchment Remediation Rate Capital Works Program (e.g. HSC, 2009) at Arcadia Park, Arcadia and at Foxglove Oval, Mt Colah. Leachate collection and treatment systems have been in operation at these two tips for a number of years, and their effectiveness assessed by monitoring the quality of water before and after treatment.

At Wisemans Ferry Tip site, which is still under rehabilitation by Works Division, leachate monitoring is a condition of the Environment Protection Licence.

7.14.1 Foxglove Oval Leachate Treatment. Site 95, 96A, 96A2, 96 and 77

Extensive rehabilitation of the Foxglove Landfill site at Mt Colah has been carried out since its closure in the 1980s. The site has been converted to sports fields and a program to capture and treat the landfill leachate has been undertaken. Considerable efforts have been taken to capture the leachate by the installation of a groundwater cut off drain, a leachate collection well, pump and soakage pit at the base of the landfill embankment in the early 2000s.

More recently a sophisticated treatment process using a combination of wetlands and an automated bio-reactor have been installed to improve ammonia removal (see HSC, 2010b). The immediate aim is to be able to transfer the treated leachate to the nearby Foxglove Oval irrigation system, where the residual nitrogen will act as a fertiliser for the grass.

Routine water quality testing has monitored the performance of the treatment system and effects of tip leachate on the downstream creeks. Sampling has been carried out at the following sites: Site 95 - Raw Leachate collected by the interception drains below the tip embankment, and pumped to an above-ground tank; Sites 96A and 96A2 - the leachate after passing through the two bio-reactors; Site 96 Treated Leachate after flowing through the Bio-filter and wetland treatment system; and Site 77 in Gleeson Creek about 200m downstream of the tip embankment.

The results of analysis are presented in Appendices A.95, A.96, A.96A ,A.96A2 and A.77 and in Figure 15.

The test results show that;

(1) the bio-reactor and wetland treatment process (which includes partial dilution by rainfall onto the wetlands area) results in significant improvement in leachate water quality. Test results in Tables A.95 and A.96 showed reduction in the mean electrical conductivity from about 1350 to 1100, a rise in pH by 0.1 pH units. The same tables and Figure 15 show that the treatment converts ammonium to nitrate nitrogen; in the process ammonium nitrogen concentrations decrease by an average of about 90% and the net output concentration of nitrogen-containing compounds (i.e. Total Nitrogen) is about 60% lower than the input concentrations.

(2) ammonium-nitrogen concentrations in the downstream receiving creek (Gleeson Creek at Site 77) however remain significant. These arise from impact of urban sewer leaks and landfill leachate. Recent works to reduce leachate entering the creek have been undertaken to improve the capture of landfill leachate and to increase the size of the Bio-reactor (HSC, 2010b).

7.14.2 Arcadia Landfill. Site 18 Raw Leachate , Site 94 Treated Leachate, and Site 122 downstream creek

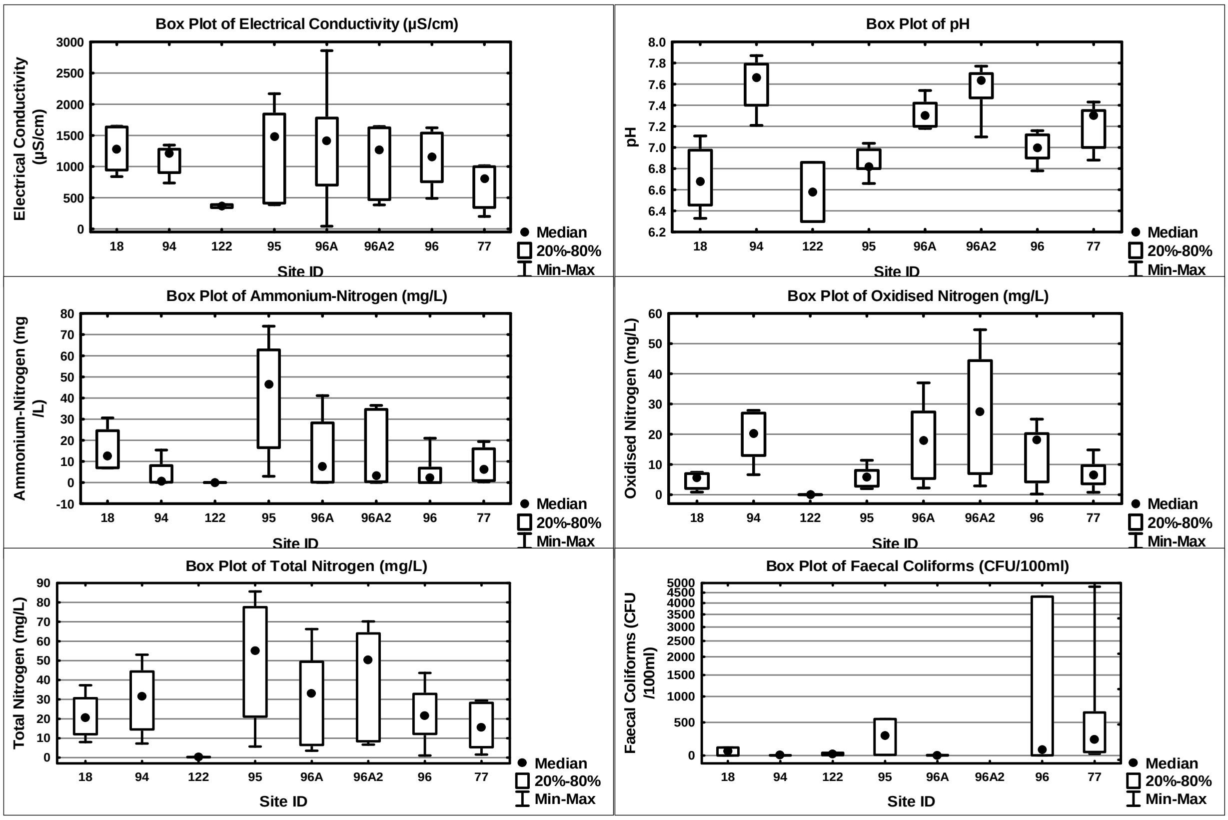
The Arcadia Landfill near Arcadia Park was remediated in 1997/1998 by clay capping. Water management included separation of stormwater and seepages. The captured leachate is collect in underground tanks, and treated using a trailer-mounted bioreactor (see HSC, 2010b). Water is tested at three sites to assess the effectiveness of seepage collection and the bioreactor performance. The sampling sites are: Site 18 Leachate from underground tanks; Site 94 leachate after passing through the bioreactor; and Site 122 about 200m down slope of the landfill in the nearest permanent waterway in the upper catchment of Calabash Creek. Site 122 is within healthy undisturbed bushland in a shallow valley surrounded by rural residential developments and Arcadia Park. The catchment area of site 122 is estimated to be about 1.2 km^2 of which about 50% is bushland.

Results of monitoring are presented Tables A.18, A.94 and A.122 and summarised in Figure 15 Sampling occurred 5 times during the year..

The collected leachate was slightly salty with electrical conductivity of about 1300 uS/cm, pH about 6.6, negligible Faecal coliforms, but with a total nitrogen content of about 20 to 30 mg/L, most of which is ammonium nitrogen. Bioreactor treatment marginally reduced electrical conductivity to about 1200 uS/cm, raised pH by about 1 pH unit, and removed about 70% of the ammonia and converted it to oxidised nitrogen. Unexpectedly the total nitrogen concentration appeared to increase during the treatment – the most likely cause is sampling issues. There was difficulty collecting a representative sample of the raw leachate from a large underground tank which was probably stratified and could not be mixed before sampling.

Testing of the nearest creek down slope at Site 122 was carried out on two selected occasions; both a few days after wet weather when the creek had reduced to a small flow (2 L/min) and believed to be fed exclusively by groundwater inputs. The nitrogen nutrient concentrations at site 122 were very low and satisfied the REHVs for aquatic ecosystem protection. The results indicate that seepage from the landfill does not have a significant impact on Calabash Creek.

Figure 15: Arcadia and Foxglove Landfills leachate treatment facilities: Distribution of Selected parameters



7.14.3 Wisemans Ferry Landfill – Sites 56 and 112

The Wisemans Ferry Tip site has ceased operation as a tip and, in 2002, a Closure Plan was submitted to Department of Environment, Climate Change and Water (DECCW). The tip has been clay capped, and revegetation and water management has been ongoing. The Environment Protection Licence issued by DECC has required ongoing water quality monitoring at the Wisemans Ferry Tip site. Two sites are monitored quarterly: the leachate collection dam (Site 56) and Riser "C" (Site 112) below the tip embankment. The results are incorporated by the Works Division in Council's reports to DECCW.

7.15 Biological Monitoring Results

7.15.1 Estuarine Phytoplanktonic Algae

In addition to the chlorophyll monitoring probes (section 5.4.1), which give real time data on chlorophyll concentrations at 5 sites in the estuary, a program of sampling phytoplanktonic algae and identification was carried out.

The planktonic algae monitoring in The Berowra Estuary continued in the 2010-2011 period on a monthly basis at two sites ; Site 60 in the centre of Berowra Creek near the car ferry at Berowra Waters, and at Calabash Bay Site 61 which is about 2 km further downstream adjacent to Council's chlorophyll monitoring probe. Further discussion of these sites and results are presented in section 7.9.

Sampling for planktonic algae was introduced from November 2010 at the chlorophyll monitoring probe sites. Samples were taken at the same time as the probes were serviced (at approximately 3 to 4 week periods).

Based on the negative results for the presence of harmful algal species listed in Table 2 over the last 5 years, the expensive algal identification was discontinued from the summer Recreational Water Monitoring in December 2010 (see Section 7.11).

7.15.2 Macroinvertebates and Diatom Indicator Monitoring

Work continued towards following up the recommendations made by GHD (GHD, 2007), including further assessment of Reference Sites, of the link between impervious surface areas, stormpipe connectivity with creeks, and the impacts these physical features have on macroinvertebrate results. A review of the 2002-2007 Macroinvertebrate- Diatom monitoring program was contracted to an independent expert whose report (Wright, 2010) recommended that:

- the program from 2002-2007 suffered from insufficient Reference Site data to enable rigorous statistical analysis. As a first step to continuing the program more bushland reference sites should be surveyed to help confirm that the sole reference site (Site 37) used in the earlier work is in fact representative of undisturbed local freshwater creeks.
- The available dataset collected during 2002-2007 revealed that spring versus autumn biota were statistically identical. Thus two samplings per year could be reduced to one sample per year.
- Future sampling should continue to use the same sampling and laboratory procedures which are robust and industry best practice.
- Future sampling should concentrate on pool edge habitats but, as many sites did not have riffle zones, the sampling of riffles could be discontinued.
- Consideration should be given to redistributing the landuse grouping to enable better comparison between landuses
- Additional information on the stream ecological condition at sample sites should be collected, including use of the Riparian, Channel and Environmental inventory (RCE) method as well as accurate determination of impervious areas and connected impervious surface areas within catchments.
- Relate the water quality data to biota sampling to better assess the attributes that are driving the stream ecological condition.
- The data so far gathered is of excellent scientific quality, which together with a number of suggested projects, should be published in the scientific literature.
- The data could be combined with water quality data into community education material which more simply presents information on the health of local streams.

During the 2010-2011 reporting year a number of the recommendations have been followed through;

- Eight unimpacted reference sites were chosen and sampled for macroinvertebrates and diatoms in May-June 2011. Samples were analysed by specialist limnologists: macroinvertebrates by Chris Madden of

Freshwater Macroinvertebrates of Kyneton in South Australia; and diatoms by Jason Sonneman of Ecological of Kyneton in Victoria. Ian Wright of Wright Environmental Consulting is currently evaluating the results.

- Community education material in the form of a Health Report Card is to be prepared giving a health grade to each sampling site. This has involved developing a grading system for ranking the environmental health of creeks and estuary based on physical-chemical parameters, microbial contamination, as well as macroinvertebrates and diatoms (in freshwaters) and phytoplanktonic chlorophyll-a (estuary). The Health Report Card is due to be finalised in early 2012.

Photo 30: Collecting macroinvertebrates at Site 54 in Laughtondale Creek

7.16 Sewage and septic impacts

As discussed in sections 7.5 to 7.8, water monitoring of many creeks in the Shire has shown that at times, high faecal bacterial levels were present, especially after storms. The monitoring program could not always identify the exact sources of the contamination, however it did provide circumstantial evidence that sewage and septic systems were the likely sources of contamination. Within sewered areas a number of significant sources of bacteria and nutrients associated with the sewer system are known to include:

- Leakages from sewer pipes resulting from pipe cracks and blockages
- Surcharges during storms of raw sewage from designed overflow points built into the pipe network, and
- By-passes of partially treated sewage from STPs during storm events

During the 2010-2011 year Sydney Water reported that:

- there were two dry weather bypasses, one at West Hornsby STP on 18/10/2010 and one at Hornsby Heights STP on 24/9/2010, both due to equipment failure at the plants.
- by-passes occurred at STPs: nine by-passes at West Hornsby and 12 at Hornsby Heights STPs occurred during wet weather flows or equipment failure. The largest volume by-passes occurred during the 6 largest rainfall events during the reporting period (see Figure 4),
- there were 82 call-outs for emergency repairs to the sewer systems in the Shire. The majority were sewer leakages caused by tree roots entering and blocking pipes; many were reported by Sydney water to have had localised impacts on nearby stormwater systems and waterways.

Council's Environment Health Team reported that a number of public complaints were made to Council of sewage seepages or odours, some of these were traced to Sydney Water's sewage pipes, and others were traced to private properties. Property owners are responsible for maintaining the private sewer pipes on their property and to ensure that plant roots and stormwater runoff do not enter the sewerage system and cause leaks. Leakages from sewer pipes occurring in private properties must be fixed at the property owner's expense by licensed plumbers.

Large areas of the Shire are not sewered, particularly along the Berowra Estuary and in the rural areas north of Dural. Unsewered properties must manage their waste waters by on-site disposal or use of pump out facilities. Council has strict requirements for on-site treatment of sewage and greywaters to minimise the pollution of creeks and waterways. On-site treatment systems must have independent inspections on a regular basis which are reported to Council; problems are followed up by Council's Environmental Health Officers. A number of villages are fitted with septic tanks which require regular pump-out. In addition, Council regularly audits the performance of on-site systems to help minimise the contamination of the waterways by septic seepages. Nevertheless, quality of the receiving waters downstream of the rural areas is impacted by faecal bacteria and nutrients arising from rural landuse practices and sewage disposal. For example, (1) close downstream of the unsewered areas of Cowan Village (sample site 62), Galston Village (sample site 64) and Glenorie (sample site 80), concentrations of faecal coliforms and/or nutrients exceed Guidelines a significant number of the time, and (2) the tidal section of Marramarra Creek at times contains elevated nitrogen nutrients and chlorophyll , and low dissolved oxygen levels, that fail Guidelines and signify slight eutrophication of the estuarine ecosystem, and (3) downstream of Glenorie Village contamination of Glenorie Creek simultaneously with sediment, nutrients and faecal bacteria point to repeated incidences of illegal siphoning of septic tanks.

8 Conclusions

8.1 Freshwater Creeks

The variations in water quality in the Shire's freshwater creeks is highlighted by comparison with water quality Guidelines as well as by comparison with Reference creeks located in catchments unimpacted by human developments and activities. Sites were sampled to a scheduled monthly program to ensure that variation in water quality is measured over a range of seasons and weather.

8.1.1 Suspended Sediment

During 2010-2011 turbidity and suspended solids levels mostly satisfied Guidelines in creeks below rural areas but in creeks below urban and industrial areas turbidity mostly failed while suspended solids occasionally failed, . particularly after rainfall. In natural undisturbed bushland areas suspended solids and turbidity levels in creek waters generally increase only after large storms when overland stormflow occur. However, within developed areas with conventional stormwater systems connected directly to creeks, even very small rainfall events result in rapid wash off from the large impervious areas carrying sediments from roadways, hard surfaces and disturbed/unvegetated soils at development sites, or from and illegal discharges. On most occasions turbidity and suspended solids were naturally elevated at sites in the Hawkesbury and lower Berowra Estuary due to the resuspension of fine sediments by wind and tidal flows.

8.1.2 Faecal Coliforms

Faecal coliforms results in creeks downstream of the urban and rural areas were considered to be moderate throughout the year, and high below industrial areas. However, at all sites the maximum concentrations found during the year were well above Guideline levels and usually occurred immediately after storms. High levels were shown, at times, to extend well out into the Berowra Estuary. These problems are related to higher suspended solids in wash off from developed areas, from leaking sewerage infrastructure, from wet weather by-passes of sewage at the STPs and surcharges at designed sewer overflow points. In the unsewered rural areas faecal contamination was often found, particularly after rain, downstream of Glenorie village and Galston village.

8.1.3 Nutrients

All industrial and most urban test sites continued to show consistently high levels of nutrients which exceeded the Guidelines for nitrogen species and phosphorus most of the time. Sources of nutrients within developed areas include spills, dust fallout, fertilisers, detergents, eroding soils, decomposing lawn clippings, pet faeces, sewage seepages or sewer overflows. These contaminants wash into creeks more quickly and effectively from hard surfaces in areas with extensive impervious surfaces and conventional stormwater systems connected directly to creeks.

Within the rural areas nitrogen and phosphorus concentrations were elevated at sites closest to onsite sewage treatment systems and rural activities, and exceeded REHVs most of the time. Specifically, drainage from Galston Village (Site 64) often had elevated nutrient and faecal coliforms levels. Glenorie Creek (site 80) consistently had very poor water quality again this year.

Hornsby Heights and West Hornsby Sewage Treatment Plants discharge tertiary treated effluent to Waitara and Calna Creeks to a Standard set by Environment Protection Licences. Significant reductions in effluent nitrogen levels were achieved after major STP upgrades in the early 2000s. Nevertheless the residual nitrogen in present day STP discharges, combined with whole-of-catchment inputs, still result in all monitoring sites in Berowra Creek catchment downstream of the STPs regularly exceeding recommended Guideline concentrations of oxidised nitrogen and ammonium nitrogen.

Total Nitrogen (TN) is considered to be one of the key indicators of the environmental health of waterways. An initial review of historic data was carried out for twenty six site where TN has been measured monthly for up to 14 years. At each site the trend in the annual ‘median’ values was assessed. Increasing median values over time was considered to indicate degradation of water quality while reduction in median values indicated improvement. Based on this method it was found that, for TN in freshwater creeks, approximately 40% of sites are improving, 40% of sites are not changing and about 20% are degrading. There was a clear trend in reduced Total Nitrogen concentration in creeks downstream of the West Hornsby and Hornsby Heights STPs after their upgrades back in 2002, but concentrations of treated effluents are well above the Guideline values for aquatic ecosystem protection.

8.2 Estuary

8.2.1 Environmental Health

Within estuarine areas, levels of faecal indicators were generally low at Hawkesbury River sites after extended dry weather. After heavy rainfall in the catchment bacteria were moderately high at Berowra Waters, in the upper part of the estuary at Crosslands Reserve and in the upper tidal section of Marramarra Creek.

The action of wet weather run-off from urban and rural areas contributed to periodic high levels of turbidity/suspended solids in the upper estuary areas. Estuary areas in or close to the Hawkesbury River had high turbidity and suspended solids generally arising from wind and tidal movement.

Chlorophyll-a concentrations exceeded Guideline levels at Berowra Waters when algal activity increased. Concentrations of potentially harmful algae were found on a number of occasions but were not sufficiently hazardous to cause the Regional Algal Coordinating Committee to issue public warnings. Oxidised nitrogen (mainly Nitrate) concentrations, sourced from developed areas, particularly from the STP discharges, remained well above Guideline levels in the Berowra Estuary and was the likely nutrient source supporting the excessive algal growths.

8.2.2 Recreational Monitoring of Estuarine Swimming Sites

Recreational water monitoring over the summer season showed that Brooklyn Baths continued to be classified as Good (Low Risk) as regards bacterial and chemical contamination, but aesthetic aspects of suspended silt, typical of the Hawkesbury system, resulted in generally fair to poor water clarity. Berowra Creek at Crosslands Reserve had a Poor (Moderate Risk) microbial classification for recreational water use due to occasional sewage pollution especially after heavy rain. Indications are that swimming should be avoided at Crosslands for up to 5 days after storms to allow time for settling and tidal flushing.

8.3 Catchment Remediation and Water Reuse Programs

Water quality monitoring supported Council’s Catchments Remediation Capital Works Program and projects developed under Council’s Total Water Cycle Management Strategy. This included testing at constructed wetlands, landfill sites, stormwater harvesting sites, and water reuse projects.

At the rehabilitated Foxglove Landfill site (now Foxglove Oval) a biofilter reactor and constructed wetland reduced concentrations of nitrogen nutrients from the collected landfill leachate. Stormwater harvesting schemes near numerous sports fields and at Council’s nursery at Pennant Hills, is providing valuable irrigation water to save townwater supplies; monitoring highlighted which water quality and maintenance issues need attention, but in general the collected waters were fit for purpose.

8.4 General Environmental Health

Chemical, physical and biological water quality results for 2010-2011 show that the surrounding land-use, rainfall and seasons play a major role in aquatic health of the Shires waterways. Rainfall contributed to the transport and deposition into waterways of land based pollutants such as sediment, nutrients and general litter. This was especially significant in areas with traditional piped stormwater infrastructure where wash off moves rapidly and directly to creeks. At sites influenced by sewage and stormwater, the nutrients and suspended solids concentrations, turbidity and Faecal coliforms were usually greater after wet weather than dry. It is clear that storms of over 25mm rain result in major by-passes of partially treated sewer at West Hornsby and Hornsby Heights STPs, and probably raw sewer surcharging from designed overflow points along sewer mains into creeks. At industrial areas, given the influence of large areas of impermeable surfaces and diverse activities, stormwater wash off had a significant effect on water quality degradation, and it was noted that Guideline values were regularly exceeded during wet and dry weather. Water quality in creeks downstream of urban and rural areas was sometimes acceptable during base flow conditions, but unfortunately these creeks were often affected by sewage leaks or illegal discharges. Creeks below extensive areas of impervious surfaces in urban and industrial areas suffer additional physical stress from more frequent ‘flash-flooding’ as a result of rapid stormwater wash off. These episodes of contamination and flash flows damage stream ecology which then struggle to recover before the next episode. High concentrations of oxidised nitrogen, sourced predominantly from treated sewage effluent from the STPs, remained a major impediment to the improvement of the environmental health of Berowra Creek below Fishponds.

The Guideline values for ‘slightly to moderately disturbed ecosystems’ were used for the water quality assessments. These Guidelines reflect a Community expectation that creek ecosystems in the Shire’s bushland areas should be maintained in a good condition. Unfortunately, the upper sections of creeks draining from intensive industrial, urban and rural developments have been historically ‘highly disturbed’. While catchment remediation initiatives undertaken by Council have been shown to improve water quality downstream of works, the vast extent of disturbances caused by past land developments means that much work remains to be done to return the creeks to a better condition.

Progress has been made towards developing a Water Quality Report Card for Hornsby Shire. The process has been, initially in the preparation of an SOE report, to apply Grades to each water quality indicator at each site based on the frequency that tests satisfied the Guideline values. A preliminary method, set out in Appendix B, used three key water parameters at freshwater sites: suspended solids, total nitrogen and total phosphorus, and three parameters at estuarine sites: chlorophyll, total nitrogen and total phosphorus. The rating can be considered “good” at a site if the Guideline values for the three parameters are simultaneously satisfied more than 50% of the time. A “poor” rating for under 25% of the time. Based on this methodology the measured ratings for sites in creeks and the estuary in 2010-2011 were “Good” at 36% of sites, “Fair at 8% and “Poor” at 56% of sites. This methodology is being further developed for use in a Water Quality Report Card to be finalised in early 2012.

Photo 31. “Berowra Sunrise” Berowra Waters by Craig Sheil. Entry in 2011 Hornsby Shire Photographic Competition

9 References and further reading

ANZECC (1992). *Australian Water Quality Guidelines for Fresh and Marine Waters* Australian and New Zealand Conservation Council, National Water Quality Management Strategy, Paper No.4.. Canberra

ANZECC/ARMCANZ (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy. Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand. Canberra.

APHA (2005). *Standard Methods for the Examination of Water and Wastewater*, American Public Health Association. 21th Edition, Washington USA.

AMBS (2005). *Macroinvertebrates and Diatom Monitoring. 2002-2005 Final Report*. Australian Museum Business Services report to Hornsby Council. August.

Brett, S. (2007). Pers. Comm.. Manager, MicroAlgal Services, Ormond, Victoria.

Brodie, J. (1995) The problems of nutrients and eutrophication in the Australian marine environment. *State of the Marine Environment Report for Australia* Edited by Zann, L.P and Sutton, D. Great Barrier Reef Marine Park Authority, Townsville

Coad, P., A. Rubio-Zuazo and R. Kadluczka (2010). A Management Response to Ecosystems and Health Risks from Estuarine Algal Blooms. Presentation at the 19th NSW Coastal Conference, Batemans Bay. (Proceedings available at www.coastalconference.com)

DEC (2006). Managing Urban Stormwater. Harvesting and Reuse. Department of Environment and Conservation. April

Ecowise Environmental, 2010. *Risk Management Plan for Pumping Hornsby Quarry and Review of Impacts*. Report to Hornsby Shire Council. February

GHD (2007). *Macroinvertebrate and Diatom Catchment Assessments*. 2006-2007 Final Report. July.

Hallegraeff, G. (2002). *Aquaculturist's Guide to Harmful Australian Microalgae*. School of Plant Science, Hobart.

HSC (2009). *Water Quality Monitoring Program. Annual Report 2008-2009.* Water Catchments Team, Hornsby Shire Council

HSC (2010a). *Water Quality Monitoring Program. Annual Report 2009-2010.* Water Catchments Team, Hornsby Shire Council

HSC (2011a). *Estuary Management Annual Report*. 2009-2010. Water Catchments Team, Hornsby Shire Council.

HSC (2011b). *Catchment Remediation Capital Works Program. Annual Report*.2009-2010. Water Catchments Team, Hornsby Shire Council

HSC (2011c). River Health Report Card – Hornsby Shire. Companion Technical Report. (draft only). Water Catchments Team, Hornsby Shire Council.

HSC (2011d). Sustainable Total Water Cycle Management Strategy, Water Catchments Team, Hornsby Shire Council.

NHMRC (2008). *Guidelines for Managing Risks in Recreational Water.* National Health and Medical Research Council. Australian Government Publishing Service, Canberra. February

NHMRC, NRMMC (2004). *Australian Guidelines for Water Recycling. Stormwater Harvesting and Reuse*. *Australian Drinking Water Guidelines.* National Health and Medical Research Council, and National Resources Management Ministerial Council. National Water Quality Management Strategy.

NRMMC, EPHC, NHMRC (2009). *Stormwater Harvesting and Reuse*. National Resource Management Ministerial Council & Environment Protection and Heritage, & National Health and Medical Research Council. National Water Quality Management Strategy. Document 23. July

NSW Food Authority. (2008). *NSW Shellfish Program. Marine Biotoxin Management Plan*. Version 2.01. July. Appendix 12.

RACC (2009-DRAFT). Metropolitan South Coast Regional Algae Co-ordinating Committee. *Guidelines for Management Response to Marine and Freshwater Algal Blooms.* For Application in the Sydney metropolitan South Coast Catchments. Metropolitan South Coast Regional Algae Co-ordinating Committee. NSW Office of Water. November. Table 1.

Sinden, G. and Wainsbrough, T. (1996) *The Northern Rivers - A Water Quality Assessment*. Environment Protection Authority, Chatswood, NSW, Australia.

SPCC (1989). *Pollution Control for Urban Stormwater*. State Pollution Control Commission, NSW

Wright, I. (2011). Review of Hornsby Council's Aquatic Ecosystem Program (2002-2007) Macroinvertebrates and Diatoms. Report prepared for Hornsby Shire Council. January.

10 Glossary

Algae: simple chlorophyll-bearing plants which are capable of photosynthesis. They may occur in all aquatic environments, and may be microscopic in size. Algal monitoring in The Berowra Estuary refers to the collection and identification of phytoplanktonic species and aims to help protect stakeholders by early detection of harmful species or algal blooms

Algal Bloom: An unusually large concentration of algal planktonic organisms made up of one or a few species. In the estuarine environment blooms may be noticed by a change in water colour and smell, by surface froths, or even fish kills. Blooms of certain algal species at times produce toxic chemicals which are accumulated by aquatic organisms and may kill them or render them unfit to eat.

Ammonia: Ammonia is present naturally in surface and wastewaters and its concentration is generally low in groundwater because it adsorbs to soil particles and clays and is not leached readily from soils (Rowe and Abdel-Magid, 1995). It is a nitrogen source for algae (CSIRO, 1996). Ammonia is often an indicator of contamination by raw sewage. (See nitrogen)

Assimilation: The incorporation of absorbed substances into cellular material.

AUSRIVAS: Australian River Assessment Scheme. A rapid biological assessment method for collecting, processing and cataloguing macroinvertebrates from freshwater streams.

Base flow of water in creeks refers to the low flows generally fed by groundwater seepages. Thus water flows can continue in creeks even when rain and rainfall runoff from land has not occurred for extended periods, because water stored in the ground slowly seeps out at lower elevations into creeks.

Catchment: The area of land above a chosen stream site from which rainfall and water discharges all drain to that site.

Chlorophyll-a: This is a biological pigment which enables plants, including algae, to photosynthesize. The pigment concentration is measured in a water samples to provide an indication of the biomass of phytoplankton (microscopic, suspended plants) in the water; high concentrations may identify undesirable growth of phytoplankton.

Conductivity: Conductivity or electrical conductivity is a measure of the ability of an aqueous solution to conduct an electrical current (APHA, 1998). This ability depends on the presence of ions; on their total concentration, mobility and valance; and on the temperature of measurement. Solutions of most inorganic compounds are relatively good conductors whilst molecules of organic compounds that do not ionise in solution conduct current very poorly.

Control Site. See Reference Site

Correlation: The linear relationship between two or more variables.

Diatoms: A large group of microscopic algae found as single celled or colonial organisms, characterised by a cell wall containing silica. Diatoms are an important part of estuarine phytoplankton and benthic surface growths on rock and plant surfaces in both estuarine and freshwater streams. The diversity and richness of diatom species is used as an indicator of stream health.

Dissolved Oxygen: Oxygen in water is measured as dissolved oxygen (DO). The maximum amount of DO that will dissolve in water (i.e. when the water is saturated with DO) is dependant on temperature, altitude and the presence of other solutes. Pure water at equilibrium with moist air at sea level is 100% saturated when the concentration of oxygen at 0^0C equates to 14.63 mg oxygen per litre of water. The value percent saturation is the relative amount of DO in water compared with the theoretical maximum that can be dissolved. Low DO % saturation in rivers may indicate eutrophication problems where DO is being consumed be chemical and biological reactions. Supersaturated conditions, when DO is greater than 100%, may occur in waters when oxygen input, due to algal or plant photosynthesis, exceeds that lost by respiration of via the water-air interface by diffusion to the atmosphere.

Ecology: Study of living organisms and their relationships to one another and the environment.

Ecosystem: A community composed of plants and animals which, together with its physical environment, functions as a unit.

Enterococci: A group of streptococcal bacteria, usually non-pathogenic, found in the human intestinal tract. Enterococci present in waters at recreational sites are considered indicators of human faecal contamination. They are able to survive longer in saline waters than faecal coliforms. Although they are not particularly harmful themselves to humans, high enterococci counts in water indicates increased likelihood for the presence of more harmful micro-organisms and higher risk of infection.

Erosion: The wearing away of the substrate as a result of factors including weathering and human use.

Estuary: A partially enclosed coastal river mouth, characterised by tidal effects and mixing of fresh and sea water. The Berowra Creek estuary is the waterway starting at the tidal limit of Berowra Creek and reaching to its mouth at the Hawkesbury River near Bar Island.

Eutrophication or eutrophic conditions: Abundance of nutrients in waterways resulting in high rates of phytoplankton productivity frequently resulting in oxygen depletion below the surface layer of the water body.

Faecal coliforms: Faecal coliforms are bacteria that inhabit the intestines of humans and other mammals and are present in faeces. Direct detection of many serious pathogens in waterways is not feasible because they occur intermittently in the water column, there are many possible species, they are difficult to detect and the analysis costs are prohibitive. For this reason, Faecal coliforms are measured as an indicator bacteria. Faecal coliforms are present in large numbers in human faeces but it is important to note that coliforms are not themselves pathogenic under normal conditions, although they can cause diarrhoea and sometimes urinary tract infections (Tortora *et al*, 1986). They are commonly used as an indicator of sewage pollution in water. (Sinden and Wainsbrough, 1996). The biggest impact of water-borne micro organisms is on human health. Micro-organism levels in urban waterways are generally highest after heavy storms due to contributions from unabated stormwater runoff, bypass at sewage treatment plants and leaks from sewage infrastructure.

Groundwater: Water below the surface of the earth, generally occurring in the pore spaces of rocks and soils. The base flow conditions of creeks generally originates from groundwater seepages

Leachate: Water which has passed through the soil and contains soluble substances from it. At landfill sites the leachate that collects may contain high concentrations of ammonia and organic compounds.

Macroinvertebrates: A group name given to a wide range of small animal species commonly found in freshwater streams and visible to the naked eye. Sometimes referred to as “Water Bugs”. Includes various species of insects, crustaceans, molluscs and worms including stoneflies, mayflies, shrimps, flatworms, blood worms, leeches, mosquito larvae and beetles. The diversity and richness of macroinvertebrate species, and the presence or absence of particular types, is used as an indicator of stream health.

Microalgae. See Algae

Monitoring: The observation and assessment of a certain area over time. Monitoring of water quality may take the form of: visual appearance (e.g. clarity, colour, scums, oily films), suspended particles (e.g. clays, algae, bacteria), dissolved chemicals (e.g. Nutrients, salts), microorganisms (e.g. Bacteria), or plant and animal life (e.g. Algae, macroinvertebrates)

Nitrogen: The dissolved forms of nitrogen include ammonia (NH_3 and NH_4) and oxidised nitrogen (NO_2 and NO_3). The particulate form of nitrogen is mainly organic. Nitrogen is essential to plant growth but in large amounts can contribute to excessive plant growth (possibly favouring exotic species or algal blooms) that can cause the eutrophication of waters. The principal anthropogenic sources of N which may reach the coastal zone are agricultural runoff and sewage discharges (Brodie, 1995). Other sources of nitrogenous compounds include decaying vegetation, leachate from landfill, animal faeces, industrial wastewater and fertilisers, urban runoff and atmospheric fallout of gaseous nitrogenous compounds.

Nuisance organisms/plants: Plants and/or organisms that are usually introduced species which affect the health of an aquatic ecosystem and may indicate a stressed or imbalanced ecosystem.

pH: pH is the measure of the hydrogen ion concentration in the water and is an indicator of the acidity or alkalinity of water. The pH scale ranges from 0 which is extremely acidic to 14 which is extremely alkaline. A pH of 7.0 is neutral. pH can affect the toxicity of pollutants such as ammonia, aluminium and cyanide and the rate at which pesticides break down in soil.

Phosphorus: Phosphorus is one of the main nutrients required for the growth of algae and aquatic plants. The major anthropogenic inputs of phosphorus to coastal waters are agricultural runoff and sewage discharges (Brodie, 1995). Phosphorus concentrations are one indicator of a river's potential for algal production. Human activity may increase the amount of phosphorus entering rivers such as from stock or human effluent, as a residue from fertiliser application or attached to eroded soil particles. The dissolved form of phosphorus is mainly phosphate (PO_4).

Phytoplankton: see Algae

Reference Site: A monitoring site against which other sites are compared. In Councils' studies the sites are chosen in catchments unimpacted by man's land development activities. Ideally, in environmental studies of waterways, the reference creek is chosen, if possible, to have a similar catchment type and geology.

Run off (stormwater): see wash off

Sedimentation: Material of varying size, both mineral and organic, deposited away from its site of origin by the action of water, wind, gravity or ice.

Stratification of water: Water stratification occurs when water of high and low salinity, oxygenation, density or temperature, forms layers that act as barriers to water mixing.

Suspended solids: The concentration of material suspended in the water; usually measured in units of milligrams of suspended solids per litre of water. Water clarity will decrease with increasing concentrations of suspended solids. High levels of suspended solids have the potential to reduce the amount of light available to benthic and planktonic aquatic organisms for their metabolism and photosynthesis.

Tidal flushing: The action by which an estuary or river exchanges water with the ocean due to the flow of water caused by the tides.

Temperature: Temperature is the basic physical characteristic of the water body. Temperature fluctuations occur naturally between seasons, however unnatural variation to the season cycle can be detrimental to an aquatic ecosystem.

Turbidity: Turbidity is a measure of the light scattering properties of water. It indicates how much silt, algae and other material is suspended in the water column. Highly turbid water may harm aquatic organisms. Some streams are naturally turbid due to the clay soils in their catchment.

Wash off: a term used here to relate the effect of stormwater flowing off land and washing litter, loose dirt and dust from the surface of land and carrying it into storm drains and creeks, with the process of washing, for example, a car.

11 Appendix A. Water Quality Results

Water Quality Results

Summary Tables of Annual Mean, Median, Minimum, Maximum, 20th and 80th Percentiles, and Standard Deviation Values for Testing during July 2010 to June 2011

Table A.01: Summary Statistics for Combined Reference Sites Data for July 2010 to Nov 2011

Reference Sites 2010-2011 (Sites 36, 37, 54, 114, 123, 146, 147, 149, 157, 160, 161, 164)		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile
Estimated Flow rate (L/min)		65	850	80	0	10000	20	420
Temperature (oC)		68	15.8	15.5	9.3	22.8	11.9	19.9
Electrical ConductivityC (ms/cm)		66	0.2	0.2	0.1	0.5	0.1	0.3
Electrical Conductivity (µS/cm)		66	193	166	99	431	130	250
Turbidity (NTU)		68	2.4	0.4	-0.2	21.0	0.0	2.8
Dissolved oxygen (mg/L)		68	9.2	9.6	0.3	11.7	8.4	10.7
Dissolved oxygen (%sat)		68	93	96	48	114	89	102
pH		67	5.16	4.98	3.94	7.26	4.42	5.91
limits)		66	0.1	0.1	0.1	0.2	0.1	0.1
Suspended Solids (mg/L)	(2)	67	1.5	1.0	1.0	7.0	1.0	1.0
Ammonium-Nitrogen (mg/L)	(0.01)	68	0.01	0.01	0.01	0.03	0.01	0.01
Oxidised Nitrogen (mg/L)	(0.01)	68	0.02	0.01	0.01	0.27	0.01	0.01
Total Nitrogen (mg/L)	(0.05)	68	0.16	0.13	0.06	0.58	0.08	0.21
Total Phosphorus(mg/L)	(0.002)	68	0.006	0.004	0.001	0.044	0.002	0.006
Faecal Coliforms (CFU/100ml)	(1)	65	120	32	0.5	820	3.0	224
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	31	6	1	1.0	80	1.0	4
Chloride (mg/L)	(0.1)	33	54	44	24	121	34	71
Sulphate as SO42-(mg/L)	(0.1)	33	6.3	6.3	2.7	9.3	4.6	8.1
Fluoride (mg/L)	(0.05)	35	0.04	0.03	0.03	0.13	0.03	0.06
Sodium (mg/L)	(0.05)	35	27	22	14	51	19	33
Potassium (mg/L)	(0.05)	35	1.4	1.2	0.6	2.7	0.9	1.8
Magnesium (mg/L)	(0.01)	35	4.7	3.7	2.0	12.3	3.0	6.1
Calcium (mg/L)	(0.01)	35	1.9	1.5	0.3	15.2	0.5	2.3
Aluminium (ug/L)	(10)	31	323	247	37	1330	154	334
Arsenic (ug/L)	(1)	31	0.5	0.5	0.5	0.5	0.5	0.5
Cadmium (ug/L)	(1)	31	0.5	0.5	0.5	0.5	0.5	0.5
Chromium (ug/L)	(1)	31	0.6	0.5	0.5	1.0	0.5	0.5
Copper (ug/L)	(1)	31	1.7	1.0	0.5	6.0	1.0	2.0
Lead (ug/L)	(1)	31	0.6	0.5	0.5	2.0	0.5	0.5
Manganese (ug/L)	(1)	31	95	34	3	489	12	85
Molybdenum (ug/L)	(1)	31	0.5	0.5	0.5	2.0	0.5	0.5
Nickel (ug/L)	(1)	31	1.7	0.5	0.5	10.0	0.5	3.0
Selenium (ug/L)	(3)	31	1.5	1.5	1.5	1.5	1.5	1.5
Silver (ug/L)	(1)	31	0.5	0.5	0.5	0.5	0.5	0.5
Uranium (ug/L)	(1)	31	0.5	0.5	0.5	0.5	0.5	0.5
Zinc (ug/L)	(10)	31	15.9	12.0	5.0	65.0	5.0	20.0
Boron (ug/L)	(5)	31	20.9	21.0	9.0	33.0	16.0	26.0
Iron (ug/L)	(20)	31	398	232	63	1410	136	652
Mercury (ug/L)	(0.1 to 0.01)	29	0.1	0.1	0.1	0.5	0.1	0.1
BOD5/CBOD5(mg/L)	(2)	3	1.0	1.0	1.0	1.0	1.0	1.0
Total Organic Carbon(mg/L)	(2)	9	4.3	3.8	2.8	8.8	3.2	4.5

Table A.1: Summary Statistics for Site 1 Berowra Creek at Galston Gorge for July 2010 to June 2011

Site 1: Berowra Creek at Galston Gorge		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)		14	16.1	15.7	10.7	22.5	11.9	20.8	4.1
Electrical Conductivity (mS/cm)		13	0.45	0.45	0.24	0.64	0.33	0.56	0.12
Electrical Conductivity (µS/cm)		13	437	447	253	617	268	561	124
Turbidity (NTU)		14	3.8	0.7	0.0	19.7	0.0	7.2	6.4
Dissolved oxygen (mg/L)		14	9.2	9.3	6.7	11.0	7.8	10.5	1.4
Dissolved oxygen (%sat)		14	93	95	77	100	87	99	7
pH		14	7.3	7.4	6.9	7.8	7.0	7.5	0.3
Salinity (ppt)		13	0.2	0.2	0.1	0.3	0.2	0.3	0.1
Suspended Solids (mg/L)	(2)	14	2	1	1	11	1	3	3
Ammonium-Nitrogen (mg/L)	(0.01)	14	0.104	0.020	0.010	0.570	0.010	0.230	0.173
Oxidised Nitrogen (mg/L)	(0.01)	14	1.48	1.40	0.28	3.50	0.50	2.20	0.97
Total Nitrogen (mg/L)	(0.05)	14	2.04	1.81	0.65	4.38	1.03	2.69	1.03
Total Phosphorus(mg/L)	(0.002)	14	0.085	0.059	0.043	0.208	0.053	0.126	0.054
Faecal Coliforms (CFU/100ml)	(1)	14	697	65	10.0	6400	24.0	870	1674
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	2	62	62	59	64	59	64	4
Chloride (mg/L)	(0.1)	2	63	63	58	68	58	68	7
Sulphate as SO42-(mg/L)	(0.1)	2	37	37	35	39	35	39	3
Fluoride (mg/L)	(0.05)	2	0.33	0.33	0.25	0.41	0.25	0.41	0.11
Sodium (mg/L)	(0.05)	3	49.9	50.4	39.2	60.0	39.2	60.0	10.4
Potassium (mg/L)	(0.05)	2	9.7	9.7	9.2	10.2	9.2	10.2	0.7
Magnesium (mg/L)	(0.01)	2	6.0	6.0	5.0	7.0	5.0	7.0	1.4
Calcium (mg/L)	(0.01)	3	27.2	24.9	21.7	34.9	21.7	34.9	6.9
Aluminium (ug/L)	(10)	3	74	58	57	106	57	106	28
Arsenic (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L)	(1)	3	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Copper (ug/L)	(1)	3	2.3	2.0	2.0	3.0	2.0	3.0	0.6
Lead (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Manganese (ug/L)	(1)	3	15	15	14	15	14	15	1
Molybdenum (ug/L)	(1)	3	0.8	1.0	0.5	1.0	0.5	1.0	0.3
Nickel (ug/L)	(1)	3	1.7	2.0	1.0	2.0	1.0	2.0	0.6
Selenium (ug/L)	(3)	3	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L)	(10)	3	13	14	5	19	5	19	7
Boron (ug/L)	(5)	3	39	36	33	49	33	49	9
Iron (ug/L)	(20)	3	393	399	298	481	298	481	92
Mercury (ug/L)	(0.1 to 0.01)	2	0.05	0.05	0.05	0.05			
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(0.2)	3	8	7	6	9	6	9	2

Table A.2: Summary Statistics for Site 2 Tunks Creek at Galston Gorge for July 2010 to June 2011

Site 2 Tunks Creek		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		12	1843	600	15	10000	200	2500	2935
Temperature (oC)		13	14.4	13.8	9.5	20.7	10.1	19.5	4.2
Electrical Conductivity (mS/cm)		12	0.31	0.32	0.20	0.39	0.28	0.37	0.06
Electrical Conductivity (µS/cm)		12	308	310	176	405	283	349	56
Turbidity (NTU)		13	4.3	1.3	0.0	17.9	0.6	9.2	5.7
Dissolved oxygen (mg/L)		13	10.0	10.2	6.8	11.8	8.4	11.2	1.6
Dissolved oxygen (%sat)		13	96	98	75	112	92	101	9
pH		13	6.9	6.8	6.4	7.2	6.7	7.1	0.3
Salinity (ppt)		12	0.2	0.2	0.1	0.2	0.1	0.2	0.0
Suspended Solids (mg/L)	(2)	13	3	1	1	16	1	3	5
Ammonium-Nitrogen (mg/L)	(0.01)	13	0.007	0.005	0.005	0.010	0.005	0.010	0.003
Oxidised Nitrogen (mg/L)	(0.01)	13	0.13	0.09	0.01	0.43	0.03	0.21	0.13
Total Nitrogen (mg/L)	(0.05)	13	0.39	0.32	0.21	0.83	0.21	0.48	0.20
Total Phosphorus(mg/L)	(0.002)	13	0.012	0.010	0.003	0.035	0.005	0.015	0.009
Faecal Coliforms (CFU/100ml)	(1)	13	41	5	0.5	270	0.5	72	76
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	2	17	17	15	20			
Chloride (mg/L)	(0.1)	3	73	74	66	79	66	79	7
Sulphate as SO42-(mg/L)	(0.1)	3	19	18	17	23	17	23	3
Fluoride (mg/L)	(0.05)	3	0.05	0.03	0.03	0.10	0.03	0.10	0.04
Sodium (mg/L)	(0.05)	4	38.3	38.5	34.7	41.5	34.7	41.5	3.0
Potassium (mg/L)	(0.05)	3	3.6	3.7	3.2	3.9	3.2	3.9	0.3
Magnesium (mg/L)	(0.01)	3	6.9	6.8	6.0	7.8	6.0	7.8	0.9
Calcium (mg/L)	(0.01)	4	7.5	7.5	7.3	7.9	7.3	7.9	0.3
Aluminium (ug/L)	(10)	2	112	112	67	157			
Arsenic (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Cadmium (ug/L)	(1)	2	0.50	0.50	0.50	0.50			
Chromium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Copper (ug/L)	(1)	2	0.8	0.8	0.5	1.0			
Lead (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Manganese (ug/L)	(1)	2	8	8	6	10			
Molybdenum (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Nickel (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Selenium (ug/L)	(3)	2	1.5	1.5	1.5	1.5			
Silver (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Uranium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Zinc (ug/L)	(10)	2	7	7	5	8			
Boron (ug/L)	(5)	2	26	26	23	28			
Iron (ug/L)	(20)	2	318	318	200	435			
Mercury (ug/L)	(0.1 to 0.01)	1	0.05						
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(0.2)	2	8	8	6	10			

Table A.4: Summary Statistics for Site 4 Berowra Creek at Westleigh for July 2010 to June 2010

Site 4 Berowra Creek near Westleigh		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		12	7525	550	100	75000	200	1200	21425
Temperature (oC)		12	15.1	15.0	8.7	21.5	10.2	19.8	4.3
Electrical Conductivity (mS/cm)		11	0.28	0.29	0.15	0.44	0.18	0.38	0.10
Electrical Conductivity (µS/cm)		11	273	261	138	450	194	382	103
Turbidity (NTU)		12	6.5	2.6	0.3	37.2	1.6	8.1	10.1
Dissolved oxygen (mg/L)		12	9.5	9.3	7.8	11.6	8.4	10.6	1.2
Dissolved oxygen (%sat)		12	93	93	85	110	88	96	7
pH		12	7.1	7.1	7.0	7.4	7.0	7.2	0.1
Salinity (ppt)		11	0.1	0.1	0.1	0.2	0.1	0.2	0.1
Suspended Solids (mg/L)	**(2)**	12	3	1	1	15	1	3	4
Ammonium-Nitrogen (mg/L)	**(0.01)**	12	0.017	0.010	0.010	0.050	0.010	0.020	0.012
Oxidised Nitrogen (mg/L)	**(0.01)**	12	0.51	0.47	0.06	1.44	0.17	0.71	0.37
Total Nitrogen (mg/L)	**(0.05)**	12	0.76	0.67	0.35	1.66	0.39	0.93	0.37
Total Phosphorus(mg/L)	**(0.002)**	12	0.057	0.067	0.013	0.080	0.027	0.079	0.025
Faecal Coliforms (CFU/100ml)	**(1)**	12	975	365	17.0	6000	87.0	710	1731
Enterococci (CFU/100ml)	**(1)**	0					0.0	0	
Bicarbonate Alkalinity (mg/CaCO3/L)	**(2)**	2	42	42	32	52			
Chloride (mg/L)	**(0.1)**	2	74	74	74	74			
Sulphate as SO42-(mg/L)	**(0.1)**	2	21	21	15	26			
Fluoride (mg/L)	**(0.05)**	2	0.17	0.17	0.13	0.21			
Sodium (mg/L)	**(0.05)**	4	27.9	26.8	20.6	37.3	20.6	37.3	7.4
Potassium (mg/L)	**(0.05)**	3	2.7	2.9	1.9	3.4	1.9	3.4	0.8
Magnesium (mg/L)	**(0.01)**	3	4.8	4.4	3.8	6.3	3.8	6.3	1.3
Calcium (mg/L)	**(0.01)**	4	14.5	13.8	11.9	18.3	11.9	18.3	2.8
Aluminium (ug/L)	**(10)**	3	82	57	49	140	49	140	50
Arsenic (ug/L)	**(1)**	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L)	**(1)**	3	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L)	**(1)**	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Copper (ug/L)	**(1)**	3	2.7	3.0	2.0	3.0	2.0	3.0	0.6
Lead (ug/L)	**(1)**	3	1.0	0.5	0.5	2.0	0.5	2.0	0.9
Manganese (ug/L)	**(1)**	3	11	12	7	13	7	13	3
Molybdenum (ug/L)	**(1)**	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Nickel (ug/L)	**(1)**	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Selenium (ug/L)	**(3)**	3	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L)	**(1)**	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L)	**(1)**	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L)	**(10)**	3	17	18	3	31	3	31	14
Boron (ug/L)	**(5)**	3	34	33	32	37	32	37	3
Iron (ug/L)	**(20)**	3	607	468	378	974	378	974	321
Mercury (ug/L)	**(0.1 to 0.01)**	2	0.05	0.05	0.05	0.05			
BOD5/CBOD5(mg/L)	**(2)**	1	1						
Total Organic Carbon(mg/L)	**(0.2)**	2	7	7	6	8			

Table A.5: Summary Statistics for Site 5 Pyes Creek Cherrybrook for July 2010 to June 2011

Site 5 Pyes Creek at Cherrybrook		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		13	1732	150	40	20000	60	250	5498
Temperature (oC)		13	15.5	15.8	9.0	22.4	11.2	20.3	4.3
Electrical Conductivity (mS/cm)		12	0.51	0.54	0.21	0.81	0.26	0.69	0.20
Electrical Conductivity (µS/cm)		12	493	535	190	769	228	645	196
Turbidity (NTU)		13	7.4	3.3	0.0	42.7	2.2	8.5	11.1
Dissolved oxygen (mg/L)		13	8.3	8.2	5.2	12.1	6.2	10.3	2.0
Dissolved oxygen (%sat)		13	81	81	58	109	67	95	15
pH		13	7.1	7.1	7.0	7.5	7.0	7.3	0.1
Salinity (ppt)		12	0.3	0.3	0.1	0.4	0.1	0.4	0.1
Suspended Solids (mg/L)	**(2)**	13	3	1	1	17	1	2	5
Ammonium-Nitrogen (mg/L)	**(0.01)**	13	0.027	0.020	0.005	0.080	0.010	0.040	0.021
Oxidised Nitrogen (mg/L)	**(0.01)**	13	0.49	0.51	0.12	1.00	0.19	0.70	0.26
Total Nitrogen (mg/L)	**(0.05)**	13	0.81	0.82	0.41	1.39	0.57	1.01	0.26
Total Phosphorus(mg/L)	**(0.002)**	13	0.038	0.031	0.014	0.125	0.019	0.041	0.029
Faecal Coliforms (CFU/100ml)	**(1)**	13	989	210	35.0	4800	96.0	1700	1462
Bicarbonate Alkalinity (mg/CaCO3/L)	**(2)**	3	82	87	69	91	69	91	12
Chloride (mg/L)	**(0.1)**	3	99	102	70	124	70	124	27
Sulphate as SO42-(mg/L)	**(0.1)**	3	29	27	19	41	19	41	11
Fluoride (mg/L)	**(0.05)**	4	0.21	0.20	0.14	0.30	0.14	0.30	0.07
Sodium (mg/L)	**(0.05)**	5	49.2	54.6	20.3	73.7	31.6	64.2	19.6
Potassium (mg/L)	**(0.05)**	4	3.3	3.3	2.7	4.0	2.7	4.0	0.7
Magnesium (mg/L)	**(0.01)**	4	8.7	8.9	3.8	13.2	3.8	13.2	3.9
Calcium (mg/L)	**(0.01)**	5	26.4	27.4	13.0	35.5	19.1	33.3	8.5
Aluminium (ug/L)	**(10)**	3	55	42	34	89	34	89	30
Arsenic (ug/L)	**(1)**	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L)	**(1)**	3	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L)	**(1)**	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Copper (ug/L)	**(1)**	3	2.7	3.0	2.0	3.0	2.0	3.0	0.6
Lead (ug/L)	**(1)**	3	0.7	0.5	0.5	1.0	0.5	1.0	0.3
Manganese (ug/L)	**(1)**	3	42	25	22	78	22	78	32
Molybdenum (ug/L)	**(1)**	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Nickel (ug/L)	**(1)**	3	0.8	1.0	0.5	1.0	0.5	1.0	0.3
Selenium (ug/L)	**(3)**	3	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L)	**(1)**	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L)	**(1)**	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L)	**(10)**	3	7	5	3	14	3	14	6
Boron (ug/L)	**(5)**	3	34	34	29	40	29	40	6
Iron (ug/L)	**(20)**	3	664	658	573	762	573	762	95
Mercury (ug/L)	**(0.1 to 0.01)**	2	0.05	0.05	0.05	0.05			
BOD5/CBOD5(mg/L)	**(2)**	1	1						
Total Organic Carbon(mg/L)	**(0.2)**	2	7	7	7	8			

Table A.6: Summary Statistics for Site 6 Georges Creek Dural for July2010 to June 2011

Site 6 Georges Creek at Dural	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)	13	1698	100	40	20000	60	400	5502
Temperature (oC)	13	15.3	15.5	8.8	22.0	11.2	20.1	4.4
Electrical Conductivity (mS/cm)	12	0.39	0.42	0.26	0.54	0.28	0.44	0.09
Electrical Conductivity (µS/cm)	12	379	390	252	487	305	433	77
Turbidity (NTU)	13	13.2	4.4	1.9	88.7	2.3	8.0	24.3
Dissolved oxygen (mg/L)	13	9.1	8.2	6.6	11.8	7.8	11.0	1.7
Dissolved oxygen (%sat)	13	90	93	62	110	82	100	13
pH	13	7.2	7.2	7.0	7.5	7.2	7.3	0.1
Salinity (ppt)	12	0.2	0.2	0.1	0.3	0.2	0.3	0.0
Suspended Solids (mg/L) (2)	13	5	1	1	33	1	6	9
Ammonium-Nitrogen (mg/L) (0.01)	13	0.389	0.020	0.010	2.600	0.010	0.250	0.859
Oxidised Nitrogen (mg/L) (0.01)	13	0.27	0.22	0.09	0.50	0.11	0.47	0.16
Total Nitrogen (mg/L) (0.05)	13	1.06	0.59	0.39	3.56	0.45	1.21	0.98
Total Phosphorus(mg/L) (0.002)	13	0.084	0.057	0.013	0.237	0.039	0.119	0.068
Faecal Coliforms (CFU/100ml) (1)	13	448	150	5.0	2900	55.0	550	767
Bicarbonate Alkalinity (mg/CaCO3/L) (2)	3	63	62	51	76	51	76	13
Chloride (mg/L) (0.1)	3	75	74	60	90	60	90	15
Sulphate as SO42-(mg/L) (0.1)	3	19	18	16	24	16	24	4
Fluoride (mg/L) (0.05)	4	0.19	0.17	0.10	0.31	0.10	0.31	0.09
Sodium (mg/L) (0.05)	5	41.0	39.9	27.9	50.6	33.3	49.3	8.9
Potassium (mg/L) (0.05)	4	4.9	4.8	3.9	6.0	3.9	6.0	0.9
Magnesium (mg/L) (0.01)	4	6.8	6.6	5.7	8.5	5.7	8.5	1.2
Calcium (mg/L) (0.01)	5	18.7	17.8	16.8	21.0	17.0	20.9	2.0
Aluminium (ug/L) (10)	3	96	103	73	112	73	112	20
Arsenic (ug/L) (1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L) (1)	3	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L) (1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Copper (ug/L) (1)	3	1.7	2.0	1.0	2.0	1.0	2.0	0.6
Lead (ug/L) (1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Manganese (ug/L) (1)	3	16	13	11	23	11	23	6
Molybdenum (ug/L) (1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Nickel (ug/L) (1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Selenium (ug/L) (3)	3	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L) (1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L) (1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L) (10)	3	4	5	3	5	3	5	1
Boron (ug/L) (5)	3	33	31	27	42	27	42	8
Iron (ug/L) (20)	3	795	817	672	896	672	896	114
Mercury (ug/L) (0.1 to 0.01)	2	0.05	0.05	0.05	0.05			
BOD5/CBOD5(mg/L) (2)	1	1						
Total Organic Carbon(mg/L) (0.2)	2	10	10	8	11			

Table A.8: Summary Statistics for Site 8 Devlins creek Cheltenham for July 2010 to June 2011

Site 8. Devlins Creek at Cheltenham	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)	12	10408	550	200	100000	300	2000	28655
Temperature (oC)	12	16.3	15.7	11.1	22.9	11.9	20.7	4.4
Electrical Conductivity (mS/cm)	11	0.44	0.49	0.14	0.71	0.26	0.59	0.19
Electrical Conductivity (µS/cm)	11	438	493	151	719	246	578	186
Turbidity (NTU)	12	11.2	5.6	1.6	40.8	3.1	15.2	13.4
Dissolved oxygen (mg/L)	12	9.3	9.5	7.1	11.1	7.7	10.9	1.4
Dissolved oxygen (%sat)	12	94	94	79	107	84	103	9
pH	11	7.2	7.2	7.0	7.6	7.1	7.3	0.2
Salinity (ppt)	11	0.2	0.2	0.1	0.4	0.1	0.3	0.1
Suspended Solids (mg/L) (2)	12	5	2	1	19	1	7	6
Ammonium-Nitrogen (mg/L) (0.01)	12	0.109	0.040	0.005	0.810	0.020	0.060	0.224
Oxidised Nitrogen (mg/L) (0.01)	12	0.40	0.33	0.15	0.83	0.22	0.56	0.21
Total Nitrogen (mg/L) (0.05)	12	0.86	0.69	0.52	2.20	0.59	1.05	0.46
Total Phosphorus(mg/L) (0.002)	12	0.053	0.049	0.016	0.096	0.030	0.074	0.025
Faecal Coliforms (CFU/100ml) (1)	12	7844	770	80.0	72000	160.0	6900	20387
Bicarbonate Alkalinity (mg/CaCO3/L) (2)	2	65	65	52	78			
Chloride (mg/L) (0.1)	2	103	103	95	110			
Sulphate as SO42-(mg/L) (0.1)	2	33	33	27	39			
Fluoride (mg/L) (0.05)	2	0.20	0.20	0.19	0.20			
Sodium (mg/L) (0.05)	4	46.5	46.9	33.6	58.6	33.6	58.6	12.8
Potassium (mg/L) (0.05)	3	4.0	4.3	2.5	5.1	2.5	5.1	1.3
Magnesium (mg/L) (0.01)	3	7.1	6.9	5.5	8.8	5.5	8.8	1.6
Calcium (mg/L) (0.01)	4	21.9	22.8	16.7	25.3	16.7	25.3	4.2
Aluminium (ug/L) (10)	3	72	66	45	106	45	106	31
Arsenic (ug/L) (1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L) (1)	3	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L) (1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Copper (ug/L) (1)	3	5.0	3.0	3.0	9.0	3.0	9.0	3.5
Lead (ug/L) (1)	3	1.2	1.0	0.5	2.0	0.5	2.0	0.8
Manganese (ug/L) (1)	3	35	33	31	40	31	40	5
Molybdenum (ug/L) (1)	3	1.0	0.5	0.5	2.0	0.5	2.0	0.9
Nickel (ug/L) (1)	3	1.3	1.0	1.0	2.0	1.0	2.0	0.6
Selenium (ug/L) (3)	3	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L) (1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L) (1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L) (10)	3	24	23	15	33	15	33	9
Boron (ug/L) (5)	3	41	38	34	50	34	50	8
Iron (ug/L) (20)	3	1257	1160	1140	1470	1140	1470	185
Mercury (ug/L) (0.1 to 0.01)	2	0.05	0.05	0.05	0.05			
BOD5/CBOD5(mg/L) (2)	1	1						
Total Organic Carbon(mg/L) (0.2)	2	8	8	8	9			

Table A.10: Summary Statistics for Site 10 Larool Creek Thornleigh for July 2010 to June 2011

Site 10 Larool Creek Thornleigh		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		23	165	50	1	2000	25	100	419
Temperature (oC)		24	16.1	16.3	10.7	21.9	12.1	20.4	3.6
Electrical Conductivity (mS/cm)		23	1.07	0.61	0.21	9.80	0.38	0.86	1.95
Electrical Conductivity (µS/cm)		23	660	584	175	2064	370	769	412
Turbidity (NTU)		24	31.2	13.7	1.4	219.9	6.9	40.6	44.6
Dissolved oxygen (mg/L)		24	8.3	8.5	5.8	10.9	7.6	9.1	1.1
Dissolved oxygen (%sat)		24	85	85	54	106	75	91	12
pH		24	7.7	7.5	6.9	10.1	7.4	7.7	0.7
Salinity (ppt)		23	0.3	0.3	0.1	1.1	0.2	0.4	0.2
Suspended Solids (mg/L)	(2)	24	14	5	1	66	2	26	19
Ammonium-Nitrogen (mg/L)	(0.01)	24	0.299	0.160	0.005	1.480	0.080	0.470	0.357
Oxidised Nitrogen (mg/L)	(0.01)	24	0.67	0.60	0.06	1.72	0.25	1.07	0.48
Total Nitrogen (mg/L)	(0.05)	24	1.74	1.36	0.65	6.00	0.83	2.37	1.28
Total Phosphorus(mg/L)	(0.002)	24	0.137	0.076	0.031	0.810	0.036	0.168	0.184
Faecal Coliforms (CFU/100ml)	(1)	24	8274	2950	250.0	100000	620.0	9800	20054
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	3	98	96	75	124	75	124	24
Chloride (mg/L)	(0.1)	3	84	71	43	139	43	139	49
Sulphate as SO42-(mg/L)	(0.1)	3	30	22	22	47	22	47	14
Fluoride (mg/L)	(0.05)	4	0.41	0.30	0.26	0.77	0.26	0.77	0.24
Sodium (mg/L)	(0.05)	5	122.8	57.8	39.4	378.0	41.0	237.1	144.5
Potassium (mg/L)	(0.05)	4	5.0	4.9	3.9	6.2	3.9	6.2	1.0
Magnesium (mg/L)	(0.01)	4	10.2	9.4	6.8	15.2	6.8	15.2	3.7
Calcium (mg/L)	(0.01)	5	31.1	30.0	21.7	40.1	24.7	38.0	7.2
Aluminium (ug/L)	(10)	4	796	219	76	2670	76	2670	1251
Arsenic (ug/L)	(1)	4	0.6	0.5	0.5	1.0	0.5	1.0	0.3
Cadmium (ug/L)	(1)	4	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L)	(1)	4	1.4	0.5	0.5	4.0	0.5	4.0	1.8
Copper (ug/L)	(1)	4	15.3	15.0	4.0	27.0	4.0	27.0	11.9
Lead (ug/L)	(1)	4	2.4	2.0	0.5	5.0	0.5	5.0	1.9
Manganese (ug/L)	(1)	4	109	67	45	256	45	256	100
Molybdenum (ug/L)	(1)	4	4.1	3.0	0.5	10.0	0.5	10.0	4.2
Nickel (ug/L)	(1)	4	2.9	2.5	0.5	6.0	0.5	6.0	2.6
Selenium (ug/L)	(3)	4	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L)	(10)	4	146	150	28	255	28	255	104
Boron (ug/L)	(5)	4	41	35	29	65	29	65	17
Iron (ug/L)	(20)	4	2242	2115	787	3950	787	3950	1660
Mercury (ug/L)	(0.1 to 0.01)	3	0.07	0.05	0.05	0.10	0.05	0.10	0.03
BOD5/CBOD5(mg/L)	(2)	6	59	7	1	185	1	152	86
Total Organic Carbon(mg/L)	(0.2)	5	27	7	5	106	6	57	44

Table A.12: Summary Statistics for Site 12 Hornsby Creek Leighton Place Hornsby for July 2010 to June 2011

Site 12 Hornsby Creek at Leighton Place Hornsby		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		23	8511	200	60	150000	100	600	31935
Temperature (oC)		24	16.3	16.1	10.9	22.7	12.3	20.1	3.6
Electrical Conductivity (mS/cm)		23	0.31	0.34	0.06	0.47	0.25	0.41	0.10
Electrical Conductivity (µS/cm)		23	303	316	75	442	230	395	103
Turbidity (NTU)		24	15.3	7.1	1.5	100.0	2.2	18.2	23.2
Dissolved oxygen (mg/L)		24	9.8	9.7	8.3	11.4	8.8	10.6	0.8
Dissolved oxygen (%sat)		24	99	99	91	108	96	103	4
pH		24	7.6	7.6	6.9	8.0	7.4	7.8	0.3
Salinity (ppt)		23	0.2	0.2	0.1	0.2	0.1	0.2	0.0
Suspended Solids (mg/L)	(2)	24	8	2	1	65	1	10	17
Ammonium-Nitrogen (mg/L)	(0.01)	24	0.062	0.040	0.010	0.240	0.020	0.100	0.061
Oxidised Nitrogen (mg/L)	(0.01)	24	0.77	0.76	0.34	1.79	0.41	1.00	0.35
Total Nitrogen (mg/L)	(0.05)	24	1.61	1.34	0.67	5.45	0.71	2.12	1.13
Total Phosphorus(mg/L)	(0.002)	24	0.068	0.047	0.019	0.247	0.031	0.084	0.058
Faecal Coliforms (CFU/100ml)	(1)	24	7573	1500	100.0	62000	260.0	11000	14815
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	3	58	58	49	67	49	67	9
Chloride (mg/L)	(0.1)	3	64	60	55	77	55	77	12
Sulphate as SO42-(mg/L)	(0.1)	3	27	27	25	29	25	29	2
Fluoride (mg/L)	(0.05)	4	0.34	0.31	0.09	0.63	0.09	0.63	0.23
Sodium (mg/L)	(0.05)	5	29.8	31.7	24.3	33.9	24.8	33.8	4.6
Potassium (mg/L)	(0.05)	4	3.2	3.1	2.6	4.0	2.6	4.0	0.7
Magnesium (mg/L)	(0.01)	4	6.2	6.1	5.6	6.9	5.6	6.9	0.7
Calcium (mg/L)	(0.01)	5	21.5	21.0	18.4	25.9	19.6	23.7	2.7
Aluminium (ug/L)	(10)	4	213	118	103	513	103	513	201
Arsenic (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L)	(1)	4	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L)	(1)	4	2.8	3.0	1.0	4.0	1.0	4.0	1.3
Copper (ug/L)	(1)	4	7.3	8.5	1.0	11.0	1.0	11.0	4.5
Lead (ug/L)	(1)	4	0.9	0.5	0.5	2.0	0.5	2.0	0.8
Manganese (ug/L)	(1)	4	13	13	11	15	11	15	2
Molybdenum (ug/L)	(1)	4	1.1	1.0	0.5	2.0	0.5	2.0	0.6
Nickel (ug/L)	(1)	4	0.9	1.0	0.5	1.0	0.5	1.0	0.3
Selenium (ug/L)	(3)	4	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L)	(10)	4	72	68	34	119	34	119	39
Boron (ug/L)	(5)	4	39	40	28	47	28	47	8
Iron (ug/L)	(20)	4	560	550	500	638	500	638	64
Mercury (ug/L)	(0.1 to 0.01)	3	0.07	0.05	0.05	0.10	0.05	0.10	0.03
BOD5/CBOD5(mg/L)	(2)	7	2	1	1	4	1	3	1
Total Organic Carbon(mg/L)	(0.2)	5	6	5	4	7	4	7	1

Table A.13: Summary Statistics for Site 13 Sams Creek Mt Kuring-gai for July 2010 to June 2011

Site 13 Sams Creek Mt Kuring-gai		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		22	140	10	1	1500	3	100	342
Temperature (oC)		22	16.1	15.8	9.9	21.8	12.9	19.9	3.7
Electrical Conductivity (mS/cm)		21	0.27	0.27	0.10	0.57	0.20	0.32	0.10
Electrical Conductivity (µS/cm)		20	254	233	94	521	170	308	103
Turbidity (NTU)		21	41.3	4.4	0.4	552.5	1.5	16.2	120.6
Dissolved oxygen (mg/L)		22	7.6	7.8	1.1	10.2	6.8	9.3	2.0
Dissolved oxygen (%sat)		22	77	80	9	102	73	88	20
pH		22	7.1	7.1	6.2	7.5	7.0	7.3	0.3
Salinity (ppt)		21	0.1	0.1	0.1	0.3	0.1	0.2	0.1
Suspended Solids (mg/L)	(2)	22	18	1	1	244	1	8	52
Ammonium-Nitrogen (mg/L)	(0.01)	22	0.064	0.040	0.005	0.210	0.020	0.090	0.057
Oxidised Nitrogen (mg/L)	(0.01)	22	0.17	0.15	0.01	0.44	0.10	0.19	0.11
Total Nitrogen (mg/L)	(0.05)	22	0.53	0.54	0.28	0.87	0.39	0.62	0.15
Total Phosphorus(mg/L)	(0.002)	22	0.056	0.049	0.023	0.153	0.028	0.078	0.032
Faecal Coliforms (CFU/100ml)	(1)	22	3201	675	7.0	41000	90.0	3500	8650
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	3	76	75	68	86	68	86	9
Chloride (mg/L)	(0.1)	3	33	36	26	37	26	37	6
Sulphate as SO42-(mg/L)	(0.1)	3	18	17	13	23	13	23	5
Fluoride (mg/L)	(0.05)	3	0.17	0.08	0.08	0.35	0.08	0.35	0.16
Sodium (mg/L)	(0.05)	3	22.5	23.1	18.1	26.4	18.1	26.4	4.2
Potassium (mg/L)	(0.05)	3	3.2	2.9	2.5	4.2	2.5	4.2	0.9
Magnesium (mg/L)	(0.01)	3	6.3	6.5	4.2	8.2	4.2	8.2	2.0
Calcium (mg/L)	(0.01)	3	26.1	26.3	20.8	31.3	20.8	31.3	5.3
Aluminium (ug/L)	(10)	2	44	44	24	63			
Arsenic (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Cadmium (ug/L)	(1)	2	0.50	0.50	0.50	0.50			
Chromium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Copper (ug/L)	(1)	2	2.0	2.0	1.0	3.0			
Lead (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Manganese (ug/L)	(1)	2	163	163	50	276			
Molybdenum (ug/L)	(1)	2	6.5	6.5	3.0	10.0			
Nickel (ug/L)	(1)	2	1.3	1.3	0.5	2.0			
Selenium (ug/L)	(3)	2	1.5	1.5	1.5	1.5			
Silver (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Uranium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Zinc (ug/L)	(10)	2	66	66	49	83			
Boron (ug/L)	(5)	2	36	36	29	43			
Iron (ug/L)	(20)	2	1145	1145	1110	1180			
Mercury (ug/L)	(0.1 to 0.01)	2	0.15	0.15	0.10	0.20			
Oil&Grease (mg/L)	(2)	1	18						
BOD5/CBOD5(mg/L)	(2)	4	3	1	1	9	1	9	4
Total Organic Carbon(mg/L)	(0.2)	5	8	8	6	11	6	10	2

Table A.18: Water quality data: Arcadia Tip: Site 18 Raw Leachate Collection Tank (see also A.94 Treated Leachate Tank) Data for July 2010 to June 2011

Site 18 Raw Leachate Water Arcadia Landfill		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)		4	16.4	15.7	13.5	20.7	13.5	20.7	3.0
Electrical Conductivity (mS/cm)		4	1.35	1.39	0.90	1.70	0.90	1.70	0.40
Electrical Conductivity (µS/cm)		4	1289	1334	840	1649	840	1649	407
Turbidity (NTU)		4	12.8	12.9	5.4	20.0	5.4	20.0	6.8
Dissolved oxygen (mg/L)		4	3.0	3.2	0.3	5.3	0.3	5.3	2.2
Dissolved oxygen (%sat)		4	30	31	4	53	4	53	22
pH		4	6.7	6.6	6.3	7.1	6.3	7.1	0.3
Salinity (ppt)		4	0.7	0.7	0.5	0.9	0.5	0.9	0.2
Suspended Solids (mg/L)	(2)	3	4	3	1	7	1	7	3
Ammonium-Nitrogen (mg/L)	(0.01)	4	14.268	9.835	6.800	30.600	6.800	30.600	11.195
Oxidised Nitrogen (mg/L)	(0.01)	4	5.11	6.09	0.85	7.40	0.85	7.40	2.93
Total Nitrogen (mg/L)	(0.05)	4	20.45	18.25	8.00	37.30	8.00	37.30	12.35
Total Phosphorus(mg/L)	(0.002)	3	0.016	0.018	0.011	0.019	0.011	0.019	0.004
Faecal Coliforms (CFU/100ml)	(1)	2	55	55	0.5	110			
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	1	354						
Chloride (mg/L)	(0.1)	1	75						
Sodium (mg/L)	(0.05)	2	77.8	77.8	59.1	96.5			
Potassium (mg/L)	(0.05)	2	36.8	36.8	24.7	48.9			
Magnesium (mg/L)	(0.01)	2	29.8	29.8	22.6	37.0			
Calcium (mg/L)	(0.01)	2	124.4	124.4	95.7	153.0			
Aluminium (ug/L)	(10)	1	21						
Arsenic (ug/L)	(1)	1	0.5						
Cadmium (ug/L)	(1)	1	0.50						
Chromium (ug/L)	(1)	1	0.5						
Copper (ug/L)	(1)	1	4.0						
Lead (ug/L)	(1)	1	0.5						
Manganese (ug/L)	(1)	1	129						
Molybdenum (ug/L)	(1)	1	0.5						
Nickel (ug/L)	(1)	1	15.0						
Selenium (ug/L)	(3)	1	1.5						
Silver (ug/L)	(1)	1	0.5						
Uranium (ug/L)	(1)	1	0.5						
Zinc (ug/L)	(10)	1	28						
Boron (ug/L)	(5)	1	652						
Iron (ug/L)	(20)	2	855	855	530	1180			
Total Organic Carbon(mg/L)	(0.2)	1	15						

Table A.23: Summary Statistics for Site 23 Waitara Creek upstream of West Hornsby STP. Data for July 2010 to June 2011

Site 23 Waitara Ck upstream of West Hornsby STP		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		12	2492	800	0	15000	150	2000	4509
Temperature (oC)		12	15.8	15.4	9.7	23.0	11.2	19.8	4.3
Electrical Conductivity (mS/cm)		11	0.33	0.31	0.14	0.54	0.28	0.38	0.10
Electrical Conductivity (µS/cm)		10	297	294	98	510	255	350	106
Turbidity (NTU)		11	26.0	10.8	2.7	172.0	5.5	17.8	49.1
Dissolved oxygen (mg/L)		12	7.0	7.9	1.4	11.5	3.6	9.9	3.1
Dissolved oxygen (%sat)		12	69	74	16	101	42	91	28
pH		11	7.1	7.0	6.8	7.5	6.9	7.4	0.2
Salinity (ppt)		11	0.2	0.2	0.1	0.3	0.1	0.2	0.1
Suspended Solids (mg/L)	(2)	12	14	3	1	110	2	11	31
Ammonium-Nitrogen (mg/L)	(0.01)	12	0.129	0.030	0.005	1.150	0.005	0.100	0.324
Oxidised Nitrogen (mg/L)	(0.01)	12	0.28	0.27	0.01	0.58	0.09	0.45	0.18
Total Nitrogen (mg/L)	(0.05)	12	0.81	0.64	0.47	2.23	0.52	0.90	0.48
Total Phosphorus(mg/L)	(0.002)	12	0.100	0.063	0.036	0.415	0.044	0.102	0.105
Faecal Coliforms (CFU/100ml)	(1)	12	6153	2800	110.0	46000	940.0	5400	12676
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	2	60	60	60	60			
Chloride (mg/L)	(0.1)	2	53	53	47	58			
Sulphate as SO42-(mg/L)	(0.1)	2	19	19	14	23			
Fluoride (mg/L)	(0.05)	2	0.20	0.20	0.10	0.29			
Sodium (mg/L)	(0.05)	3	31.1	32.2	27.7	33.3	27.7	33.3	3.0
Potassium (mg/L)	(0.05)	2	3.1	3.1	3.0	3.2			
Magnesium (mg/L)	(0.01)	2	6.2	6.2	6.1	6.4			
Calcium (mg/L)	(0.01)	3	19.1	20.0	16.6	20.8			
Aluminium (ug/L)	(10)	2	133	133	78	188			
Arsenic (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Cadmium (ug/L)	(1)	2	0.50	0.50	0.50	0.50			
Chromium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Copper (ug/L)	(1)	2	5.0	5.0	4.0	6.0			
Lead (ug/L)	(1)	2	0.8	0.8	0.5	1.0			
Manganese (ug/L)	(1)	2	53	53	39	66			
Molybdenum (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Nickel (ug/L)	(1)	2	0.8	0.8	0.5	1.0			
Selenium (ug/L)	(3)	2	1.5	1.5	1.5	1.5			
Silver (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Uranium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Zinc (ug/L)	(10)	2	14	14	11	17			
Boron (ug/L)	(5)	2	29	29	21	37			
Iron (ug/L)	(20)	2	1056	1056	882	1230			
Mercury (ug/L)	(0.1 to 0.01)	1	0.05						
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(0.2)	3	9	9	9	11	9	11	1

able A.36: Summary Statistics for Site 36 Murray Anderson Creek, Reference site in Kuring-gai NP. Data for July 2010 to Oct 2011

Site 36 Murray Anderson Ck (Reference)		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		15	1056	200	20	6000	60	1750	1960
Temperature (oC)		16	14.7	14.2	10.0	21.6	11.2	19.0	3.8
Electrical Conductivity (mS/cm)		15	0.15	0.16	0.10	0.21	0.13	0.18	0.03
Electrical Conductivity (µS/cm)		15	142	146	97	174	113	166	26
Turbidity (NTU)		16	0.5	0.0	-0.2	8.0	-0.2	0.2	2.0
Dissolved oxygen (mg/L)		16	10.3	10.3	9.0	11.7	9.3	11.1	0.9
Dissolved oxygen (%sat)		16	101	100	96	107	97	105	4
pH		16	4.9	4.9	4.3	5.8	4.5	5.5	0.4
Salinity (ppt)		15	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Suspended Solids (mg/L)	(2)	16	1	1	1	2	1	1	0
Ammonium-Nitrogen (mg/L)	(0.01)	16	0.005	0.005	0.005	0.010	0.005	0.005	0.001
Oxidised Nitrogen (mg/L)	(0.01)	16	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Total Nitrogen (mg/L)	(0.05)	16	0.10	0.08	0.05	0.25	0.07	0.12	0.05
Total Phosphorus(mg/L)	(0.002)	16	0.003	0.003	0.001	0.006	0.002	0.004	0.002
Faecal Coliforms (CFU/100ml)	(1)	16	94	10	0.5	820	2.0	25	222
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	5	1	1	1	1	1	1	0
Chloride (mg/L)	(0.1)	6	40	42	28	48	31	47	8
Sulphate as SO42-(mg/L)	(0.1)	6	6	6	5	6	5	6	1
Fluoride (mg/L)	(0.05)	7	0.03	0.03	0.03	0.03	0.03	0.03	0.00
Sodium (mg/L)	(0.05)	6	20.5	22.0	15.9	23.8	16.5	22.8	3.4
Potassium (mg/L)	(0.05)	6	0.8	0.8	0.6	1.1	0.6	0.9	0.2
Magnesium (mg/L)	(0.01)	6	3.1	3.3	2.0	3.9	2.3	3.8	0.8
Calcium (mg/L)	(0.01)	6	0.5	0.6	0.3	0.8	0.3	0.6	0.2
Aluminium (ug/L)	(10)	4	278	244	154	471	154	471	138
Arsenic (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L)	(1)	4	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L)	(1)	4	0.6	0.5	0.5	1.0	0.5	1.0	0.3
Copper (ug/L)	(1)	4	2.3	1.0	1.0	6.0	1.0	6.0	2.5
Lead (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Manganese (ug/L)	(1)	4	31	30	15	49	15	49	14
Molybdenum (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Nickel (ug/L)	(1)	4	1.0	0.8	0.5	2.0	0.5	2.0	0.7
Selenium (ug/L)	(3)	4	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L)	(10)	4	11	11	5	18	5	18	5
Boron (ug/L)	(5)	4	16	16	9	23	9	23	6
Iron (ug/L)	(20)	4	234	173	136	452	136	452	147
Mercury (ug/L)	(0.1 to 0.01)	4	0.06	0.05	0.05	0.10	0.05	0.10	0.03
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(0.2)	2	4	4	3	5			

Table A.37: Summary Statistics for Site 37 Smugglers Creek, Reference Site in Marramarra NP. Data for July 2010 to Oct 2011

Site 37 Smugglers Ck (Reference)		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		17	739	120	2	10000	50	200	2397
Temperature (oC)		17	14.7	14.1	9.2	22.8	11.3	16.7	4.1
Electrical Conductivity (mS/cm)		16	0.20	0.20	0.13	0.30	0.18	0.22	0.04
Electrical Conductivity (µS/cm)		16	201	204	128	286	166	239	46
Turbidity (NTU)		17	1.2	0.1	-0.2	8.3	0.0	2.0	2.1
Dissolved oxygen (mg/L)		17	9.7	9.7	0.3	12.2	9.1	11.2	2.6
Dissolved oxygen (%sat)		17	99	100	88	108	94	104	6
pH		17	5.4	5.5	4.6	6.3	5.2	5.5	0.4
Salinity (ppt)		16	0.1	0.1	0.1	0.2	0.1	0.1	0.0
Suspended Solids (mg/L)	(2)	17	1	1	1	3	1	1	1
Ammonium-Nitrogen (mg/L)	(0.01)	17	0.006	0.005	0.005	0.010	0.005	0.005	0.002
Oxidised Nitrogen (mg/L)	(0.01)	17	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Total Nitrogen (mg/L)	(0.05)	17	0.11	0.10	0.07	0.21	0.07	0.15	0.04
Total Phosphorus(mg/L)	(0.002)	17	0.004	0.004	0.001	0.008	0.002	0.005	0.002
Faecal Coliforms (CFU/100ml)	(1)	16	66	21	0.5	350	2.0	80	110
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	3	2	1	1	4	1	4	2
Chloride (mg/L)	(0.1)	4	68	68	54	81	54	81	12
Sulphate as SO42-(mg/L)	(0.1)	4	5	5	3	7	3	7	2
Fluoride (mg/L)	(0.05)	5	0.05	0.03	0.03	0.11	0.03	0.09	0.04
Sodium (mg/L)	(0.05)	5	30.9	32.4	24.8	34.9	27.4	33.8	3.8
Potassium (mg/L)	(0.05)	5	1.2	1.1	1.0	1.8	1.0	1.5	0.3
Magnesium (mg/L)	(0.01)	5	5.6	5.9	4.0	6.6	4.9	6.3	0.9
Calcium (mg/L)	(0.01)	5	1.5	1.5	0.9	1.9	1.1	1.8	0.4
Aluminium (ug/L)	(10)	3	87	100	37	124	37	124	45
Arsenic (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L)	(1)	3	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Copper (ug/L)	(1)	3	2.2	1.0	0.5	5.0	0.5	5.0	2.5
Lead (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Manganese (ug/L)	(1)	3	44	42	40	49	40	49	5
Molybdenum (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Nickel (ug/L)	(1)	3	1.5	2.0	0.5	2.0	0.5	2.0	0.9
Selenium (ug/L)	(3)	3	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L)	(10)	3	20	5	5	51	5	51	27
Boron (ug/L)	(5)	3	18	20	12	22	12	22	5
Iron (ug/L)	(20)	3	501	380	141	983	141	983	434
Mercury (ug/L)	(0.1 to 0.01)	2	0.05	0.05	0.05	0.05	0.05		
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(0.2)	1	4						

Table A.38: Site 38 Sandbrook Inlet - see data on page 75

Table A.39: Summary Statistics for Site 39 Joe Crafts Creek for July 2010 to June 2011

Site 39 Joe Crafts Creek		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		12	4539	500	120	40000	250	800	11502
Temperature (oC)		12	15.5	15.6	9.8	22.3	11.1	20.0	4.5
Electrical Conductivity (mS/cm)		11	0.21	0.20	0.10	0.29	0.18	0.25	0.05
Electrical Conductivity (µS/cm)		11	190	191	116	268	162	215	46
Turbidity (NTU)		12	5.8	1.5	0.0	37.3	0.0	10.4	11.1
Dissolved oxygen (mg/L)		12	9.6	9.4	7.8	11.5	8.5	10.9	1.3
Dissolved oxygen (%sat)		12	95	95	86	103	90	101	6
pH		12	7.2	7.2	6.8	7.6	6.9	7.5	0.3
Salinity (ppt)		11	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Suspended Solids (mg/L)	(2)	12	2	1	1	6	1	1	2
Ammonium-Nitrogen (mg/L)	(0.01)	12	0.006	0.005	0.005	0.010	0.005	0.005	0.002
Oxidised Nitrogen (mg/L)	(0.01)	12	0.16	0.18	0.02	0.41	0.03	0.21	0.12
Total Nitrogen (mg/L)	(0.05)	12	0.37	0.34	0.16	0.61	0.26	0.51	0.14
Total Phosphorus(mg/L)	(0.002)	12	0.009	0.007	0.004	0.024	0.004	0.009	0.007
Faecal Coliforms (CFU/100ml)	(1)	12	459	39	0.5	4500	10.0	62	1288
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	2	21	21	20	22			
Chloride (mg/L)	(0.1)	3	40	41	37	43	37	43	3
Sulphate as SO42-(mg/L)	(0.1)	3	12	13	10	14	10	14	2
Fluoride (mg/L)	(0.05)	4	0.09	0.08	0.06	0.15	0.06	0.15	0.04
Sodium (mg/L)	(0.05)	4	22.1	21.2	19.6	26.5	19.6	26.5	3.1
Potassium (mg/L)	(0.05)	4	1.6	1.7	1.5	1.7	1.5	1.7	0.1
Magnesium (mg/L)	(0.01)	4	4.1	3.9	3.7	4.9	3.7	4.9	0.6
Calcium (mg/L)	(0.01)	4	8.3	8.1	7.1	9.9	7.1	9.9	1.2
Aluminium (ug/L)	(10)	2	143	143	35	250			
Arsenic (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Cadmium (ug/L)	(1)	2	0.50	0.50	0.50	0.50			
Chromium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Copper (ug/L)	(1)	2	0.8	0.8	0.5	1.0			
Lead (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Manganese (ug/L)	(1)	2	10	10	3	16			
Molybdenum (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Nickel (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Selenium (ug/L)	(3)	2	1.5	1.5	1.5	1.5			
Silver (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Uranium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Zinc (ug/L)	(10)	2	17	17	5	28			
Boron (ug/L)	(5)	2	25	25	25	25			
Iron (ug/L)	(20)	2	301	301	144	458			
Mercury (ug/L)	(0.1 to 0.01)	1	0.05						
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(0.2)	3	8	7	5	12	5	12	4

Table A.42: Summary Statistics for Site 42 Colah Creek at Wylds Rd Glenorie for July 2010 to June 2011

Site 42 Colah Ck at Wylds Road		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		13	8335	300	5	100000	100	1000	27574
Temperature (oC)		13	15.2	14.3	9.9	22.2	10.3	21.1	4.8
Electrical Conductivity (mS/cm)		12	0.39	0.41	0.24	0.48	0.33	0.44	0.07
Electrical Conductivity (µS/cm)		12	380	395	233	468	292	440	73
Turbidity (NTU)		13	12.8	7.9	2.5	59.0	3.5	16.6	15.5
Dissolved oxygen (mg/L)		13	9.2	8.9	6.5	11.5	7.3	10.9	1.7
Dissolved oxygen (%sat)		13	91	88	72	130	81	97	15
pH		13	7.0	7.0	6.6	7.5	6.8	7.1	0.2
Salinity (ppt)		12	0.2	0.2	0.1	0.3	0.2	0.2	0.0
Suspended Solids (mg/L)	(2)	13	6	3	1	25	2	7	6
Ammonium-Nitrogen (mg/L)	(0.01)	13	0.018	0.010	0.005	0.060	0.010	0.030	0.015
Oxidised Nitrogen (mg/L)	(0.01)	13	0.39	0.23	0.02	1.35	0.10	0.58	0.39
Total Nitrogen (mg/L)	(0.05)	13	0.82	0.70	0.38	1.90	0.48	1.22	0.48
Total Phosphorus(mg/L)	(0.002)	13	0.048	0.028	0.018	0.132	0.023	0.066	0.036
Faecal Coliforms (CFU/100ml)	(1)	13	885	89	41.0	8000	68.0	920	2169
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	2	42	42	37	47	37	47	7
Chloride (mg/L)	(0.1)	3	68	70	53	81	53	81	14
Sulphate as SO42-(mg/L)	(0.1)	3	25	25	18	32	18	32	7
Fluoride (mg/L)	(0.05)	3	0.10	0.07	0.06	0.17	0.06	0.17	0.06
Sodium (mg/L)	(0.05)	3	39.0	40.0	31.6	45.5	31.6	45.5	7.0
Potassium (mg/L)	(0.05)	3	5.6	5.9	4.9	6.2	4.9	6.2	0.6
Magnesium (mg/L)	(0.01)	3	7.8	7.8	6.2	9.3	6.2	9.3	1.5
Calcium (mg/L)	(0.01)	3	14.9	15.6	13.2	16.0	13.2	16.0	1.5
Aluminium (ug/L)	(10)	1	395						
Arsenic (ug/L)	(1)	1	0.5						
Cadmium (ug/L)	(1)	1	0.50						
Chromium (ug/L)	(1)	1	1.0						
Copper (ug/L)	(1)	1	2.0						
Lead (ug/L)	(1)	1	0.5						
Manganese (ug/L)	(1)	1	54						
Molybdenum (ug/L)	(1)	1	0.5						
Nickel (ug/L)	(1)	1	1.0						
Selenium (ug/L)	(3)	1	1.5						
Silver (ug/L)	(1)	1	0.5						
Uranium (ug/L)	(1)	1	0.5						
Zinc (ug/L)	(10)	1	18						
Boron (ug/L)	(5)	1	39						
Iron (ug/L)	(20)	1	1710						
Mercury (ug/L)	(0.1 to 0.01)	1	0.05						
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(0.2)	3	9	8	6	14	6	14	4

Table A.43: Summary Statistics for Site 43 Calna Creek, just above tidal limit of Berowra Creek for July 2010 to June 2011

Site 43 Calna Creek just above tidal limit		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		12	3058	2000	1200	10000	1500	4000	2411
Temperature (oC)		12	16.0	16.0	11.5	21.4	12.3	20.3	3.9
Electrical Conductivity (mS/cm)		11	0.57	0.56	0.32	0.74	0.48	0.70	0.13
Electrical Conductivity (µS/cm)		11	548	542	312	744	473	654	121
Turbidity (NTU)		12	2.2	1.1	0.0	9.7	0.4	3.8	2.8
Dissolved oxygen (mg/L)		12	9.7	9.5	8.4	11.4	8.8	10.7	1.0
Dissolved oxygen (%sat)		12	97	98	89	104	95	100	4
pH		12	7.8	7.8	7.3	8.0	7.6	8.0	0.2
Salinity (ppt)		11	0.3	0.3	0.2	0.4	0.2	0.3	0.1
Suspended Solids (mg/L)	(2)	11	4	1	1	27	1	1	8
Ammonium-Nitrogen (mg/L)	(0.01)	12	0.009	0.010	0.005	0.020	0.005	0.010	0.004
Oxidised Nitrogen (mg/L)	(0.01)	12	1.98	1.57	0.54	5.40	0.91	2.80	1.41
Total Nitrogen (mg/L)	(0.05)	12	2.52	2.04	0.94	6.60	1.23	3.61	1.62
Total Phosphorus(mg/L)	(0.002)	12	0.052	0.027	0.017	0.223	0.022	0.080	0.058
Faecal Coliforms (CFU/100ml)	(1)	12	240	18	1.0	980	6.0	710	382
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	2	80	80	79	81			
Chloride (mg/L)	(0.1)	3	89	88	77	101	77	101	12
Sulphate as SO42-(mg/L)	(0.1)	3	32	30	29	37	29	37	4
Fluoride (mg/L)	(0.05)	3	0.41	0.41	0.41	0.42	0.41	0.42	0.01
Sodium (mg/L)	(0.05)	4	59.3	55.6	47.1	78.8	47.1	78.8	14.5
Potassium (mg/L)	(0.05)	3	10.5	9.4	8.5	13.5	8.5	13.5	2.7
Magnesium (mg/L)	(0.01)	3	6.5	5.9	5.7	8.1	5.7	8.1	1.3
Calcium (mg/L)	(0.01)	4	36.8	34.7	30.7	47.2	30.7	47.2	7.5
Aluminium (ug/L)	(10)	2	63	63	61	65			
Arsenic (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Cadmium (ug/L)	(1)	2	0.50	0.50	0.50	0.50			
Chromium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Copper (ug/L)	(1)	2	3.5	3.5	2.0	5.0			
Lead (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Manganese (ug/L)	(1)	2	4	4	4	4			
Molybdenum (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Nickel (ug/L)	(1)	2	2.0	2.0	2.0	2.0			
Selenium (ug/L)	(3)	2	1.5	1.5	1.5	1.5			
Silver (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Uranium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Zinc (ug/L)	(10)	2	13	13	10	16			
Boron (ug/L)	(5)	2	51	51	37	64			
Iron (ug/L)	(20)	2	144	144	142	146			
Mercury (ug/L)	(0.1 to 0.01)	1	0.05						
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(0.2)	3	8	6	6	10	6	10	2

Table A.45: Summary Statistics for Site 45 Berowra Creek at stepping stones at Fishponds Waterhole for July 2010 to June 2011

Site 45 Berowar Ck at Fishponds		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		12	13542	4000	2000	100000	3000	10000	27673
Temperature (oC)		13	18.1	17.7	12.3	24.7	13.6	22.5	4.1
Electrical Conductivity (mS/cm)		12	0.56	0.60	0.26	0.70	0.47	0.69	0.14
Electrical Conductivity (µS/cm)		11	536	569	211	673	475	653	141
Turbidity (NTU)		12	11.0	1.5	0.0	96.0	0.5	10.5	27.2
Dissolved oxygen (mg/L)		13	9.4	9.4	8.5	10.8	8.6	10.1	0.8
Dissolved oxygen (%sat)		13	99	99	91	108	97	103	5
pH		12	7.6	7.6	7.1	7.9	7.4	7.7	0.2
Salinity (ppt)		12	0.3	0.3	0.1	0.4	0.2	0.3	0.1
Suspended Solids (mg/L)	(2)	13	8	1	1	80	1	4	22
Ammonium-Nitrogen (mg/L)	(0.01)	13	0.137	0.020	0.010	1.000	0.010	0.080	0.293
Oxidised Nitrogen (mg/L)	(0.01)	13	1.51	1.60	0.21	3.10	0.38	2.60	0.93
Total Nitrogen (mg/L)	(0.05)	13	2.27	2.20	0.71	4.03	1.50	3.45	1.06
Total Phosphorus(mg/L)	(0.002)	13	0.116	0.062	0.043	0.330	0.054	0.224	0.096
Chlorophyll-A (ug/L)	(2)	13	1.6	0.8	0.1	7.8	0.3	1.7	2.2
Faecal Coliforms (CFU/100ml)	(1)	13	31237	360	45.0	340000	78.0	3200	94219
Enterococci (CFU/100ml)	(1)	13	2648	90	21.0	22000	39.0	1100	6420
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	2	89	89	72	106			
Chloride (mg/L)	(0.1)	2	85	85	78	92			
Sulphate as SO42-(mg/L)	(0.1)	2	61	61	49	72			
Fluoride (mg/L)	(0.05)	2	0.46	0.46	0.37	0.55			
Sodium (mg/L)	(0.05)	3	63.5	63.2	52.9	74.5	52.9	74.5	10.8
Potassium (mg/L)	(0.05)	2	14.5	14.5	12.4	16.6			
Magnesium (mg/L)	(0.01)	2	8.5	8.5	6.1	10.9			
Calcium (mg/L)	(0.01)	3	36.0	38.5	28.3	41.2	28.3	41.2	6.8
Aluminium (ug/L)	(10)	2	86	86	81	91			
Arsenic (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Cadmium (ug/L)	(1)	2	0.50	0.50	0.50	0.50			
Chromium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Copper (ug/L)	(1)	2	4.0	4.0	2.0	6.0			
Lead (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Manganese (ug/L)	(1)	2	21	21	12	30			
Molybdenum (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Nickel (ug/L)	(1)	2	2.5	2.5	2.0	3.0			
Selenium (ug/L)	(3)	2	1.5	1.5	1.5	1.5			
Silver (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Uranium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Zinc (ug/L)	(10)	2	34	34	13	54			
Boron (ug/L)	(5)	2	56	56	51	60			
Iron (ug/L)	(20)	2	211	211	209	212			
Mercury (ug/L)	(0.1 to 0.01)	1	0.05						
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(0.2)	3	8	7	6	11			

Table A.46: Summary Statistics for Site 46 Tributary of Terrys Creek North Epping for July 2010 to June 2011

Site 46 Tributary of Terrys Ck, North Epping		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		9	1034	60	30	8000	30	800	2624
Temperature (oC)		8	17.2	17.6	11.9	22.6	12.4	21.6	4.3
Electrical Conductivity (mS/cm)		7	0.34	0.42	0.06	0.48	0.15	0.47	0.17
Electrical Conductivity (µS/cm)		7	338	415	70	475	130	465	167
Turbidity (NTU)		8	11.2	2.7	1.5	60.5	1.5	13.0	20.3
Dissolved oxygen (mg/L)		8	10.3	10.3	8.9	11.8	9.4	10.9	0.9
Dissolved oxygen (%sat)		8	106	106	100	114	103	110	4
pH		8	7.4	7.4	7.1	7.7	7.1	7.6	0.2
Salinity (ppt)		7	0.2	0.2	0.0	0.2	0.1	0.2	0.1
Suspended Solids (mg/L)	(2)	8	6	1	1	32	1	7	11
Ammonium-Nitrogen (mg/L)	(0.01)	8	0.098	0.025	0.010	0.620	0.020	0.030	0.211
Oxidised Nitrogen (mg/L)	(0.01)	8	0.21	0.15	0.04	0.80	0.05	0.22	0.25
Total Nitrogen (mg/L)	(0.05)	8	0.58	0.45	0.29	1.21	0.33	0.93	0.33
Total Phosphorus(mg/L)	(0.002)	8	0.049	0.039	0.011	0.125	0.011	0.086	0.040
Faecal Coliforms (CFU/100ml)	(1)	8	3071	1190	30.0	8800	60.0	7800	3693
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	2	65	65	60	70			
Chloride (mg/L)	(0.1)	2	56	56	31	81			
Sulphate as SO42-(mg/L)	(0.1)	2	28	28	28	28			
Fluoride (mg/L)	(0.05)	2	0.20	0.20	0.13	0.26			
Sodium (mg/L)	(0.05)	4	44.1	42.3	41.7	50.3	41.7	50.3	4.1
Potassium (mg/L)	(0.05)	3	3.8	3.7	3.1	4.6	3.1	4.6	0.7
Magnesium (mg/L)	(0.01)	3	6.8	7.0	6.2	7.2	6.2	7.2	0.5
Calcium (mg/L)	(0.01)	4	23.9	24.3	21.2	25.8	21.2	25.8	2.0
Aluminium (ug/L)	(10)	3	42	41	23	61	23	61	19
Arsenic (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L)	(1)	3	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Copper (ug/L)	(1)	3	1.3	1.0	1.0	2.0	1.0	2.0	0.6
Lead (ug/L)	(1)	3	1.0	0.5	0.5	2.0	0.5	2.0	0.9
Manganese (ug/L)	(1)	3	46	43	31	63	31	63	16
Molybdenum (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Nickel (ug/L)	(1)	3	1.7	2.0	1.0	2.0	1.0	2.0	0.6
Selenium (ug/L)	(3)	3	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L)	(10)	3	10	10	5	14	5	14	5
Boron (ug/L)	(5)	3	34	32	30	40	30	40	5
Iron (ug/L)	(20)	3	1123	1010	800	1560	800	1560	392
Mercury (ug/L)	(0.1 to 0.01)	2	0.05	0.05	0.05	0.05			
BOD5/CBOD5(mg/L)	(2)	1	1						

Table A.38: Summary Statistics for Site 38 Sandbrook Inlet Brooklyn for July 2010 to June 2011

Site 38 Sandbrook Inlet		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Secchi Depth (m)		12	0.8	0.8	0.6	1.2	0.7	1.0	0.2
Temperature (oC)		12	19.6	20.2	14.2	25.8	15.3	24.5	4.5
Electrical Conductivity (mS/cm)		11	39.2	42.9	14.1	44.7	39.7	44.5	9.6
Turbidity (NTU)		12	12.5	10.7	5.9	21.0	9.2	18.0	4.6
Dissolved oxygen (mg/L)		12	7.3	7.4	5.4	8.9	6.8	8.1	0.9
Dissolved oxygen (%sat)		12	92	93	77	100	89	98	6
pH		12	7.6	7.6	7.2	7.8	7.5	7.7	0.1
Salinity (ppt)		11	25.1	27.5	8.2	28.9	25.3	28.8	6.5
Suspended Solids (mg/L)	(2)	12	10	9	1	19	7	14	5
Ammonium-Nitrogen (mg/L)	(0.01)	12	0.011	0.010	0.005	0.020	0.010	0.010	0.005
Oxidised Nitrogen (mg/L)	(0.01)	12	0.04	0.03	0.01	0.10	0.02	0.07	0.03
Total Nitrogen (mg/L)	(0.05)	12	0.27	0.28	0.19	0.47	0.22	0.29	0.07
Total Phosphorus(mg/L)	(0.002)	12	0.021	0.019	0.016	0.036	0.018	0.022	0.005
Chlorophyll-A (ug/L)	(2)	12	4.2	3.6	2.1	11.4	2.6	5.0	2.5
Faecal Coliforms (CFU/100ml)	(1)	12	8	4	0.5	27	1.0	15	10
Enterococci (CFU/100ml)	(1)	11	9	5	1.0	38	3.0	10	11

Table A.48: Summary Statistics for Site 48 Marramarra Creek at Orange Orchard in Marramarra NP for July 2010 to June 2011

Site 48 Marramarra Ck at Orange Orchard		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Secchi Depth (m)		6	0.8	0.8	0.5	1.0	0.6	1.0	0.2
Temperature (oC)		13	18.1	18.3	12.5	25.6	13.4	23.0	4.8
Electrical Conductivity (mS/cm)		12	28.6	32.7	0.7	39.9	16.6	36.9	12.5
Turbidity (NTU)		13	13.8	12.2	7.1	25.2	8.9	20.3	5.8
Dissolved oxygen (mg/L)		13	7.5	7.0	4.8	11.2	5.9	9.1	1.8
Dissolved oxygen (%sat)		13	86	87	69	108	76	98	12
pH		13	7.0	7.1	6.3	7.3	7.0	7.2	0.3
Salinity (ppt)		12	17.9	20.4	0.3	25.4	9.7	23.5	8.1
Suspended Solids (mg/L)	(2)	13	11	10	4	28	6	13	6
Ammonium-Nitrogen (mg/L)	(0.01)	13	0.022	0.020	0.010	0.060	0.010	0.030	0.013
Oxidised Nitrogen (mg/L)	(0.01)	13	0.07	0.02	0.01	0.66	0.01	0.03	0.18
Total Nitrogen (mg/L)	(0.05)	13	0.40	0.36	0.19	1.15	0.24	0.49	0.25
Total Phosphorus(mg/L)	(0.002)	13	0.03	0.03	0.01	0.07	0.02	0.04	0.01
Chlorophyll-A (ug/L)	(2)	13	7.53	5.50	1.70	29.00	2.20	9.60	8.15
Faecal Coliforms (CFU/100ml)	(1)	13	139	39	7	960	12	64	275
Enterococci (CFU/100ml)	(1)	12	83	26	3	710	10	38	199
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(0.2)	2	6	6	5.0	7			

Table A.49: Summary Statistics for Site 49 Still Creek Mansfield Rd Galston for July 2010 to June 2011

Site 49 Still Creek at mansfield Road		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		12	2725	70	2	30000	30	150	8607
Temperature (oC)		13	15.1	14.2	10.2	21.7	10.9	19.9	4.4
Electrical Conductivity (mS/cm)		12	0.53	0.51	0.34	0.85	0.44	0.59	0.13
Electrical Conductivity (µS/cm)		12	510	489	293	861	448	585	140
Turbidity (NTU)		13	9.4	2.7	0.4	45.8	0.8	6.5	15.9
Dissolved oxygen (mg/L)		13	10.2	9.8	8.1	12.1	9.0	11.6	1.3
Dissolved oxygen (%sat)		13	101	100	90	111	95	107	6
pH		13	7.1	7.2	6.7	7.5	7.0	7.3	0.2
Salinity (ppt)		12	0.3	0.3	0.2	0.4	0.2	0.3	0.1
Suspended Solids (mg/L)	(2)	13	3	1	1	16	1	7	5
Ammonium-Nitrogen (mg/L)	(0.01)	13	0.013	0.010	0.005	0.040	0.005	0.010	0.012
Oxidised Nitrogen (mg/L)	(0.01)	13	0.27	0.12	0.02	1.04	0.04	0.56	0.30
Total Nitrogen (mg/L)	(0.05)	13	0.68	0.55	0.31	1.67	0.34	1.19	0.45
Total Phosphorus(mg/L)	(0.002)	13	0.036	0.020	0.005	0.145	0.009	0.038	0.044
Faecal Coliforms (CFU/100ml)	(1)	13	661	38	5.0	6600	9.0	150	1830
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	2	42	42	40	44	40	44	3
Chloride (mg/L)	(0.1)	3	105	105	93	118	93	118	13
Sulphate as SO42-(mg/L)	(0.1)	3	22	20	19	27	19	27	4
Fluoride (mg/L)	(0.05)	3	0.10	0.09	0.08	0.12	0.08	0.12	0.02
Sodium (mg/L)	(0.05)	3	54.6	56.2	49.2	58.4	49.2	58.4	4.8
Potassium (mg/L)	(0.05)	3	7.1	7.3	6.8	7.3	6.8	7.3	0.3
Magnesium (mg/L)	(0.01)	3	10.9	11.6	9.2	12.0	9.2	12.0	1.5
Calcium (mg/L)	(0.01)	3	15.1	15.5	14.2	15.6	14.2	15.6	0.8
Aluminium (ug/L)	(10)	1	168	168					
Arsenic (ug/L)	(1)	1	0.5	0.5					
Cadmium (ug/L)	(1)	1	0.50	0.50					
Chromium (ug/L)	(1)	1	0.5	0.5					
Copper (ug/L)	(1)	1	3.0	3.0					
Lead (ug/L)	(1)	1	0.5	0.5					
Manganese (ug/L)	(1)	1	20	20					
Molybdenum (ug/L)	(1)	1	0.5	0.5					
Nickel (ug/L)	(1)	1	2.0	2.0					
Selenium (ug/L)	(3)	1	1.5	1.5					
Silver (ug/L)	(1)	1	0.5	0.5					
Uranium (ug/L)	(1)	1	0.5	0.5					
Zinc (ug/L)	(10)	1	5	5					
Boron (ug/L)	(5)	1	38	38					
Iron (ug/L)	(20)	1	1330	1330					
Mercury (ug/L)	(0.1 to 0.01)	1	0.05	0.05					
BOD5/CBOD5(mg/L)	(2)	1	1	1					
Total Organic Carbon(mg/L)	(0.2)	3	7	7	4	11	4	11	4

Table A.52: Summary Statistics for Site 52 Calna Creek upstream of Hornsby Heights STP for July 2010 to June 2011

Site 52 Calna Creek above West Hornsby STP	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)	13	1035	150	40	10000	60	1000	2713
Temperature (oC)	13	14.8	14.6	10.5	21.0	10.6	19.3	4.0
Electrical Conductivity (mS/cm)	12	0.28	0.28	0.19	0.36	0.25	0.31	0.04
Electrical Conductivity (µS/cm)	12	281	288	188	340	266	302	37
Turbidity (NTU)	13	25.6	1.3	0.2	268.5	0.6	9.3	73.7
Dissolved oxygen (mg/L)	13	8.3	8.4	6.1	10.2	6.9	9.6	1.3
Dissolved oxygen (%sat)	13	81	83	67	97	73	89	9
pH	13	7.0	7.0	6.7	7.4	6.9	7.2	0.2
Salinity (ppt)	12	0.1	0.1	0.1	0.2	0.1	0.2	0.0
Suspended Solids (mg/L) (2)	13	11	1	1	108	1	3	30
Ammonium-Nitrogen (mg/L) (0.01)	13	0.358	0.020	0.010	4.400	0.010	0.020	1.214
Oxidised Nitrogen (mg/L) (0.01)	13	0.21	0.14	0.02	0.74	0.06	0.47	0.23
Total Nitrogen (mg/L) (0.05)	13	0.78	0.34	0.20	4.90	0.24	0.92	1.27
Total Phosphorus(mg/L) (0.002)	13	0.053	0.019	0.008	0.424	0.011	0.038	0.112
Faecal Coliforms (CFU/100ml) (1)	13	1897	100	16.0	22000	64.0	520	6046
Bicarbonate Alkalinity (mg/CaCO3/L) (2)	2	51	51	47	56			
Chloride (mg/L) (0.1)	2	49	49	45	52			
Sulphate as SO42-(mg/L) (0.1)	2	14	14	13	15			
Fluoride (mg/L) (0.05)	2	0.19	0.19	0.14	0.23			
Sodium (mg/L) (0.05)	3	29.9	32.7	22.4	34.6	22.4	34.6	6.6
Potassium (mg/L) (0.05)	2	2.1	2.1	2.1	2.1			
Magnesium (mg/L) (0.01)	2	6.8	6.8	5.4	8.1			
Calcium (mg/L) (0.01)	3	17.8	17.6	14.3	21.5	14.3	21.5	3.6
Aluminium (ug/L) (10)	2	32	32	25	38			
Arsenic (ug/L) (1)	2	0.5	0.5	0.5	0.5			
Cadmium (ug/L) (1)	2	0.50	0.50	0.50	0.50			
Chromium (ug/L) (1)	2	0.5	0.5	0.5	0.5			
Copper (ug/L) (1)	2	1.8	1.8	0.5	3.0			
Lead (ug/L) (1)	2	0.5	0.5	0.5	0.5			
Manganese (ug/L) (1)	2	41	41	31	51			
Molybdenum (ug/L) (1)	2	0.5	0.5	0.5	0.5			
Nickel (ug/L) (1)	2	0.5	0.5	0.5	0.5			
Selenium (ug/L) (3)	2	1.5	1.5	1.5	1.5			
Silver (ug/L) (1)	2	0.5	0.5	0.5	0.5			
Uranium (ug/L) (1)	2	0.5	0.5	0.5	0.5			
Zinc (ug/L) (10)	2	26	26	12	39			
Boron (ug/L) (5)	2	39	39	27	50			
Iron (ug/L) (20)	2	1148	1148	955	1340			
Mercury (ug/L) (0.1 to 0.01)	1	0.05						
BOD5/CBOD5(mg/L) (2)	1	1						
Total Organic Carbon(mg/L) (0.2)	3	6	5	4	10	4	10	3

Table A.54. Summary Statistics for Site 54 Laughtondale Creek (reference) at Laughtondale for July 2010 to June 2011

Site 54 Laughtondale Ck (Reference)	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)	4	60	65	10	100	10	100	47
Temperature (oC)	4	14.4	13.9	10.4	19.6	10.4	19.6	4.0
Electrical Conductivity (mS/cm)	4	0.25	0.23	0.14	0.40	0.14	0.40	0.12
Electrical Conductivity (µS/cm)	4	247	211	158	407	158	407	115
Turbidity (NTU)	4	1.4	1.5	-0.2	3.0	-0.2	3.0	1.4
Dissolved oxygen (mg/L)	4	9.7	9.5	8.8	11.0	8.8	11.0	1.0
Dissolved oxygen (%sat)	4	95	95	91	98	91	98	3
pH	4	4.9	5.1	4.1	5.4	4.1	5.4	0.6
Salinity (ppt)	4	0.1	0.1	0.1	0.2	0.1	0.2	0.1
Suspended Solids (mg/L) (2)	4	2	2	1	3	1	3	1
Ammonium-Nitrogen (mg/L) (0.01)	4	0.005	0.005	0.005	0.005	0.005	0.005	0.000
Oxidised Nitrogen (mg/L) (0.01)	4	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Total Nitrogen (mg/L) (0.05)	4	0.09	0.08	0.06	0.12	0.06	0.12	0.03
Total Phosphorus(mg/L) (0.002)	4	0.006	0.006	0.004	0.007	0.004	0.007	0.001
Faecal Coliforms (CFU/100ml) (1)	3	26	23	12.0	43	12.0	43	16
Bicarbonate Alkalinity (mg/CaCO3/L) (2)	1	1						
Chloride (mg/L) (0.1)	1	111						
Sulphate as SO42-(mg/L) (0.1)	1	7						
Fluoride (mg/L) (0.05)	1	0.08						
Sodium (mg/L) (0.05)	1	50.2						
Potassium (mg/L) (0.05)	1	2.7						
Magnesium (mg/L) (0.01)	1	9.5						
Calcium (mg/L) (0.01)	1	3.3						
Aluminium (ug/L) (10)	1	1330						
Arsenic (ug/L) (1)	1	0.5						
Cadmium (ug/L) (1)	1	0.50						
Chromium (ug/L) (1)	1	0.5						
Copper (ug/L) (1)	1	1.0						
Lead (ug/L) (1)	1	2.0						
Manganese (ug/L) (1)	1	486						
Molybdenum (ug/L) (1)	1	0.5						
Nickel (ug/L) (1)	1	10.0						
Selenium (ug/L) (3)	1	1.5						
Silver (ug/L) (1)	1	0.5						
Uranium (ug/L) (1)	1	0.5						
Zinc (ug/L) (10)	1	57						
Boron (ug/L) (5)	1	18						
Iron (ug/L) (20)	1	98						
Mercury (ug/L) (0.1 to 0.01)	1	0.05						
Total Organic Carbon(mg/L) (2)	1	4						

Table A.55: Summary Data for Site 55 Hawkesbury River at Brooklyn Baths for December 2010 to March 2011

Site 55 Hawkesbury River at Brooklyn Baths	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Secchi Depth (m)	17	1.1	1.0	0.7	1.4	0.9	1.3	0.2
Temperature (oC)	18	23.6	23.8	20.3	26.4	22.4	24.9	1.4
Electrical Conductivity (mS/cm)	17	46.3	48.3	28.2	51.1	44.6	50.3	6.0
Turbidity (NTU)	18	8.3	8.0	2.6	19.6	4.4	11.5	4.1
Dissolved oxygen (mg/L)	18	6.6	6.5	5.5	7.9	6.1	7.0	0.6
Dissolved oxygen (%sat)	18	92	91	79	105	87	99	6
pH	18	7.8	7.8	7.4	7.9	7.7	7.9	0.1
Salinity (ppt)	18	30.2	31.6	17.5	33.5	28.8	33.0	4.1
Suspended Solids (mg/L) (2)	18	6	5	1	12	3	8	3
Ammonium-Nitrogen (mg/L) (0.01)	18	0.018	0.020	0.010	0.030	0.010	0.020	0.007
Oxidised Nitrogen (mg/L) (0.01)	18	0.04	0.03	0.01	0.09	0.02	0.05	0.02
Total Nitrogen (mg/L) (0.05)	18	0.27	0.25	0.21	0.42	0.22	0.32	0.06
Total Phosphorus(mg/L) (0.002)	18	0.021	0.020	0.014	0.035	0.017	0.023	0.005
Chlorophyll-A (ug/L) (2)	18	2.4	2.1	1.2	5.8	1.7	3.2	1.1
Faecal Coliforms (CFU/100ml) (1)	18	16	3	0.5	240	1.0	5	56
Enterococci (CFU/100ml) (1)	18	3	2	0.5	16	0.5	4	4
Total Organic Carbon(mg/L) (0.2)	3	3	3	2	4	2	4	1

Table A.56: Summary Statistics for Site 56 Wisemans Ferry Tip Leachate Collection Dam for July 10 to June 11 (see also Table A.112 for Riser C)

Site 56 Leachate Collection-Wisemans Ferry Landfill	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	3	15.3	13.9	12.1	19.9	12.1	19.9	4.1
Electrical Conductivity (mS/cm)	3	0.58	0.58	0.42	0.74	0.42	0.74	0.16
Electrical Conductivity (µS/cm)	3	571	573	416	725	416	725	155
Turbidity (NTU)	3	5.0	5.8	1.1	8.0	1.1	8.0	3.5
Dissolved oxygen (mg/L)	3	13.4	14.1	11.4	14.6	11.4	14.6	1.7
Dissolved oxygen (%sat)	3	132	131	125	141	125	141	8
pH	3	8.3	8.1	8.0	8.8	8.0	8.8	0.4
Salinity (ppt)	3	0.3	0.3	0.2	0.4	0.2	0.4	0.1
Suspended Solids (mg/L) (2)	3	4	5	2	6	2	6	2
Ammonium-Nitrogen (mg/L) (0.01)	3	0.012	0.010	0.005	0.020	0.005	0.020	0.008
Oxidised Nitrogen (mg/L) (0.01)	3	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Total Nitrogen (mg/L) (0.05)	3	0.60	0.52	0.33	0.94	0.33	0.94	0.31
Total Phosphorus(mg/L) (0.002)	3	0.033	0.016	0.010	0.073	0.010	0.073	0.035
Faecal Coliforms (CFU/100ml) (1)	3	8	1	0.5	21	0.5	21	12

Table A.60: Summary Statistics for Site 60 Berowra Creek Berowra Waters 50m downstream of Berowra Ferry for July 2010 to June 2011

Site 60 Berowra Creek near Ferry Berowra Waters	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Secchi Depth (m)	12	2.0	2.1	0.7	3.7	1.0	2.5	0.8
Temperature (oC)	12	19.6	19.8	13.5	26.3	14.5	25.3	4.9
Electrical Conductivity (mS/cm)	11	29.3	32.4	13.2	37.1	20.4	35.1	8.1
Turbidity (NTU)	12	3.0	1.2	0.0	10.4	0.5	7.6	3.6
Dissolved oxygen (mg/L)	12	6.9	6.7	4.5	9.5	5.3	8.4	1.6
Dissolved oxygen (%sat)	12	83	80	63	109	65	97	16
pH	12	7.3	7.3	7.0	7.6	7.0	7.6	0.2
Salinity (ppt)	11	18.2	20.2	7.5	23.3	12.3	22.2	5.4
Suspended Solids (mg/L) (2)	12	5	3	1	24	1	8	6
Ammonium-Nitrogen (mg/L) (0.01)	12	0.044	0.035	0.005	0.100	0.010	0.090	0.037
Oxidised Nitrogen (mg/L) (0.01)	12	0.14	0.07	0.01	0.42	0.03	0.32	0.15
Total Nitrogen (mg/L) (0.05)	12	0.50	0.42	0.28	0.96	0.35	0.69	0.20
Total Phosphorus(mg/L) (0.002)	12	0.033	0.029	0.015	0.069	0.019	0.038	0.016
Soluble Reactive Phosphorus (mg/L)(0.002)	10	0.008	0.007	0.001	0.020	0.002	0.014	0.007
Chlorophyll-A (ug/L) (2)	12	10.2	7.0	1.3	27.2	4.8	14.9	7.5
Faecal Coliforms (CFU/100ml) (1)	12	554	11	1.0	6100	4.0	43	1751
Enterococci (CFU/100ml) (1)	11	123	3	0.5	1100	0.5	20	330
Total Organic Carbon(mg/L) (0.2)	2	7	7	5	8			

Table A.61: Summary Statistics for Site 61 Berowra Creek midstream off Calabash Bay for July 2010 to June 2011

Site 61 Berowra Creekoff Calabash Bay	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Secchi Depth (m)	14	1.8	2.0	0.5	3.1	0.9	2.3	0.8
Temperature (oC)	14	18.8	17.7	13.7	26.5	13.9	24.8	4.8
Electrical Conductivity (mS/cm)	13	29.1	32.5	15.1	38.1	16.3	36.8	9.0
Turbidity (NTU)	14	5.2	2.3	0.3	22.1	1.1	8.9	6.3
Dissolved oxygen (mg/L)	14	7.8	7.7	5.8	10.6	6.2	8.9	1.4
Dissolved oxygen (%sat)	14	92	89	76	133	80	98	14
pH	14	7.4	7.4	7.0	7.8	7.2	7.6	0.2
Salinity (ppt)	13	18.0	20.4	7.9	24.2	9.0	23.3	6.1
Suspended Solids (mg/L) (2)	13	6	5	1	26	1	7	7
Ammonium-Nitrogen (mg/L) (0.01)	13	0.027	0.010	0.005	0.140	0.005	0.030	0.038
Oxidised Nitrogen (mg/L) (0.01)	13	0.12	0.07	0.01	0.39	0.02	0.24	0.13
Total Nitrogen (mg/L) (0.05)	13	0.50	0.47	0.27	0.99	0.36	0.53	0.20
Total Phosphorus(mg/L) (0.002)	13	0.034	0.034	0.015	0.062	0.017	0.051	0.015
Soluble Reactive Phosphorus (mg/L)(0.002)	11	0.006	0.004	0.001	0.020	0.001	0.012	0.006
Chlorophyll-A (ug/L) (2)	13	13.9	10.6	2.9	40.6	7.5	14.7	10.8
Faecal Coliforms (CFU/100ml) (1)	13	564	6	0.5	6400	1.0	27	1769
Enterococci (CFU/100ml) (1)	12	131	3	0.5	1200	0.5	10	350
Total Organic Carbon(mg/L) (0.2)	2	6	6	5	7	5	7	1

Table A.62: Summary Statistics for Site 62 drainage from Cowan Village (upper Kimmerakong Ck) for July 2010 to June 2011

Site 62 drainage from Cowan Village		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		12	24	6	1	200	1	20	56
Temperature (oC)		12	15.3	14.9	10.2	21.5	12.4	19.0	3.6
Electrical Conductivity (mS/cm)		11	0.40	0.41	0.26	0.50	0.35	0.44	0.07
Electrical Conductivity (µS/cm)		10	385	401	245	484	326	437	70
Turbidity (NTU)		11	5.3	2.7	1.1	19.2	2.0	7.4	5.3
Dissolved oxygen (mg/L)		12	8.8	8.9	7.1	10.2	7.4	10.0	1.2
Dissolved oxygen (%sat)		12	85	87	64	96	74	96	10
pH		12	7.3	7.3	6.9	7.6	7.0	7.5	0.2
Salinity (ppt)		11	0.2	0.2	0.1	0.3	0.2	0.2	0.0
Suspended Solids (mg/L)	(2)	12	2	1	1	5	1	2	1
Ammonium-Nitrogen (mg/L)	(0.01)	12	0.023	0.020	0.005	0.070	0.010	0.030	0.018
Oxidised Nitrogen (mg/L)	(0.01)	12	1.28	1.22	0.14	3.60	0.35	1.87	0.98
Total Nitrogen (mg/L)	(0.05)	12	1.64	1.46	0.53	4.34	0.77	2.27	1.09
Total Phosphorus(mg/L)	(0.002)	12	0.040	0.038	0.014	0.079	0.020	0.057	0.020
Faecal Coliforms (CFU/100ml)	(1)	12	560	120	11.0	3200	49.0	760	949
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	3	83	80	79	91	79	91	7
Chloride (mg/L)	(0.1)	3	59	59	58	60	58	60	1
Sulphate as SO42-(mg/L)	(0.1)	3	30	29	26	36	26	36	5
Fluoride (mg/L)	(0.05)	4	0.09	0.06	0.03	0.23	0.03	0.23	0.09
Sodium (mg/L)	(0.05)	3	49.7	49.3	42.4	57.4	42.4	57.4	7.5
Potassium (mg/L)	(0.05)	3	4.0	3.7	3.5	4.9	3.5	4.9	0.8
Magnesium (mg/L)	(0.01)	3	9.3	9.2	7.7	10.9	7.7	10.9	1.6
Calcium (mg/L)	(0.01)	3	24.5	23.8	20.3	29.5	20.3	29.5	4.6
Aluminium (ug/L)	(10)	1	75						
Arsenic (ug/L)	(1)	1	0.5						
Cadmium (ug/L)	(1)	1	0.50						
Chromium (ug/L)	(1)	1	0.5						
Copper (ug/L)	(1)	1	4.0						
Lead (ug/L)	(1)	1	0.5						
Manganese (ug/L)	(1)	1	14						
Molybdenum (ug/L)	(1)	1	0.5						
Nickel (ug/L)	(1)	1	0.5						
Selenium (ug/L)	(3)	1	1.5						
Silver (ug/L)	(1)	1	0.5						
Uranium (ug/L)	(1)	1	0.5						
Zinc (ug/L)	(10)	1	5						
Boron (ug/L)	(5)	1	84						
Iron (ug/L)	(20)	1	736						
Mercury (ug/L)	(0.1 to 0.01)	1	0.20						
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(0.2)	2	11	11	11	11			

Table A.63: Summary Statistics for Site 63 Colah Creek at end Ben Bullen Rd Glenorie for July 2010 to June 2011

Site 63 Colah Road end of Ben Bullen Road		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		12	16799	1500	40	180000	500	2000	51462
Temperature (oC)		12	14.3	13.3	9.5	19.6	9.9	19.0	4.1
Electrical Conductivity (mS/cm)		11	0.44	0.45	0.26	0.54	0.34	0.53	0.10
Electrical Conductivity (µS/cm)		11	420	442	258	513	357	502	82
Turbidity (NTU)		12	10.4	4.1	1.3	56.9	2.4	8.7	16.2
Dissolved oxygen (mg/L)		12	8.9	9.8	2.4	11.7	7.5	11.2	2.7
Dissolved oxygen (%sat)		12	86	94	26	103	79	99	22
pH		12	7.0	7.0	6.8	7.3	7.0	7.1	0.1
Salinity (ppt)		11	0.2	0.2	0.1	0.3	0.2	0.3	0.0
Suspended Solids (mg/L)	(2)	12	4	1	1	27	1	2	7
Ammonium-Nitrogen (mg/L)	(0.01)	12	0.010	0.010	0.005	0.020	0.005	0.010	0.005
Oxidised Nitrogen (mg/L)	(0.01)	12	0.26	0.13	0.02	1.12	0.04	0.35	0.33
Total Nitrogen (mg/L)	(0.05)	12	0.66	0.47	0.32	1.65	0.39	1.13	0.42
Total Phosphorus(mg/L)	(0.002)	12	0.033	0.024	0.010	0.108	0.013	0.034	0.031
Faecal Coliforms (CFU/100ml)	(1)	12	1396	54	20.0	15000	26.0	300	4291
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	2	31	31	27	35			
Chloride (mg/L)	(0.1)	3	103	103	79	126	79	126	24
Sulphate as SO42-(mg/L)	(0.1)	3	24	21	20	30	20	30	6
Fluoride (mg/L)	(0.05)	3	0.10	0.07	0.06	0.16	0.06	0.16	0.06
Sodium (mg/L)	(0.05)	3	50.8	53.3	41.0	58.1	41.0	58.1	8.8
Potassium (mg/L)	(0.05)	3	5.7	5.7	5.3	6.0	5.3	6.0	0.3
Magnesium (mg/L)	(0.01)	3	9.5	10.2	7.8	10.6	7.8	10.6	1.5
Calcium (mg/L)	(0.01)	3	13.0	13.1	12.1	13.9	12.1	13.9	0.9
Aluminium (ug/L)	(10)	1	284						
Arsenic (ug/L)	(1)	1	0.5						
Cadmium (ug/L)	(1)	1	0.50						
Chromium (ug/L)	(1)	1	1.0						
Copper (ug/L)	(1)	1	1.0						
Lead (ug/L)	(1)	1	0.5						
Manganese (ug/L)	(1)	1	22						
Molybdenum (ug/L)	(1)	1	0.5						
Nickel (ug/L)	(1)	1	2.0						
Selenium (ug/L)	(3)	1	1.5						
Silver (ug/L)	(1)	1	0.5						
Uranium (ug/L)	(1)	1	0.5						
Zinc (ug/L)	(10)	1	16						
Boron (ug/L)	(5)	1	31						
Iron (ug/L)	(20)	1	1050						
Mercury (ug/L)	(0.1 to 0.01)	1	0.05						
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(0.2)	3	9	8	8	11	8	11	2

Table A.64: Summary Statistics for Site 64 drainage from Galston Village (off Salaway Rd) to Colah Creek for July 2010 to June 2011

Site 64 drainage from Galston Village		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		13	1309	100	3	15000	30	200	4122
Temperature (oC)		13	14.6	13.6	10.5	19.6	10.9	18.9	3.5
Electrical Conductivity (mS/cm)		12	0.48	0.49	0.37	0.60	0.40	0.51	0.07
Electrical Conductivity (µS/cm)		12	470	471	338	587	395	529	76
Turbidity (NTU)		13	12.8	5.4	1.1	44.5	3.3	28.0	14.7
Dissolved oxygen (mg/L)		13	8.5	9.4	0.4	11.6	6.7	10.8	3.0
Dissolved oxygen (%sat)		13	82	91	4	109	65	98	27
pH		13	7.1	7.1	6.7	7.3	7.0	7.3	0.2
Salinity (ppt)		12	0.2	0.2	0.2	0.3	0.2	0.3	0.0
Suspended Solids (mg/L)	(2)	13	3	1	1	15	1	5	4
Ammonium-Nitrogen (mg/L)	(0.01)	13	0.056	0.030	0.010	0.320	0.020	0.070	0.082
Oxidised Nitrogen (mg/L)	(0.01)	13	1.21	1.18	0.01	3.20	0.08	1.90	0.94
Total Nitrogen (mg/L)	(0.05)	13	1.66	1.77	0.35	4.65	0.57	2.45	1.17
Total Phosphorus(mg/L)	(0.002)	13	0.098	0.084	0.017	0.229	0.056	0.124	0.052
Faecal Coliforms (CFU/100ml)	(1)	13	919	510	79.0	4700	180.0	1200	1254
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	2	63	63	61	66			
Chloride (mg/L)	(0.1)	3	85	87	76	91	76	91	8
Sulphate as SO42-(mg/L)	(0.1)	3	32	32	27	36	27	36	5
Fluoride (mg/L)	(0.05)	3	0.09	0.08	0.08	0.11	0.08	0.11	0.02
Sodium (mg/L)	(0.05)	3	53.0	52.6	49.2	57.1	49.2	57.1	4.0
Potassium (mg/L)	(0.05)	3	5.2	5.2	5.2	5.3	5.2	5.3	0.1
Magnesium (mg/L)	(0.01)	3	8.4	8.2	7.4	9.6	7.4	9.6	1.1
Calcium (mg/L)	(0.01)	3	21.5	21.7	20.9	22.0	20.9	22.0	0.6
Aluminium (ug/L)	(10)	1	218						
Arsenic (ug/L)	(1)	1	0.5						
Cadmium (ug/L)	(1)	1	0.50						
Chromium (ug/L)	(1)	1	1.0						
Copper (ug/L)	(1)	1	1.0						
Lead (ug/L)	(1)	1	0.5						
Manganese (ug/L)	(1)	1	21						
Molybdenum (ug/L)	(1)	1	0.5						
Nickel (ug/L)	(1)	1	1.0						
Selenium (ug/L)	(3)	1	1.5						
Silver (ug/L)	(1)	1	0.5						
Uranium (ug/L)	(1)	1	0.5						
Zinc (ug/L)	(10)	1	19						
Boron (ug/L)	(5)	1	46						
Iron (ug/L)	(20)	1	1390						
Mercury (ug/L)	(0.1 to 0.01)	1	0.05						
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(0.2)	3	8	7	7	10	7	10	2

Table A.77: Summary Statistics for Site 77 Gleeson Creek 200m below Foxglove Oval embankment for July 2010 to June 2011

Site 77 Gleeson Ck below Landfill Mt Colah		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		13	133	60	10	400	20	350	148
Temperature (oC)		13	15.7	15.6	10.1	21.6	11.2	20.9	4.3
Electrical Conductivity (mS/cm)		12	0.74	0.82	0.21	1.05	0.36	1.02	0.31
Electrical Conductivity (µS/cm)		11	698	804	201	1015	345	997	315
Turbidity (NTU)		12	5.4	3.4	0.0	16.7	1.5	10.5	5.3
Dissolved oxygen (mg/L)		13	6.0	5.9	2.9	9.9	5.3	6.5	1.6
Dissolved oxygen (%sat)		13	59	57	32	95	53	69	16
pH		13	7.2	7.3	6.9	7.4	7.0	7.4	0.2
Salinity (ppt)		12	0.4	0.4	0.1	0.5	0.2	0.5	0.2
Suspended Solids (mg/L)	(2)	13	2	1	1	6	1	3	2
Ammonium-Nitrogen (mg/L)	(0.01)	13	7.683	6.340	0.340	19.400	0.930	16.000	7.203
Oxidised Nitrogen (mg/L)	(0.01)	13	6.90	6.50	0.80	14.80	3.60	9.60	4.05
Total Nitrogen (mg/L)	(0.05)	13	15.79	15.50	1.52	29.40	5.35	28.20	9.72
Total Phosphorus(mg/L)	(0.002)	13	0.032	0.020	0.011	0.153	0.013	0.040	0.038
Faecal Coliforms (CFU/100ml)	(1)	13	744	220	24.0	4800	48.0	680	1373
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	3	219	221	188	248	188	248	30
Chloride (mg/L)	(0.1)	3	127	138	101	143	101	143	23
Sulphate as SO42-(mg/L)	(0.1)	3	20	19	18	24	18	24	3
Fluoride (mg/L)	(0.05)	4	0.09	0.05	0.03	0.22	0.03	0.22	0.09
Sodium (mg/L)	(0.05)	4	78.5	78.8	70.2	86.4	70.2	86.4	6.9
Potassium (mg/L)	(0.05)	3	25.0	25.4	24.3	25.4	24.3	25.4	0.6
Magnesium (mg/L)	(0.01)	3	16.3	16.7	14.9	17.4	14.9	17.4	1.3
Calcium (mg/L)	(0.01)	4	51.3	51.0	47.2	56.1	47.2	56.1	3.9
Aluminium (ug/L)	(10)	2	47	47	34	60			
Arsenic (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Cadmium (ug/L)	(1)	2	0.50	0.50	0.50	0.50			
Chromium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Copper (ug/L)	(1)	2	3.0	3.0	3.0	3.0			
Lead (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Manganese (ug/L)	(1)	2	26	26	25	26			
Molybdenum (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Nickel (ug/L)	(1)	2	3.0	3.0	3.0	3.0			
Selenium (ug/L)	(3)	2	1.5	1.5	1.5	1.5			
Silver (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Uranium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Zinc (ug/L)	(10)	2	23	23	5	40			
Boron (ug/L)	(5)	2	165	165	162	168			
Iron (ug/L)	(20)	2	703	703	673	733			
Mercury (ug/L)	(0.1 to 0.01)	1	0.20						
BOD5/CBOD5(mg/L)	(2)	1	1						
Total Organic Carbon(mg/L)	(2)	3	14	14	11	17	11	17	3

Table A.80: Summary Statistics for Site 80 Glenorie Creek Glenorie for July 2010 to June 2011

Site 80 Glenorie Creek at Tekepo Rd Glenorie		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		12	580	190	20	5000	30	250	1404
Temperature (oC)		12	15.0	14.1	11.3	20.7	11.9	18.9	3.3
Electrical Conductivity (mS/cm)		11	0.50	0.51	0.40	0.57	0.44	0.56	0.06
Electrical Conductivity (µS/cm)		11	489	496	395	565	437	546	57
Turbidity (NTU)		12	15.7	5.3	2.2	62.4	4.3	27.2	20.7
Dissolved oxygen (mg/L)		12	9.4	9.5	8.2	11.5	8.4	10.3	1.0
Dissolved oxygen (%sat)		12	93	92	88	109	89	94	6
pH		12	7.1	7.1	6.9	7.3	7.0	7.3	0.2
Salinity (ppt)		11	0.3	0.3	0.2	0.3	0.2	0.3	0.0
Suspended Solids (mg/L)	(2)	12	7	5	1	25	2	8	8
Ammonium-Nitrogen (mg/L)	(0.01)	12	0.251	0.175	0.120	0.790	0.130	0.350	0.195
Oxidised Nitrogen (mg/L)	(0.01)	12	1.22	0.83	0.43	4.40	0.62	1.51	1.08
Total Nitrogen (mg/L)	(0.05)	12	2.10	1.92	1.21	5.30	1.32	2.42	1.09
Total Phosphorus(mg/L)	(0.002)	12	0.249	0.232	0.088	0.532	0.137	0.321	0.137
Faecal Coliforms (CFU/100ml)	(1)	12	2338	885	310.0	9800	330.0	3400	3053
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	1	59						
Chloride (mg/L)	(0.1)	1	73						
Sulphate as SO42-(mg/L)	(0.1)	1	47						
Fluoride (mg/L)	(0.05)	1	0.10						
Sodium (mg/L)	(0.05)	1	45.0						
Potassium (mg/L)	(0.05)	1	10.6						
Magnesium (mg/L)	(0.01)	1	11.3						
Calcium (mg/L)	(0.01)	1	21.3						
Total Organic Carbon(mg/L)	(0.2)	2	10	10	9	11	9	11	2

Table A.85 Summary Statistics for Site 85 Discharge Water from Hornsby Quarry into Old Mans Creek July 2010 to June 2011

Site 85. Discharge Water from Hornsby Quarry		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		15	3600	3600	3600	3600	3600	3600	0
Temperature (oC)		16	19.8	19.2	13.4	27.3	14.0	26.0	5.4
Electrical Conductivity (mS/cm)		15	0.88	0.88	0.85	0.92	0.86	0.90	0.02
Electrical Conductivity (µS/cm)		15	871	877	830	892	863	883	15
Turbidity (NTU)		16	0.3	0.0	-0.2	2.8	0.0	0.4	0.7
Dissolved oxygen (mg/L)		16	8.9	9.0	6.1	10.7	8.1	10.0	1.3
Dissolved oxygen (%sat)		16	98	106	59	120	78	115	20
pH		15	8.2	8.3	7.7	8.5	7.8	8.5	0.3
Salinity (ppt)		15	0.4	0.4	0.4	0.5	0.4	0.5	0.0
Suspended Solids (mg/L)	(2)	12	1	1	1	1	1	1	0
Ammonium-Nitrogen (mg/L)	(0.01)	13	0.009	0.005	0.005	0.030	0.005	0.010	0.008
Oxidised Nitrogen (mg/L)	(0.01)	13	0.02	0.01	0.01	0.06	0.01	0.05	0.02
Total Nitrogen (mg/L)	(0.05)	13	0.20	0.19	0.16	0.26	0.18	0.23	0.03
Total Phosphorus(mg/L)	(0.002)	13	0.007	0.006	0.004	0.011	0.005	0.010	0.003
Chlorophyll-A (ug/L)	(2)	15	2.9	2.0	0.9	7.5	1.6	4.1	1.8
Faecal Coliforms (CFU/100ml)	(1)	13	9	6	0.5	32	3.0	16	9
Enterococci (CFU/100ml)	(1)	13	2	3	0.5	6	0.5	3	2
Sodium (mg/L)	(0.05)	1	68.1						
Calcium (mg/L)	(0.01)	1	49.0						
Aluminium (ug/L)	(10)	3	9	5	5	16	5	16	6
Arsenic (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L)	(1)	3	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Copper (ug/L)	(1)	3	0.7	0.5	0.5	1.0	0.5	1.0	0.3
Lead (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Manganese (ug/L)	(1)	3	3	2	1	7	1	7	3
Molybdenum (ug/L)	(1)	3	11.3	11.0	11.0	12.0	11.0	12.0	0.6
Nickel (ug/L)	(1)	3	0.7	0.5	0.5	1.0	0.5	1.0	0.3
Selenium (ug/L)	(3)	3	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L)	(10)	3	5	5	1	9	1	9	4
Boron (ug/L)	(5)	3	18	16	15	24	15	24	5
Iron (ug/L)	(20)	3	10	10	8	11	8	11	2
Mercury (ug/L)	(0.1 to 0.01)	1	0.10						
Total Organic Carbon(mg/L)	(2)	1	3						

Table A.94: Summary Statistics for Site 94 Arcadia Tip Treated Leachate Tank. Data for July 2009 to June 2010 (see also A.18 – Raw leachate collection tank)

Site 94 Treated leachate Arcadia Landfill	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	5	16.1	16.3	11.8	21.8	12.9	19.1	3.8
Electrical Conductivity (mS/cm)	5	1.17	1.24	0.80	1.38	0.97	1.34	0.23
Electrical Conductivity (µS/cm)	5	1116	1211	735	1344	905	1279	233
Turbidity (NTU)	5	3.1	0.8	0.0	13.2	0.4	7.1	5.6
Dissolved oxygen (mg/L)	5	6.0	6.1	2.7	8.6	4.3	7.7	2.1
Dissolved oxygen (%sat)	5	60	62	31	84	46	73	19
pH	5	7.6	7.7	7.2	7.9	7.4	7.8	0.2
Salinity (ppt)	5	0.6	0.6	0.4	0.7	0.5	0.7	0.1
Suspended Solids (mg/L) (2)	3	4	1	1	9	1	9	5
Ammonium-Nitrogen (mg/L) (0.01)	5	3.389	0.540	0.005	15.400	0.193	8.010	6.719
Oxidised Nitrogen (mg/L) (0.01)	5	20.02	20.20	6.60	27.90	12.95	27.00	8.36
Total Nitrogen (mg/L) (0.05)	5	29.86	31.50	7.30	53.00	14.50	44.40	16.95
Total Phosphorus(mg/L) (0.002)	4	0.015	0.016	0.010	0.020	0.010	0.020	0.004
Faecal Coliforms (CFU/100ml) (1)	2	3	3	0.5	5			
Bicarbonate Alkalinity (mg/CaCO3/L) (2)	1	309						
Chloride (mg/L) (0.1)	1	114						
Sodium (mg/L) (0.05)	2	87.2	87.2	81.7	92.6			
Potassium (mg/L) (0.05)	2	41.5	41.5	35.2	47.8			
Magnesium (mg/L) (0.01)	2	32.6	32.6	29.3	35.9			
Calcium (mg/L) (0.01)	2	104.5	104.5	103.0	106.0			
Aluminium (ug/L) (10)	1	15						
Arsenic (ug/L) (1)	1	0.5						
Cadmium (ug/L) (1)	1	0.50						
Chromium (ug/L) (1)	1	0.5						
Copper (ug/L) (1)	1	4.0						
Lead (ug/L) (1)	1	0.5						
Manganese (ug/L) (1)	1	14						
Molybdenum (ug/L) (1)	1	0.5						
Nickel (ug/L) (1)	1	12.0						
Selenium (ug/L) (3)	1	1.5						
Silver (ug/L) (1)	1	0.5						
Uranium (ug/L) (1)	1	0.5						
Zinc (ug/L) (10)	1	24						
Boron (ug/L) (5)	1	641						
Iron (ug/L) (20)	2	154	154	115	193			
Total Organic Carbon(mg/L) (2)	1	22						

TableA.95: Summary Statistics for Site 95 Foxglove Oval Raw leachate collection tank for July 2010 to June 2011

Site 95 Foxglove Landfill - Raw Leachate	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	10	19.0	20.3	14.2	22.2	15.9	21.6	2.9
Electrical ConductivityC (ms/cm)	9	1.4	1.6	0.4	2.3	0.4	1.9	0.7
Electrical Conductivity (µS/cm)	9	1351	1479	388	2170	414	1844	632
Turbidity (NTU)	10	25.1	20.6	3.3	58.9	10.4	41.3	17.6
Dissolved oxygen (mg/L)	10	3.8	3.9	1.3	6.3	2.2	5.4	1.6
Dissolved oxygen (%sat)	10	41	42	15	70	23	56	18
pH	10	6.9	6.8	6.7	7.0	6.8	7.0	0.1
Salinity (ppt)	9	0.7	0.8	0.2	1.2	0.2	1.0	0.4
Suspended Solids (mg/L)	2	13	13	9	17	9	17	6
Ammonium-Nitrogen (mg/L)	10	42.55	46.65	3.00	74.00	16.50	62.80	24.30
Oxidised Nitrogen (mg/L)	10	5.74	5.73	2.00	11.40	2.80	8.03	2.95
Total Nitrogen (mg/L)	10	51.44	55.00	5.66	85.60	21.15	77.50	28.06
Total Phosphorus(mg/L)	4	0.04	0.03	0.02	0.07	0.02	0.07	0.02
Faecal Coliforms (CFU/100ml)	2	285	285	10	560	10	560	389
Copper (ug/L)	1	4.0	4.0	4.0	4.0	4.0	4.0	
Lead (ug/L)	1	0.5	0.5	0.5	0.5	0.5	0.5	
Manganese (ug/L)	2	146	146	36	255	36	255	155
Zinc (ug/L)	1	25	25	25	25	25	25	
Iron (ug/L)	2	2815	2815	1650	3980	1650	3980	1648
BOD5/CBOD5(mg/L)	1	1	1	1	1	1	1	
Total Organic Carbon(mg/L)	1	13	13	13	13	13	13	

Table A.96A: Summary Statistics for Site 96A Foxglove Oval. Leachate after Bioreactor 1 treatment for July 2010 to June 2011

Site 96A. Foxglove landfill. Leachate leaving Bioreactor 1	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	9	19.4	20.9	13.5	23.9	15.4	22.3	3.6
Electrical ConductivityC (ms/cm)	8	1.2	1.3	0.5	1.9	0.5	1.7	0.5
Electrical Conductivity (µS/cm)	8	1113	1260	44	1806	520	1582	595
Turbidity (NTU)	9	188.2	130.0	56.0	654.1	77.9	250.0	183.5
Dissolved oxygen (mg/L)	9	1.7	1.7	0.8	2.4	1.4	2.3	0.5
Dissolved oxygen (%sat)	9	19	19	10	28	16	25	5
pH	9	7.3	7.3	7.2	7.5	7.2	7.5	0.1
Salinity (ppt)	8	0.6	0.7	0.2	0.9	0.2	0.9	0.3
Suspended Solids (mg/L)	1	70						
Ammonium-Nitrogen (mg/L)	9	14.25	13.00	0.01	41.10	0.40	37.50	15.79
Oxidised Nitrogen (mg/L)	9	19.01	23.40	2.20	37.00	7.50	28.50	11.44
Total Nitrogen (mg/L)	9	34.76	37.00	3.88	66.20	9.20	54.60	20.10
Total Phosphorus(mg/L)	2	0.09	0.09	0.07	0.11	0.07	0.11	0.03
Faecal Coliforms (CFU/100ml)	1	7						
BOD5/CBOD5(mg/L)	1	6						

Table A.96A2: Summary Statistics for Site 96A2 Foxglove Oval. Leachate after Bioreactor 2 treatment for July 2010 to June 2011

Site 96A2. Foxglove landfill. Leachate leaving Bioreactor 2	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	8	20.5	21.5	14.3	24.8	16.4	22.7	3.5
Electrical ConductivityC (ms/cm)	8	1.1	1.3	0.4	1.7	0.4	1.7	0.5
Electrical Conductivity (µS/cm)	8	1104	1268	384	1643	470	1622	493
Turbidity (NTU)	8	4.2	2.9	0.0	16.0	0.0	6.0	5.3
Dissolved oxygen (mg/L)	8	5.6	4.3	3.3	9.6	3.4	9.1	2.6
Dissolved oxygen (%sat)	8	61	48	37	94	39	93	25
pH	8	7.6	7.6	7.1	7.8	7.5	7.7	0.2
Salinity (ppt)	8	0.6	0.7	0.2	0.9	0.2	0.9	0.3
Suspended Solids (mg/L)	0							
Ammonium-Nitrogen (mg/L)	8	11.04	3.30	0.03	36.50	0.41	34.60	15.38
Oxidised Nitrogen (mg/L)	8	28.58	27.40	2.90	54.60	7.00	44.40	17.55
Total Nitrogen (mg/L)	8	41.82	50.25	6.64	70.20	8.40	64.00	24.54
Total Phosphorus(mg/L)	1	0.01	0.01	0.01	0.01	0.01	0.01	
Faecal Coliforms (CFU/100ml)	0							

Table A.96: Summary Statistics for Site 96 Foxglove Oval. Leachate after wetland treatment for July 2010 to June 2011

Site 96. Foxglove Oval. Treated leachate sampled at wetland outlet. July 2010- June 2011	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	9	17.3	19.4	10.5	22.2	11.9	21.7	4.5
Electrical ConductivityC (ms/cm)	8	1.2	1.2	0.5	1.7	0.8	1.6	0.4
Electrical Conductivity (µS/cm)	8	1130	1155	492	1622	758	1537	382
Turbidity (NTU)	9	1.0	1.1	0.3	1.7	0.3	1.6	0.5
Dissolved oxygen (mg/L)	9	2.7	2.2	1.4	5.5	1.4	4.8	1.5
Dissolved oxygen (%sat)	9	27	21	15	53	16	52	15
pH	9	7.0	7.0	6.8	7.2	6.9	7.1	0.1
Salinity (ppt)	8	0.6	0.6	0.3	0.9	0.4	0.8	0.2
Suspended Solids (mg/L)	3	1	1	1	1			
Ammonium-Nitrogen (mg/L)	9	4.30	2.31	0.01	21.00	0.02	6.80	6.75
Oxidised Nitrogen (mg/L)	9	15.12	18.20	0.19	25.00	4.20	20.20	8.15
Total Nitrogen (mg/L)	9	21.52	21.50	1.09	43.60	12.20	32.80	12.33
Total Phosphorus(mg/L)	4	0.07	0.07	0.05	0.10	0.05	0.10	0.02
Faecal Coliforms (CFU/100ml)	4	1115	79	2	4300	2	4300	2124
Bicarbonate Alkalinity (mg/CaCO3/L)	1	249						
Chloride (mg/L)	2	192.5	192.5	134.0	251.0			
Sulphate as SO42-(mg/L)	1	4.5						
Fluoride (mg/L)	1	0.0						
Sodium (mg/L)	2	105.9	105.9	72.8	139.0			
Potassium (mg/L)	2	52.0	52.0	41.2	62.7			
Magnesium (mg/L)	2	23.9	23.9	17.3	30.4			
Calcium (mg/L)	2	69.3	69.3	49.7	88.9			
Copper (ug/L)	1	2.0						
Lead (ug/L)	1	0.5						
Manganese (ug/L)	2	334	334	292	375			
Zinc (ug/L)	1	7						
Iron (ug/L)	3	108	64	62	197	62	197	77
Hardness mg/L CaCO3	2	298	298	222	375			

Table A.98: Summary Statistics for Sites 98 Treated Stormwater at Council Nursery at Pennant Hills for July 2010 to June 2011

Site 98. Pennant Hills Nursery. Harvested Stormwater used for Irrigation	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	6	16.2	16.3	11.5	21.2	12.0	19.5	3.9
Electrical ConductivityC (ms/cm)	6	0.2	0.2	0.2	0.3	0.2	0.3	0.0
Electrical Conductivity (µS/cm)	6	219	213	191	251	207	239	22
Turbidity (NTU)	6	28.1	27.5	1.3	67.0	3.1	41.9	25.0
Dissolved oxygen (mg/L)	6	5.8	5.9	1.9	10.6	3.9	6.6	2.9
Dissolved oxygen (%sat)	6	57	56	21	98	43	68	26
pH	6	7.2	7.2	6.8	7.6	7.1	7.4	0.2
Salinity (ppt)	6	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Suspended Solids (mg/L)	3	1	1	1	1	1	1	0
Ammonium-Nitrogen (mg/L)	3	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Oxidised Nitrogen (mg/L)	3	0.27	0.17	0.08	0.57	0.08	0.57	0.26
Total Nitrogen (mg/L)	3	0.63	0.53	0.50	0.85	0.50	0.85	0.19
Total Phosphorus(mg/L)	3	0.21	0.20	0.17	0.26	0.17	0.26	0.05
Faecal Coliforms (CFU/100ml)	6	725	61	1	4100	1	130	1654
E Coli (CFU/100mL)	4	31	1	1	120	1	120	60
Bicarbonate Alkalinity (mg/CaCO3/L)	3	75	78	65	83	65	83	9
Chloride (mg/L)	3	20.0	20.0	18.0	22.0	18.0	22.0	2.0
Sulphate as SO42-(mg/L)	3	7.2	7.9	5.6	8.0	5.6	8.0	1.4
Fluoride (mg/L)	3	0.4	0.4	0.3	0.5	0.3	0.5	0.1
Sodium (mg/L)	3	11.7	11.3	10.8	12.9	10.8	12.9	1.1
Potassium (mg/L)	3	7.9	8.5	5.2	10.1	5.2	10.1	2.5
Magnesium (mg/L)	3	6.0	6.1	5.8	6.2	5.8	6.2	0.2
Calcium (mg/L)	3	22.5	22.1	21.2	24.1	21.2	24.1	1.5
Copper (ug/L)	1	20.0						
Lead (ug/L)	1	2.0						
Manganese (ug/L)	1	230						
Zinc (ug/L)	1	55						
Iron (ug/L)	1	407						
Hardness mg/L CaCO3	2	88	88	85	92			
SAR (Based on Mean Na, Mg and Ca)	3	0.8						

Table A.100: Summary Data for Site 100. Berowra Creek at Crosslands Reserve July 2010 to June 2011

Site 100 Berowra Creek at Crosslands		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)		27	21.5	23.5	12.5	27.8	15.0	25.3	5.0
Electrical Conductivity (mS/cm)		26	20.8	22.3	0.8	35.7	13.4	27.7	8.6
Electrical Conductivity (µS/cm)		2	2828	2828	794	4862	794	4862	2877
Turbidity (NTU)		27	4.6	2.7	1.3	37.5	2.1	3.7	7.0
Dissolved oxygen (mg/L)		27	5.7	5.4	3.7	10.1	4.0	7.4	1.8
Dissolved oxygen (%sat)		27	68	65	47	101	55	83	15
pH		27	7.0	7.0	6.5	7.5	6.9	7.1	0.2
Salinity (ppt)		26	12.6	13.4	0.4	22.5	7.7	17.0	5.5
Suspended Solids (mg/L)	(2)	27	4	3	1	25	1	6	5
Ammonium-Nitrogen (mg/L)	(0.01)	27	0.111	0.080	0.030	0.530	0.050	0.130	0.099
Oxidised Nitrogen (mg/L)	(0.01)	27	0.34	0.34	0.04	0.98	0.13	0.50	0.24
Total Nitrogen (mg/L)	(0.05)	27	0.80	0.76	0.40	1.93	0.53	0.91	0.34
Total Phosphorus(mg/L)	(0.002)	27	0.062	0.062	0.023	0.150	0.035	0.078	0.033
Chlorophyll-A (ug/L)	(2)	27	2.8	2.4	1.2	5.8	1.6	4.2	1.4
Faecal Coliforms (CFU/100ml)	(1)	27	519	42	9.0	9100	22.0	210	1801
Enterococci (CFU/100ml)	(1)	27	97	21	2.0	660	6.0	57	196
Sodium (mg/L)	(0.05)	1	5950						
Calcium (mg/L)	(0.01)	1	231						
Aluminium (ug/L)	(10)	1	118						
Arsenic (ug/L)	(1)	1	0.5						
Cadmium (ug/L)	(1)	1	0.50						
Chromium (ug/L)	(1)	1	0.5						
Copper (ug/L)	(1)	1	1.0						
Lead (ug/L)	(1)	1	0.5						
Manganese (ug/L)	(1)	1	34						
Molybdenum (ug/L)	(1)	1	5.0						
Nickel (ug/L)	(1)	1	0.5						
Selenium (ug/L)	(3)	1	1.5						
Silver (ug/L)	(1)	1	0.5						
Uranium (ug/L)	(1)	1	1.0						
Zinc (ug/L)	(10)	1	60						
Boron (ug/L)	(5)	1	2010						
Iron (ug/L)	(20)	1	170						
BOD5/CBOD5(mg/L)	(2)	2	1	1	1	1			
Total Organic Carbon(mg/L)	(2)	6	5	6	2	9	4	6	2

Table A.103: Summary Statistics for Site 103 Mouth of Milsons Passage for July 2010 to June 2011

Site 103 Hawkesbury River east end Milson Passage		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Secchi Depth (m)		13	0.7	0.8	0.3	1.1	0.4	1.0	0.3
Temperature (oC)		13	19.0	19.2	14.4	25.0	15.0	23.8	4.0
Electrical Conductivity (mS/cm)		12	40.2	44.8	9.1	48.1	40.4	46.4	11.6
Turbidity (NTU)		13	26.6	18.0	10.7	68.5	12.7	57.0	21.1
Dissolved oxygen (mg/L)		13	7.1	7.1	5.7	8.9	6.1	8.1	1.0
Dissolved oxygen (%sat)		13	88	88	79	97	82	95	7
pH		13	7.6	7.6	6.9	7.8	7.5	7.8	0.2
Salinity (ppt)		12	25.9	29.0	5.5	31.3	25.8	30.2	7.8
Suspended Solids (mg/L)	(2)	13	23	16	4	104	10	23	26
Ammonium-Nitrogen (mg/L)	(0.01)	13	0.016	0.010	0.005	0.050	0.010	0.020	0.012
Oxidised Nitrogen (mg/L)	(0.01)	13	0.05	0.03	0.01	0.15	0.02	0.08	0.04
Total Nitrogen (mg/L)	(0.05)	13	0.29	0.27	0.16	0.61	0.22	0.34	0.11
Total Phosphorus(mg/L)	(0.002)	13	0.027	0.023	0.018	0.049	0.019	0.037	0.010
Chlorophyll-A (ug/L)	(2)	13	2.9	2.9	1.8	5.9	2.1	3.3	1.1
Faecal Coliforms (CFU/100ml)	(1)	13	8	2	0.5	40	0.5	18	13
Enterococci (CFU/100ml)	(1)	13	9	2	0.5	57	0.5	18	16

Table A.104: Summary Statistics for Site 104 Middle of Hawkesbury River off Peat Island for July 2010 to June 2010

Site 104 hawkesbury River off Peats Island		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Secchi Depth (m)		13	0.9	1.0	0.4	1.2	0.8	1.1	0.2
Temperature (oC)		13	19.0	19.0	14.5	25.0	15.2	23.6	3.8
Electrical Conductivity (mS/cm)		12	41.3	46.0	9.6	47.8	44.1	47.4	11.9
Turbidity (NTU)		13	15.2	13.7	7.2	34.9	9.5	19.9	7.8
Dissolved oxygen (mg/L)		13	7.1	7.2	5.5	8.8	6.2	7.9	1.0
Dissolved oxygen (%sat)		13	89	89	79	98	82	95	6
pH		13	7.6	7.6	7.0	7.9	7.5	7.8	0.2
Salinity (ppt)		12	26.6	29.8	5.6	31.1	28.4	30.8	8.0
Suspended Solids (mg/L)	(2)	13	17	14	5	70	6	19	17
Ammonium-Nitrogen (mg/L)	(0.01)	13	0.016	0.010	0.005	0.050	0.010	0.020	0.012
Oxidised Nitrogen (mg/L)	(0.01)	13	0.04	0.03	0.01	0.14	0.02	0.07	0.04
Total Nitrogen (mg/L)	(0.05)	13	0.27	0.25	0.19	0.57	0.22	0.30	0.10
Total Phosphorus(mg/L)	(0.002)	13	0.023	0.020	0.017	0.035	0.019	0.027	0.005
Chlorophyll-A (ug/L)	(2)	13	3.0	2.8	2.0	4.7	2.2	3.6	0.9
Faecal Coliforms (CFU/100ml)	(1)	13	7	1	0.5	29	0.5	15	10
Enterococci (CFU/100ml)	(1)	13	5	1	0.5	29	0.5	7	8

Table A.105: Summary Statistics for Site 105 Under Hawkesbury River Bridge near Brooklyn STP outfall: July 2010 to June 2011-11-16

Site 105 Hawkesbury River near STP outlet road bridge		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Secchi Depth (m)		11	0.8	0.9	0.4	1.0	0.7	1.0	0.2
Temperature (oC)		13	19.0	18.8	14.6	24.8	15.3	23.1	3.7
Electrical Conductivity (mS/cm)		12	42.7	47.2	12.4	49.6	44.9	48.5	11.2
Turbidity (NTU)		13	24.1	15.2	9.0	109.2	11.0	36.3	27.1
Dissolved oxygen (mg/L)		13	7.1	7.1	5.6	8.8	6.2	7.9	0.9
Dissolved oxygen (%sat)		13	89	90	81	97	83	95	6
pH		13	7.6	7.7	7.0	7.9	7.6	7.8	0.2
Salinity (ppt)		12	27.5	30.6	7.1	32.5	27.9	31.5	7.6
Suspended Solids (mg/L)	(2)	13	19	14	6	80	10	21	19
Ammonium-Nitrogen (mg/L)	(0.01)	13	0.017	0.010	0.010	0.050	0.010	0.020	0.012
Oxidised Nitrogen (mg/L)	(0.01)	13	0.04	0.03	0.01	0.13	0.02	0.07	0.03
Total Nitrogen (mg/L)	(0.05)	13	0.29	0.26	0.18	0.57	0.24	0.30	0.10
Total Phosphorus(mg/L)	(0.002)	13	0.023	0.021	0.016	0.038	0.019	0.027	0.006
Chlorophyll-A (ug/L)	(2)	13	2.7	2.6	1.8	4.5	2.0	3.2	0.8
Faecal Coliforms (CFU/100ml)	(1)	13	6	2	0.5	31	0.5	12	9
Enterococci (CFU/100ml)	(1)	13	8	3	0.5	43	1.0	20	12

Table A.106: Summary Statistics for Site 106 Middle inside mouth of Sandbrook Inlet off Marina for July 2010 to June 2011

Site 106 entrance of Sandbrook Inlet off marina		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Secchi Depth (m)		12	0.9	0.9	0.5	1.3	0.7	1.0	0.2
Temperature (oC)		12	19.7	19.9	14.4	25.6	15.7	24.3	4.3
Electrical Conductivity (mS/cm)		11	39.9	43.1	14.1	45.9	42.2	45.2	10.0
Turbidity (NTU)		12	13.5	11.7	5.4	23.0	9.1	19.0	5.5
Dissolved oxygen (mg/L)		12	7.1	7.2	5.3	8.7	6.4	7.6	0.9
Dissolved oxygen (%sat)		12	89	90	77	94	86	93	5
pH		12	7.6	7.6	7.3	7.8	7.5	7.7	0.1
Salinity (ppt)		11	25.5	27.7	8.2	29.6	27.1	29.2	6.7
Suspended Solids (mg/L)	(2)	12	14	11	1	51	7	17	13
Ammonium-Nitrogen (mg/L)	(0.01)	12	0.014	0.010	0.005	0.020	0.010	0.020	0.006
Oxidised Nitrogen (mg/L)	(0.01)	12	0.04	0.03	0.01	0.09	0.02	0.08	0.03
Total Nitrogen (mg/L)	(0.05)	12	0.27	0.26	0.15	0.47	0.21	0.31	0.08
Total Phosphorus(mg/L)	(0.002)	12	0.021	0.020	0.015	0.039	0.016	0.022	0.007
Chlorophyll-A (ug/L)	(2)	12	3.5	3.0	1.9	9.4	2.0	3.8	2.1
Faecal Coliforms (CFU/100ml)	(1)	12	13	10	0.5	34	1.0	23	12
Enterococci (CFU/100ml)	(1)	12	11	5	0.5	44	2.0	23	13

Table A.107: Summary Statistics for Site 107: Middle Hawkesbury River off Long Island for July 2010 to June 2011

Site 107 Hawkesbury River off Long Island		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Secchi Depth (m)		12	0.9	1.0	0.3	1.5	0.5	1.2	0.4
Temperature (oC)		12	19.5	19.5	14.5	25.0	16.1	23.4	3.8
Electrical Conductivity (mS/cm)		11	41.8	46.3	11.8	50.5	44.3	47.9	11.8
Turbidity (NTU)		12	20.5	13.7	5.6	64.3	9.5	31.0	17.6
Dissolved oxygen (mg/L)		12	7.0	7.1	5.8	8.5	6.3	7.6	0.8
Dissolved oxygen (%sat)		12	89	88	81	96	84	94	5
pH		12	7.6	7.7	7.0	7.9	7.6	7.7	0.2
Salinity (ppt)		11	27.1	30.0	6.8	33.0	28.6	31.2	7.9
Suspended Solids (mg/L)	(2)	12	21	14	4	88	10	21	24
Ammonium-Nitrogen (mg/L)	(0.01)	12	0.015	0.010	0.005	0.050	0.005	0.020	0.013
Oxidised Nitrogen (mg/L)	(0.01)	12	0.05	0.03	0.01	0.14	0.02	0.06	0.04
Total Nitrogen (mg/L)	(0.05)	12	0.29	0.26	0.13	0.56	0.21	0.36	0.11
Total Phosphorus(mg/L)	(0.002)	12	0.024	0.021	0.017	0.038	0.019	0.028	0.007
Chlorophyll-A (ug/L)	(2)	12	3.2	2.9	1.5	5.6	2.4	4.6	1.3
Faecal Coliforms (CFU/100ml)	(1)	12	8	1	0.5	37	0.5	18	12
Enterococci (CFU/100ml)	(1)	12	6	3	0.5	28	1.0	12	8

Table A.108: Summary Statistics for Site 108: Hawkesbury off Bradleys Beach Dangar Island for July 2010 to June 2011

Site 108 Hawkesbury River off Bradleys Beach		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Secchi Depth (m)		13	1.1	1.1	0.7	1.8	0.9	1.3	0.3
Temperature (oC)		13	18.9	18.0	15.0	23.9	15.8	22.6	3.3
Electrical Conductivity (mS/cm)		12	47.3	50.3	23.6	51.7	47.8	51.2	8.1
Turbidity (NTU)		13	9.9	8.6	4.7	22.8	7.5	10.9	4.5
Dissolved oxygen (mg/L)		13	7.0	6.9	6.1	7.7	6.6	7.6	0.5
Dissolved oxygen (%sat)		13	90	90	82	95	88	93	3
pH		13	7.6	7.7	7.4	7.8	7.4	7.8	0.2
Salinity (ppt)		11	30.7	33.0	14.5	33.9	31.1	33.6	5.9
Suspended Solids (mg/L)	(2)	13	14	10	3	50	6	16	12
Ammonium-Nitrogen (mg/L)	(0.01)	13	0.014	0.010	0.010	0.030	0.010	0.020	0.007
Oxidised Nitrogen (mg/L)	(0.01)	13	0.03	0.02	0.01	0.08	0.02	0.05	0.02
Total Nitrogen (mg/L)	(0.05)	13	0.24	0.23	0.16	0.41	0.17	0.27	0.07
Total Phosphorus(mg/L)	(0.002)	13	0.020	0.019	0.016	0.030	0.017	0.020	0.004
Chlorophyll-A (ug/L)	(2)	13	2.9	2.3	1.2	12.8	1.5	2.5	3.0
Faecal Coliforms (CFU/100ml)	(1)	13	4	1	0.5	24	0.5	8	7
Enterococci (CFU/100ml)	(1)	13	6	1	0.5	29	0.5	14	9

Table A.110f: Summary Statistics for Site 110f: Cherrybrook Lakes – lower Lake at viewing platform for July 2010 to June 2011. Two depths: 0.5m and ~1.4m

site 110f, 0.5m	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Probe Depth (m)	9	0.5	0.5	0.5	0.5	0.5	0.5	
Temperature (oC)	9	17.8	19.6	10.0	24.3	10.3	23.2	5.6
Electrical ConductivityC (ms/cm)	9	0.36	0.38	0.20	0.56	0.20	0.51	0.13
Electrical Conductivity (µS/cm)	9	346	350	162	528	193	514	128
Turbidity (NTU)	9	0.7	0.6	0.0	1.6	0.0	1.5	0.6
Dissolved oxygen (mg/L)	9	6.5	5.5	1.4	11.2	2.7	11.1	4.1
Dissolved oxygen (%sat)	9	64	61	16	100	32	99	35
pH	9	6.9	6.8	6.4	7.4	6.5	7.4	0.4
Salinity (ppt)	9	0.2	0.2	0.1	0.3	0.1	0.3	0.1

Site 110f ~1.4m	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Probe Depth (m)	9	1.4	1.4	1.2	1.5	1.3	1.4	0.1
Temperature (oC)	9	17.7	19.5	10.0	24.2	10.3	23.1	5.6
Electrical ConductivityC (ms/cm)	9	0.36	0.38	0.20	0.56	0.20	0.51	0.13
Electrical Conductivity (µS/cm)	9	346	350	167	528	193	514	127
Turbidity (NTU)	9	0.8	0.4	0.0	3.6	0.0	1.3	1.1
Dissolved oxygen (mg/L)	9	5.9	5.1	1.1	10.1	2.2	10.0	3.7
Dissolved oxygen (%sat)	9	59	55	13	97	26	96	33
pH	9	6.8	6.8	6.1	7.4	6.5	7.3	0.4
Salinity (ppt)	9	0.2	0.2	0.1	0.3	0.1	0.3	0.1

Table A.112: Summary Statistics for Site 112 Wisemans Ferry Leachate Collection Riser "C" for July 2010 to June 2011 (see also A.56 for sediment and leachate catch dam)

Site 112 Wisemans Ferry Landfill Riser C		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)		4	18.1	17.0	15.0	23.4	15.0	23.4	3.6
Electrical Conductivity (mS/cm)		4	1.38	1.38	1.33	1.45	1.33	1.45	0.06
Electrical Conductivity (µS/cm)		4	1344	1345	1291	1395	1291	1395	56
Turbidity (NTU)		4	1.9	2.0	0.8	3.0	0.8	3.0	1.0
Dissolved oxygen (mg/L)		4	5.9	7.1	1.6	7.6	1.6	7.6	2.8
Dissolved oxygen (%sat)		4	61	74	18	76	18	76	28
pH		4	7.3	7.4	6.7	7.7	6.7	7.7	0.4
Salinity (ppt)		4	0.7	0.7	0.7	0.7	0.7	0.7	0.0
Suspended Solids (mg/L)	(2)	4	3	2	1	8	1	8	3
Ammonium-Nitrogen (mg/L)	(0.01)	4	0.006	0.005	0.005	0.010	0.005	0.010	0.003
Oxidised Nitrogen (mg/L)	(0.01)	4	12.83	12.70	4.00	21.90	4.00	21.90	9.13
Total Nitrogen (mg/L)	(0.05)	4	14.26	13.87	5.20	24.10	5.20	24.10	9.25
Total Phosphorus(mg/L)	(0.002)	4	0.037	0.033	0.031	0.051	0.031	0.051	0.009
Faecal Coliforms (CFU/100ml)	(1)	3	2	1	0.5	5	0.5	5	3
Sodium (mg/L)	(0.05)	1	83.4	83.4					
Potassium (mg/L)	(0.05)	1	33.1	33.1					
Magnesium (mg/L)	(0.01)	1	26.3	26.3					
Calcium (mg/L)	(0.01)	1	158.0	158.0					
Aluminium (ug/L)	(10)	1	71	71					
Arsenic (ug/L)	(1)	1	0.5	0.5					
Cadmium (ug/L)	(1)	1	0.50	0.50					
Chromium (ug/L)	(1)	1	2.0	2.0					
Copper (ug/L)	(1)	1	9.0	9.0					
Lead (ug/L)	(1)	1	0.5	0.5					
Manganese (ug/L)	(1)	1	1	1					
Molybdenum (ug/L)	(1)	1	2.0	2.0					
Nickel (ug/L)	(1)	1	3.0	3.0					
Selenium (ug/L)	(3)	1	1.5	1.5					
Silver (ug/L)	(1)	1	0.5	0.5					
Uranium (ug/L)	(1)	1	2.0	2.0					
Zinc (ug/L)	(10)	1	21	21					
Boron (ug/L)	(5)	1	459	459					
Iron (ug/L)	(20)	1	103	103					
BOD5/CBOD5(mg/L)	(2)	1	1	1					

Table A.114. Summary Statistics for Site 114 Muogamarra Creek in Muogamarra Nature Reserve (Reference Creek) for July 2010 to Oct 2011

Site 114 Muogamarra Creek (Reference)		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		11	524	150	20	3000	50	800	882
Temperature (oC)		11	15.1	12.9	11.2	21.1	11.7	19.3	3.7
Electrical Conductivity (mS/cm)		11	0.14	0.13	0.10	0.22	0.11	0.16	0.03
Electrical Conductivity (µS/cm)		11	132	133	69	196	110	160	34
Turbidity (NTU)		11	0.1	0.0	-0.2	1.0	0.0	0.0	0.3
Dissolved oxygen (mg/L)		11	9.7	10.2	5.7	11.7	8.8	10.8	1.6
Dissolved oxygen (%sat)		11	95	95	62	110	93	105	13
pH		11	4.7	4.5	4.2	6.3	4.4	4.9	0.6
Salinity (ppt)		11	0.1	0.1	0.0	0.1	0.1	0.1	0.0
Suspended Solids (mg/L)	(2)	12	1	1	1	3	1	1	1
Ammonium-Nitrogen (mg/L)	(0.01)	12	0.007	0.005	0.005	0.010	0.005	0.010	0.002
Oxidised Nitrogen (mg/L)	(0.01)	12	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Total Nitrogen (mg/L)	(0.05)	12	0.12	0.11	0.09	0.23	0.09	0.16	0.04
Total Phosphorus(mg/L)	(0.002)	12	0.002	0.002	0.001	0.006	0.001	0.002	0.001
Faecal Coliforms (CFU/100ml)	(1)	12	55	20	1.0	400	4.0	63	111
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	4	1	1	1	1	1	1	0
Chloride (mg/L)	(0.1)	4	36	36	28	42	28	42	6
Sulphate as SO42-(mg/L)	(0.1)	4	6	6	4	9	4	9	2
Fluoride (mg/L)	(0.05)	4	0.03	0.03	0.03	0.03	0.03	0.03	0.00
Sodium (mg/L)	(0.05)	4	19.6	19.6	17.1	22.1	17.1	22.1	2.1
Potassium (mg/L)	(0.05)	4	1.0	1.0	0.7	1.2	0.7	1.2	0.2
Magnesium (mg/L)	(0.01)	4	2.8	2.9	2.2	3.1	2.2	3.1	0.4
Calcium (mg/L)	(0.01)	4	0.4	0.4	0.3	0.4	0.3	0.4	0.0
Aluminium (ug/L)	(10)	4	231	212	187	315	187	315	57
Arsenic (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L)	(1)	4	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Copper (ug/L)	(1)	4	2.3	2.0	1.0	4.0	1.0	4.0	1.5
Lead (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Manganese (ug/L)	(1)	4	26	28	13	34	13	34	10
Molybdenum (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Nickel (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Selenium (ug/L)	(3)	4	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L)	(1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L)	(10)	4	8	8	5	12	5	12	4
Boron (ug/L)	(5)	4	21	20	15	28	15	28	6
Iron (ug/L)	(20)	4	178	175	129	232	129	232	48
Mercury (ug/L)	(0.1 to 0.01)	4	0.04	0.05	0.01	0.05	0.01	0.05	0.02
Total Organic Carbon(mg/L)	(2)	2	3	3	3	3			

Table A.115 . Summary Statistics for Site 115 Old Mans Creek downstream of discharge point of Hornsby Quarry for July 2009 to June 2010.

Site 115 Old mans Creek Hornsby, d/s Quarry Discharge		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		9	3211	3600	300	5000	2000	3600	1325
Temperature (oC)		9	16.2	14.5	11.9	24.0	13.1	21.5	4.2
Electrical Conductivity (mS/cm)		8	0.74	0.85	0.26	0.91	0.50	0.90	0.24
Electrical Conductivity (µS/cm)		8	716	847	250	861	495	856	227
Turbidity (NTU)		9	23.1	1.0	0.4	175.0	0.7	15.7	57.2
Dissolved oxygen (mg/L)		9	9.1	9.6	7.2	10.3	7.6	10.2	1.1
Dissolved oxygen (%sat)		9	92	92	82	98	88	98	5
pH		9	7.6	7.8	6.1	8.0	7.4	8.0	0.6
Salinity (ppt)		8	0.4	0.4	0.1	0.5	0.3	0.5	0.1
Suspended Solids (mg/L)	(2)	9	16	1	1	126	1	10	41
Ammonium-Nitrogen (mg/L)	(0.01)	9	0.011	0.005	0.005	0.040	0.005	0.010	0.011
Oxidised Nitrogen (mg/L)	(0.01)	9	0.08	0.04	0.01	0.26	0.01	0.19	0.09
Total Nitrogen (mg/L)	(0.05)	9	0.38	0.27	0.18	0.85	0.19	0.59	0.24
Total Phosphorus(mg/L)	(0.002)	9	0.038	0.018	0.013	0.176	0.016	0.038	0.052
Faecal Coliforms (CFU/100ml)	(1)	9	925	480	53.0	5100	91.0	850	1588
Total Organic Carbon(mg/L)	(2)	1	8	8	8	8	8	8	

Table A.120: Summary Statistics for Site 120 Greenway Park Cherrybrook. Raw harvested stormwater from underground tanks; sampled from delivery pipe in control room for July 2009 to June 2010.

Site 120: Greenway Park Cherrybrook. Harvested Stormwater - Raw Water	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	13	19.5	19.3	12.3	27.3	15.0	23.7	4.6
Electrical ConductivityC (ms/cm)	13	0.3	0.3	0.2	0.4	0.3	0.4	0.1
Electrical Conductivity (µS/cm)	13	323	312	244	390	250	385	55
Turbidity (NTU)	13	2.5	1.3	-0.2	15.5	0.8	2.7	4.0
Dissolved oxygen (mg/L)	13	4.4	4.1	2.4	7.9	4.0	4.4	1.4
Dissolved oxygen (%sat)	13	48	46	24	82	41	50	14
pH	13	7.1	7.0	6.8	7.4	6.9	7.2	0.2
Salinity (ppt)	13	6.9	0.2	0.1	88.0	0.1	0.2	24.4
Suspended Solids (mg/L)	1	3						
Ammonium-Nitrogen (mg/L)	1	0.15						
Oxidised Nitrogen (mg/L)	1	0.50						
Total Nitrogen (mg/L)	1	1.52						
Total Phosphorus(mg/L)	1	0.08						
Faecal Coliforms (CFU/100ml)	11	56	1	1	420	1	37	129
E Coli (CFU/100mL)	9	52	1	1	420	1	37	139
Bicarbonate Alkalinity (mg/CaCO3/L)	1	81						
Chloride (mg/L)	1	26.0						
Sulphate as SO42-(mg/L)	1	19.0						
Fluoride (mg/L)	1	0.1						
Sodium (mg/L)	1	21.3						
Potassium (mg/L)	1	4.5						
Magnesium (mg/L)	1	5.7						
Calcium (mg/L)	1	30.0						

Table A.121: Summary Statistics for Site 121 Greenway Park Cherrybrook. Treated harvested stormwater from storage tank near control room for July 2009 to June 2010

Site 121. Greenway Park Cherrybrook. Harvested Stormwater - Treated Water	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	15	17.6	19.1	12.1	24.4	14.0	19.8	3.3
Electrical ConductivityC (ms/cm)	15	0.3	0.3	0.2	0.4	0.2	0.3	0.1
Electrical Conductivity (µS/cm)	15	253	257	163	390	176	324	75
Turbidity (NTU)	15	8.4	1.4	-0.2	97.8	0.1	4.1	24.9
Dissolved oxygen (mg/L)	15	7.5	6.9	1.9	11.6	5.8	9.3	2.4
Dissolved oxygen (%sat)	15	79	71	21	126	63	105	27
pH	15	7.9	7.7	7.2	9.1	7.5	8.3	0.5
Salinity (ppt)	15	0.1	0.1	0.1	0.2	0.1	0.2	0.0
Suspended Solids (mg/L)	2	2	2	1	2			
Ammonium-Nitrogen (mg/L)	2	0.06	0.06	0.02	0.10			
Oxidised Nitrogen (mg/L)	2	1.56	1.56	0.67	2.45			
Total Nitrogen (mg/L)	2	2.54	2.54	1.37	3.70			
Total Phosphorus(mg/L)	2	0.12	0.12	0.06	0.19			
Faecal Coliforms (CFU/100ml)	14	3	1	1	16	1	4	4
E Coli (CFU/100mL)	12	3	1	1	16	1	4	5
Bicarbonate Alkalinity (mg/CaCO3/L)	2	87	87	79	95			
Chloride (mg/L)	2	27.0	27.0	26.0	28.0			
Sulphate as SO42-(mg/L)	2	14.8	14.8	7.5	22.0			
Fluoride (mg/L)	2	0.6	0.6	0.3	1.0			
Sodium (mg/L)	2	18.2	18.2	15.5	20.9			
Potassium (mg/L)	2	5.8	5.8	4.5	7.1			
Magnesium (mg/L)	2	4.8	4.8	3.9	5.8			
Calcium (mg/L)	2	33.2	33.2	28.5	37.9			
Copper (ug/L)	1	17.0						
Lead (ug/L)	1	0.5						
Manganese (ug/L)	1	26						
Zinc (ug/L)	1	39						
Iron (ug/L)	1	346						
Hardness mg/L CaCO3	1	124						
SAR (Based on Mean Na, Mg and Ca)	2	1.1						

Table A.123. Summary Statistics for Site 123 Peats Crater Creek in Muogamarra Nature Reserve (Reference Creek) for July 2010 to Oct 2011

Site 123 Creek draining Peats Crater	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)	11	414	100	5	2500	20	150	800
Temperature (oC)	11	15.2	13.4	10.5	21.0	12.2	19.5	3.7
Electrical Conductivity (mS/cm)	11	0.24	0.23	0.16	0.40	0.19	0.28	0.07
Electrical Conductivity (µS/cm)	11	230	220	153	401	163	266	70
Turbidity (NTU)	11	7.2	6.5	1.0	15.2	2.6	10.2	4.4
Dissolved oxygen (mg/L)	11	9.3	9.5	6.1	12.0	8.2	10.3	1.6
Dissolved oxygen (%sat)	11	92	96	67	113	87	98	12
pH	11	6.8	6.8	6.0	7.9	6.7	7.2	0.5
Salinity (ppt)	11	0.1	0.1	0.1	0.2	0.1	0.1	0.0
Suspended Solids (mg/L) (2)	11	2	1	1	5	1	2	1
Ammonium-Nitrogen (mg/L) (0.01)	11	0.012	0.010	0.010	0.020	0.010	0.010	0.004
Oxidised Nitrogen (mg/L) (0.01)	11	0.21	0.17	0.01	0.65	0.02	0.30	0.19
Total Nitrogen (mg/L) (0.05)	11	0.45	0.48	0.20	0.81	0.31	0.57	0.18
Total Phosphorus(mg/L) (0.002)	11	0.028	0.027	0.020	0.044	0.024	0.030	0.006
Faecal Coliforms (CFU/100ml) (1)	11	143	40	14.0	710	31.0	210	206
Bicarbonate Alkalinity (mg/CaCO3/L) (2)	4	33	22	8	80	8	80	34
Chloride (mg/L) (0.1)	4	52	50	39	71	39	71	14
Sulphate as SO42-(mg/L) (0.1)	4	6	6	3	8	3	8	2
Fluoride (mg/L) (0.05)	4	0.06	0.06	0.03	0.10	0.03	0.10	0.03
Sodium (mg/L) (0.05)	4	30.7	28.0	21.3	45.5	21.3	45.5	10.4
Potassium (mg/L) (0.05)	4	1.9	1.8	1.6	2.7	1.6	2.7	0.5
Magnesium (mg/L) (0.01)	4	6.9	5.7	3.7	12.3	3.7	12.3	3.8
Calcium (mg/L) (0.01)	4	6.6	4.3	2.4	15.2	2.4	15.2	6.0
Aluminium (ug/L) (10)	4	500	433	65	1070	65	1070	435
Arsenic (ug/L) (1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L) (1)	4	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L) (1)	4	1.0	0.8	0.5	2.0	0.5	2.0	0.7
Copper (ug/L) (1)	4	2.0	1.0	1.0	5.0	1.0	5.0	2.0
Lead (ug/L) (1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Manganese (ug/L) (1)	4	58	56	36	85	36	85	20
Molybdenum (ug/L) (1)	4	0.9	0.5	0.5	2.0	0.5	2.0	0.8
Nickel (ug/L) (1)	4	2.8	3.0	2.0	3.0	2.0	3.0	0.5
Selenium (ug/L) (3)	4	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L) (1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L) (1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L) (10)	4	10	10	5	16	5	16	6
Boron (ug/L) (5)	4	30	32	22	33	22	33	5
Iron (ug/L) (20)	4	841	876	582	1030	582	1030	193
Mercury (ug/L) (0.1 to 0.01)	4	0.04	0.05	0.01	0.05	0.01	0.05	0.02
Total Organic Carbon(mg/L) (0.2)	1	5						

Table A.128: Summary Statistics for Site 128 Berowra Park Oval Stormwater Harvesting. Underground raw water collection tank near Gully Rd for July 2010 to June 2011.

Site 128. Berowra Oval. Harvested Stormwater- Raw Water	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	16	17.5	18.2	12.9	24.1	13.6	20.0	3.5
Electrical ConductivityC (ms/cm)	16	0.3	0.3	0.3	0.3	0.3	0.3	0.0
Electrical Conductivity (µS/cm)	16	300	304	261	328	289	313	20
Turbidity (NTU)	16	5.2	2.9	0.3	31.9	1.5	4.3	7.7
Dissolved oxygen (mg/L)	16	7.2	7.3	2.3	9.2	6.5	8.7	1.8
Dissolved oxygen (%sat)	16	74	79	25	88	72	85	17
pH	16	7.4	7.4	7.2	7.6	7.2	7.4	0.1
Salinity (ppt)	16	0.2	0.2	0.1	0.2	0.1	0.2	0.0
Suspended Solids (mg/L)	1	7						
Ammonium-Nitrogen (mg/L)	1	0.01						
Oxidised Nitrogen (mg/L)	1	0.74						
Total Nitrogen (mg/L)	1	1.04						
Total Phosphorus(mg/L)	1	0.03						
Faecal Coliforms (CFU/100ml)	15	275	48	1	2800	17	135	714
E Coli (CFU/100mL)	13	241	48	1	1900	25	160	523
Bicarbonate Alkalinity (mg/CaCO3/L)	1	55						
Chloride (mg/L)	1	27.0						
Sulphate as SO42-(mg/L)	1	20.0						
Fluoride (mg/L)	2	0.1	0.1	0.1	0.1			
Sodium (mg/L)	1	21.1						
Potassium (mg/L)	1	2.3						
Magnesium (mg/L)	1	6.4						
Calcium (mg/L)	1	21.4						
Copper (ug/L)	1	6.0						
Lead (ug/L)	1	3.0						
Manganese (ug/L)	1	6						
Zinc (ug/L)	1	32						
Iron (ug/L)	1	976						
Hardness mg/L CaCO3	1	80						

Table A.129: Summary Statistics for Site 129 Berowra Park Oval Stormwater Harvesting. Raw water pumped from underground tank – sample collected in control room before UV treatment. July 2010 to June 2011

Site 129 Berowra Oval. Raw Harvested Stormwater- pumped to Control Room. Sampled before UV Treatement	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	5	18.9	19.0	15.7	21.0	16.9	20.9	2.2
Electrical ConductivityC (ms/cm)	5	0.3	0.3	0.3	0.3	0.3	0.3	0.0
Electrical Conductivity (µS/cm)	5	286	283	278	295	280	294	7
Turbidity (NTU)	5	2.4	1.9	0.3	5.4	0.4	4.6	2.2
Dissolved oxygen (mg/L)	5	2.4	2.2	0.9	4.9	1.1	3.8	1.6
Dissolved oxygen (%sat)	5	26	24	10	53	11	41	17
pH	5	6.9	6.8	6.6	7.1	6.6	7.1	0.2
Salinity (ppt)	5	0.1	0.1	0.1	0.2	0.1	0.1	0.0
Faecal Coliforms (CFU/100ml)	5	19	1	1	92	1	47	41
E Coli (CFU/100mL)	5	19	1	1	92	1	47	41

Table A.130: Summary Statistics for Site 130 Berowra Park Oval Stormwater Harvesting. Treated water at exit of UV lamps – sample collected in control room for July 2010 to June 2011

Site 130. Berowra Oval. UV Treated Harvested Stormwater	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	5	19.3	19.6	15.4	21.5	17.3	21.2	2.4
Electrical ConductivityC (ms/cm)	5	0.3	0.3	0.3	0.3	0.3	0.3	0.0
Electrical Conductivity (µS/cm)	5	283	280	267	297	272	295	12
Turbidity (NTU)	5	0.9	0.3	0.2	2.3	0.3	1.9	0.9
Dissolved oxygen (mg/L)	5	2.5	1.8	1.1	5.0	1.2	4.2	1.7
Dissolved oxygen (%sat)	5	27	18	12	56	13	46	19
pH	5	6.8	6.7	6.7	6.9	6.7	6.8	0.1
Salinity (ppt)	5	0.1	0.1	0.1	0.2	0.1	0.1	0.0
Faecal Coliforms (CFU/100ml)	5	1	1	1	1	1	1	0
E Coli (CFU/100mL)	5	1	1	1	1	1	1	0

Table A.131: Summary Statistics for Site 131 Berowra Park Oval Stormwater Harvesting. Treated water – sample collected from storage tank for July 2010 to June 2011

Site 131. Berowra Oval. Harvested Stormwater Stored for Irrigation	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	15	19.1	18.2	14.5	24.4	16.0	22.0	3.1
Electrical ConductivityC (ms/cm)	15	0.3	0.3	0.2	0.4	0.2	0.3	0.1
Electrical Conductivity (µS/cm)	15	276	280	189	352	231	337	53
Turbidity (NTU)	15	0.6	0.0	-0.2	3.8	0.0	1.3	1.1
Dissolved oxygen (mg/L)	15	8.2	8.5	6.9	9.1	7.4	8.8	0.7
Dissolved oxygen (%sat)	15	89	88	76	108	83	93	8
pH	15	8.5	8.7	7.5	9.8	7.6	8.8	0.6
Salinity (ppt)	15	0.1	0.1	0.1	0.2	0.1	0.2	0.0
Suspended Solids (mg/L)	3	2	1	1	3	1	3	1
Ammonium-Nitrogen (mg/L)	1	0.01						
Oxidised Nitrogen (mg/L)	1	0.41						
Total Nitrogen (mg/L)	3	0.58	0.63	0.43	0.68	0.43	0.68	0.13
Total Phosphorus(mg/L)	3	0.02	0.01	0.01	0.02	0.01	0.02	0.00
Faecal Coliforms (CFU/100ml)	15	7	1	1	70	1	3	18
E Coli (CFU/100mL)	13	7	1	1	70	1	4	19
Bicarbonate Alkalinity (mg/CaCO3/L)	1	51						
Chloride (mg/L)	3	30.7	31.0	25.0	36.0	25.0	36.0	5.5
Sulphate as SO42-(mg/L)	2	15.8	15.8	7.5	24.0			
Fluoride (mg/L)	1	0.1						
Sodium (mg/L)	3	17.2	16.0	13.5	22.1	13.5	22.1	4.4
Potassium (mg/L)	3	2.0	1.9	1.9	2.1	1.9	2.1	0.1
Magnesium (mg/L)	3	4.8	4.5	4.4	5.5	4.4	5.5	0.6
Calcium (mg/L)	3	17.2	18.9	13.0	19.7	13.0	19.7	3.7
Iron (ug/L)	2	61	61	37	84			
Hardness mg/L CaCO3	3	66	71	50	79	50	79	15

Table A.132: Summary Statistics for Site 132 Foxglove Oval Mt Colah Stormwater Harvesting. Treated water – sample collected from storage tank for July 2010 to June 2011

Site 132. Foxglove Oval Mount Colah. Water stored for irrigation	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	12	17.9	17.9	12.5	24.4	13.2	20.8	4.0
Electrical ConductivityC (ms/cm)	12	0.2	0.2	0.2	0.3	0.2	0.3	0.1
Electrical Conductivity (µS/cm)	12	221	198	178	297	180	285	49
Turbidity (NTU)	12	0.5	0.3	-0.2	2.2	0.0	0.8	0.7
Dissolved oxygen (mg/L)	12	9.2	9.4	7.8	10.5	8.2	9.8	0.8
Dissolved oxygen (%sat)	12	96	96	86	109	91	99	6
pH	12	8.0	7.8	7.5	8.8	7.7	8.3	0.4
Salinity (ppt)	12	0.1	0.1	0.1	0.2	0.1	0.1	0.0
Suspended Solids (mg/L)	1	1						
Ammonium-Nitrogen (mg/L)	1	0.01						
Oxidised Nitrogen (mg/L)	1	0.77						
Total Nitrogen (mg/L)	1	0.95						
Total Phosphorus(mg/L)	1	0.01						
Faecal Coliforms (CFU/100ml)	12	1	1	1	2	1	1	0
E Coli (CFU/100mL)	9	1	1	1	2	1	1	1
Bicarbonate Alkalinity (mg/CaCO3/L)	1	35						
Chloride (mg/L)	1	34.0						
Sulphate as SO42-(mg/L)	1	7.3						
Fluoride (mg/L)	1	1.0						
Sodium (mg/L)	1	16.4						
Potassium (mg/L)	1	2.3						
Magnesium (mg/L)	1	4.6						
Calcium (mg/L)	1	12.2						
Aluminium (ug/L)	1	14.0						
Arsenic (ug/L)	1	0.5						
Cadmium (ug/L)	1	0.5						
Chromium (ug/L)	1	0.5						
Copper (ug/L)	1	75.0						
Lead (ug/L)	1	0.5						
Manganese (ug/L)	1	5						
Molybdenum (ug/L)	1	0.5						
Nickel (ug/L)	1	0.5						
Selenium (ug/L)	1	1.5						
Silver (ug/L)	1	0.5						
Uranium (ug/L)	1	0.5						
Zinc (ug/L)	1	5						
Boron (ug/L)	1	17.0						
Iron (ug/L)	1	10						
Mercury (ug/L)	1	0.05						
SAR (Based on Mean Na, Mg and Ca)	1	1.4						

Table A.134: Summary Statistics for Site 134 Epping Oval Stormwater Harvesting. Raw Water. Sample collected from in-ground storage tank. July 2010 to June 2011

Site 134. Epping Oval. Harvested Stormwater - Raw Water	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	7	22.1	22.0	15.6	27.2	19.3	25.3	3.9
Electrical ConductivityC (ms/cm)	7	0.2	0.2	0.2	0.3	0.2	0.2	0.0
Electrical Conductivity (µS/cm)	7	198	207	150	239	174	224	31
Turbidity (NTU)	7	2.0	1.8	0.0	5.9	0.2	3.4	2.1
Dissolved oxygen (mg/L)	7	3.6	4.6	0.3	6.5	1.8	4.9	2.1
Dissolved oxygen (%sat)	7	41	50	4	65	21	62	23
pH	7	7.2	7.1	6.9	7.8	7.0	7.5	0.3
Salinity (ppt)	7	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Faecal Coliforms (CFU/100ml)	7	314	110	1	1600	4	280	577
E Coli (CFU/100mL)	6	97	50	1	280	4	200	119

Table A.137: Summary Statistics for Site 137 Epping Oval Stormwater Harvesting. Treated Water. Sample collected from above ground storage tank. July 2010 to June 2011

Site 137. Epping Oval. Harvested Storwmater Treated Water for Irrigation	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	7	19.8	20.2	13.2	23.7	16.5	23.0	3.8
Electrical ConductivityC (ms/cm)	7	0.2	0.2	0.2	0.3	0.2	0.2	0.0
Electrical Conductivity (µS/cm)	7	192	193	144	233	168	228	31
Turbidity (NTU)	7	1.5	1.3	0.7	3.1	1.0	1.7	0.8
Dissolved oxygen (mg/L)	7	8.1	8.8	6.0	9.6	6.7	9.3	1.4
Dissolved oxygen (%sat)	7	89	91	71	105	74	103	13
pH	7	8.2	8.5	7.3	8.7	7.8	8.6	0.5
Salinity (ppt)	7	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Suspended Solids (mg/L)	1	1						
Total Nitrogen (mg/L)	1	0.84						
Total Phosphorus(mg/L)	1	0.18						
Faecal Coliforms (CFU/100ml)	7	1	1	1	1	1	1	0
E Coli (CFU/100mL)	6	1	1	1	1	1	1	0
Chloride (mg/L)	1	13.0						
Sulphate as SO42-(mg/L)	1	6.2						
Sodium (mg/L)	1	9.0						
Potassium (mg/L)	1	6.3						
Magnesium (mg/L)	1	1.7						
Calcium (mg/L)	1	17.7						
Iron (ug/L)	1	75						
Hardness mg/L CaCO3	1	49						
SAR (Based on Mean Na, Mg and Ca)	1	0.8						

Table A.138: Summary Statistics for Site 138 North Epping Oval Stormwater Harvesting. Raw Water. Sample collected from small in-ground storage tank. July 2010 to June 2011

Site 138. North Epping oval. Harvested Stormwater - Raw Water	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	4	20.5	20.8	17.0	23.5	17.0	23.5	2.7
Electrical ConductivityC (ms/cm)	4	0.4	0.4	0.4	0.5	0.4	0.5	0.0
Electrical Conductivity (µS/cm)	4	395	388	366	439	366	439	32
Turbidity (NTU)	4	6.3	4.2	0.0	16.9	0.0	16.9	7.5
Dissolved oxygen (mg/L)	4	4.3	4.9	1.2	6.3	1.2	6.3	2.2
Dissolved oxygen (%sat)	4	47	55	14	66	14	66	23
pH	4	8.1	8.1	7.4	8.8	7.4	8.8	0.8
Salinity (ppt)	4	0.2	0.2	0.1	0.2	0.1	0.2	0.1
Suspended Solids (mg/L)	1	11						
Ammonium-Nitrogen (mg/L)	1	0.02						
Oxidised Nitrogen (mg/L)	1	0.64						
Total Nitrogen (mg/L)	1	1.53						
Total Phosphorus(mg/L)	1	0.12						
Faecal Coliforms (CFU/100ml)	4	105	56	1	310	1	310	146
E Coli (CFU/100mL)	3	37	1	1	110	1	110	63
Bicarbonate Alkalinity (mg/CaCO3/L)	1	82						
Chloride (mg/L)	1	43.0						
Sulphate as SO42-(mg/L)	1	37.0						
Fluoride (mg/L)	1	0.2						
Sodium (mg/L)	1	29.9						
Potassium (mg/L)	1	15.1						
Magnesium (mg/L)	1	4.3						
Calcium (mg/L)	1	36.8						
Copper (ug/L)	1	6.0						
Lead (ug/L)	1	1.0						
Manganese (ug/L)	1	9						
Zinc (ug/L)	1	36						
Iron (ug/L)	1	656						
Hardness mg/L CaCO3	1	111						

Table A.141: Summary Statistics for Site 141 North Epping Oval Stormwater Harvesting. Treated Water. Sample collected from large in-ground storage tank. July 2010 to June 2011

Site 140+141. North Epping Oval. Harvested Stormwater. Treated Water for Irrigation	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	8	21.8	22.0	15.9	26.2	18.8	24.7	3.3
Electrical Conductivity (ms/cm)	8	0.4	0.3	0.2	0.9	0.2	0.9	0.3
Electrical Conductivity (µS/cm)	8	422	333	160	885	200	853	291
Turbidity (NTU)	8	6.4	2.9	0.0	29.2	0.3	9.0	9.6
Dissolved oxygen (mg/L)	8	7.0	8.3	2.0	10.2	3.4	9.2	3.0
Dissolved oxygen (%sat)	8	78	93	21	122	36	102	35
pH	8	8.4	8.0	7.7	9.9	7.7	9.8	0.9
Salinity (ppt)	8	0.2	0.2	0.1	0.5	0.1	0.4	0.2
Suspended Solids (mg/L)	2	6	6	3	8	3	8	4
Total Nitrogen (mg/L)	2	3.00	3.00	1.25	4.74	1.25	4.74	2.47
Total Phosphorus(mg/L)	2	0.18	0.18	0.13	0.23	0.13	0.23	0.07
Faecal Coliforms (CFU/100ml)	8	15	1	1	110	1	3	39
E Coli (CFU/100mL)	7	2	1	1	5	1	3	2
Chloride (mg/L)	2	83.0	83.0	36.0	130.0			
Sulphate as SO42-(mg/L)	1	65.0						
Fluoride (mg/L)	0							
Sodium (mg/L)	2	43.9	43.9	17.9	69.9			
Potassium (mg/L)	2	23.9	23.9	9.8	38.1			
Magnesium (mg/L)	2	6.7	6.7	4.7	8.7			
Calcium (mg/L)	2	40.8	40.8	18.3	63.2			
Iron (ug/L)	2	435	435	78	791			
Hardness mg/L CaCO3	2	36	36	3	69			
SAR (Based on Mean Na, Mg, Ca)	2	2.4						

Table A.142: Summary Statistics for Site 142 Somerville Park Oval Epping Stormwater Harvesting. Raw Water. Sample collected from in-ground storage tank. July 2010 to June 2011

Site 142. Somerville Oval Epping. Harvested Stormwater. Raw Water	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	8	20.4	20.4	17.7	22.7	19.2	22.3	1.6
Electrical ConductivityC (ms/cm)	8	0.3	0.3	0.2	0.5	0.2	0.3	0.1
Electrical Conductivity (µS/cm)	8	286	276	232	429	237	304	64
Turbidity (NTU)	8	51.6	24.2	3.7	179.2	15.1	107.7	60.9
Dissolved oxygen (mg/L)	8	4.5	4.5	0.3	7.8	2.4	7.5	2.6
Dissolved oxygen (%sat)	8	50	50	4	84	24	83	29
pH	8	7.8	7.3	6.8	10.4	7.0	9.0	1.2
Salinity (ppt)	8	0.1	0.1	0.1	0.2	0.1	0.2	0.0
Suspended Solids (mg/L)	1	40						
Ammonium-Nitrogen (mg/L)	1	0.03						
Oxidised Nitrogen (mg/L)	1	1.18						
Total Nitrogen (mg/L)	1	1.60						
Total Phosphorus(mg/L)	1	0.09						
Faecal Coliforms (CFU/100ml)	8	561	31	1	3100	1	800	1070
E Coli (CFU/100mL)	7	614	6	1	3100	1	670	1132
Bicarbonate Alkalinity (mg/CaCO3/L)	1	30						
Chloride (mg/L)	1	37.0						
Sulphate as SO42-(mg/L)	1	20.0						
Fluoride (mg/L)	1	0.1						
Sodium (mg/L)	1	31.2						
Potassium (mg/L)	1	4.2						
Magnesium (mg/L)	1	5.3						
Calcium (mg/L)	1	10.5						
Copper (ug/L)	1	16.0						
Lead (ug/L)	1	7.0						
Manganese (ug/L)	1	34						
Zinc (ug/L)	1	84						
Iron (ug/L)	1	2640						
Hardness mg/L CaCO3	1	44						

Table A.145: Summary Statistics for Site 145 Somerville Park Oval Epping Stormwater Harvesting. Treated Water. Sample collected from in-ground storage tank. July 2010 to June 2011

Site 145. Somerville Oval Epping. Harvested Stormwater. Treated Water for irrigation	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Temperature (oC)	8	20.1	20.1	17.6	21.6	19.6	21.4	1.3
Electrical ConductivityC (ms/cm)	8	0.2	0.2	0.2	0.3	0.2	0.3	0.0
Electrical Conductivity (µS/cm)	8	228	246	164	271	179	264	42
Turbidity (NTU)	8	13.4	13.8	0.0	34.6	1.1	21.0	12.4
Dissolved oxygen (mg/L)	8	7.4	7.2	4.0	11.5	4.5	11.0	2.8
Dissolved oxygen (%sat)	8	82	80	47	130	49	120	32
pH	8	7.6	7.4	7.0	8.7	7.1	7.9	0.6
Salinity (ppt)	8	0.1	0.1	0.1	0.2	0.1	0.1	0.0
Suspended Solids (mg/L)	2	1	1	1	1			
Total Nitrogen (mg/L)	2	1.02	1.02	0.71	1.32			
Total Phosphorus(mg/L)	2	0.04	0.04	0.01	0.07			
Faecal Coliforms (CFU/100ml)	8	48	10	1	290	1	56	99
E Coli (CFU/100mL)	7	52	10	1	290	1	47	106
Chloride (mg/L)	2	33.0	33.0	27.0	39.0			
Sulphate as SO42-(mg/L)	1	22.0						
Sodium (mg/L)	2	22.1	22.1	13.9	30.3			
Potassium (mg/L)	2	2.8	2.8	2.3	3.3			
Magnesium (mg/L)	2	4.7	4.7	4.1	5.3			
Calcium (mg/L)	2	14.0	14.0	11.4	16.5			
Iron (ug/L)	2	405	405	37	773			
Hardness mg/L CaCO3	2	57	57	52	61			
SAR (Based on Mean Na, Mg and Ca)	2	1.8						

Table A.146. Summary Statistics for Site 146 Yatala Creek in Kuring-gai National Park (Reference Creek) for July 2010 to Oct 2011

Site 146 Yatala Creek (Reference)	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)	8	1464	300	50	10000	60	500	3453
Temperature (oC)	8	16.3	16.9	10.7	20.4	12.0	20.3	3.7
Electrical Conductivity (mS/cm)	8	0.14	0.14	0.10	0.17	0.12	0.17	0.03
Electrical Conductivity (µS/cm)	8	135	135	102	165	120	156	20
Turbidity (NTU)	8	4.3	1.7	0.0	14.0	0.3	14.0	6.0
Dissolved oxygen (mg/L)	8	9.7	9.4	8.7	11.5	8.9	10.6	1.0
Dissolved oxygen (%sat)	8	99	97	88	114	96	103	8
pH	8	6.3	6.3	6.0	6.8	6.1	6.6	0.3
Salinity (ppt)	8	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Suspended Solids (mg/L) (2)	8	2	1	1	4	1	4	1
Ammonium-Nitrogen (mg/L) (0.01)	8	0.006	0.005	0.005	0.010	0.005	0.005	0.002
Oxidised Nitrogen (mg/L) (0.01)	8	0.03	0.02	0.01	0.13	0.01	0.03	0.04
Total Nitrogen (mg/L) (0.05)	8	0.15	0.13	0.08	0.30	0.09	0.26	0.08
Total Phosphorus(mg/L) (0.002)	8	0.005	0.004	0.003	0.010	0.003	0.008	0.003
Faecal Coliforms (CFU/100ml) (1)	8	139	25	1.0	600	1.0	400	230
Bicarbonate Alkalinity (mg/CaCO3/L) (2)	4	6	6	4	7	4	7	2
Chloride (mg/L) (0.1)	4	34	36	24	41	24	41	7
Sulphate as SO42-(mg/L) (0.1)	4	7	7	6	8	6	8	1
Fluoride (mg/L) (0.05)	4	0.06	0.05	0.03	0.13	0.03	0.13	0.05
Sodium (mg/L) (0.05)	4	18.8	19.6	14.4	21.5	14.4	21.5	3.2
Potassium (mg/L) (0.05)	4	1.2	1.2	1.0	1.3	1.0	1.3	0.1
Magnesium (mg/L) (0.01)	4	2.9	3.0	2.0	3.5	2.0	3.5	0.6
Calcium (mg/L) (0.01)	4	2.3	2.3	1.9	2.6	1.9	2.6	0.3
Aluminium (ug/L) (10)	4	419	197	81	1200	81	1200	525
Arsenic (ug/L) (1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L) (1)	4	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L) (1)	4	0.6	0.5	0.5	1.0	0.5	1.0	0.3
Copper (ug/L) (1)	4	1.0	1.0	1.0	1.0	1.0	1.0	0.0
Lead (ug/L) (1)	4	0.9	0.5	0.5	2.0	0.5	2.0	0.8
Manganese (ug/L) (1)	4	9	9	6	12	6	12	3
Molybdenum (ug/L) (1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Nickel (ug/L) (1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Selenium (ug/L) (3)	4	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L) (1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L) (1)	4	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L) (10)	4	17	15	5	31	5	31	11
Boron (ug/L) (5)	4	18	18	13	22	13	22	4
Iron (ug/L) (20)	4	409	377	224	657	224	657	196
Mercury (ug/L) (0.1 to 0.01)	4	0.03	0.04	0.01	0.05	0.01	0.05	0.02
BOD5/CBOD5(mg/L) (2)	1	1						
Total Organic Carbon(mg/L) (0.2)	2	4	4	3	5			

Table A.147. Summary Statistics for Site 147 unnamed Creek draining from Pennant Hills Ovals area into Lane Cove National Park (Reference Creek) for July 2010 to Oct 2011

Site 147 Unnamed Ck Lane Cove NP (Reference)	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)	8	42	20	4	150	10	80	50
Temperature (oC)	9	15.2	14.8	10.3	20.3	11.5	19.6	3.7
Electrical Conductivity (mS/cm)	9	0.16	0.15	0.11	0.22	0.12	0.20	0.04
Electrical Conductivity (µS/cm)	9	158	147	130	204	130	179	27
Turbidity (NTU)	9	0.3	0.0	-0.2	1.4	-0.2	1.1	0.6
Dissolved oxygen (mg/L)	9	9.6	9.6	8.2	11.6	8.8	10.4	1.0
Dissolved oxygen (%sat)	9	95	96	88	103	91	99	5
pH	9	5.6	5.7	4.2	6.3	5.5	6.0	0.6
Salinity (ppt)	9	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Suspended Solids (mg/L) (2)	9	1	1	1	3	1	1	1
Ammonium-Nitrogen (mg/L) (0.01)	9	0.006	0.005	0.005	0.010	0.005	0.010	0.002
Oxidised Nitrogen (mg/L) (0.01)	9	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Total Nitrogen (mg/L) (0.05)	9	0.17	0.16	0.11	0.24	0.12	0.21	0.04
Total Phosphorus(mg/L) (0.002)	9	0.003	0.003	0.001	0.007	0.002	0.005	0.002
Faecal Coliforms (CFU/100ml) (1)	9	72	20	1.0	320	5.0	150	105
Bicarbonate Alkalinity (mg/CaCO3/L) (2)	6	2	2	1	3	1	2	1
Chloride (mg/L) (0.1)	6	44	44	33	58	37	50	9
Sulphate as SO42-(mg/L) (0.1)	6	8	9	5	9	8	9	1
Fluoride (mg/L) (0.05)	6	0.04	0.03	0.03	0.06	0.03	0.06	0.02
Sodium (mg/L) (0.05)	6	21.0	19.3	17.5	27.4	18.7	23.9	3.8
Potassium (mg/L) (0.05)	6	1.3	1.3	1.0	1.4	1.2	1.4	0.2
Magnesium (mg/L) (0.01)	6	4.1	3.8	3.4	5.2	3.5	4.8	0.8
Calcium (mg/L) (0.01)	6	2.1	2.0	1.6	2.7	1.8	2.4	0.4
Aluminium (ug/L) (10)	6	248	239	153	382	219	258	75
Arsenic (ug/L) (1)	6	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L) (1)	6	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L) (1)	6	0.6	0.5	0.5	1.0	0.5	0.5	0.2
Copper (ug/L) (1)	6	1.2	1.0	1.0	2.0	1.0	1.0	0.4
Lead (ug/L) (1)	6	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Manganese (ug/L) (1)	6	7	4	2	24	3	7	8
Molybdenum (ug/L) (1)	6	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Nickel (ug/L) (1)	6	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Selenium (ug/L) (3)	6	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L) (1)	6	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L) (1)	6	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L) (10)	6	14	13	5	26	10	15	7
Boron (ug/L) (5)	6	18	18	7	29	12	23	8
Iron (ug/L) (20)	6	93	85	39	151	63	136	44
Mercury (ug/L) (0.1 to 0.01)	6	0.04	0.05	0.01	0.05	0.01	0.05	0.02
Total Organic Carbon(mg/L) (0.2)	2	6	6	4	9	4	9	4

Table A.149. Summary Statistics for Site 149 Duckpond Ridge Creek in Marramarra Park (Reference Creek) for July 2010 to Oct 2011

Site 149 Duckpond Ridge Ck (Reference)	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)	12	609	125	10	5000	60	400	1409
Temperature (oC)	12	13.5	12.4	9.0	19.8	9.6	18.9	4.0
Electrical Conductivity (mS/cm)	12	0.30	0.29	0.20	0.46	0.20	0.39	0.09
Electrical Conductivity (µS/cm)	12	288	279	157	431	230	342	87
Turbidity (NTU)	12	2.0	1.9	-0.2	7.9	0.0	2.7	2.1
Dissolved oxygen (mg/L)	12	9.6	9.9	6.2	12.0	7.8	11.4	2.0
Dissolved oxygen (%sat)	12	91	90	68	107	83	104	13
pH	12	4.2	4.3	3.9	4.5	4.0	4.4	0.2
Salinity (ppt)	12	0.2	0.2	0.1	0.2	0.1	0.2	0.0
Suspended Solids (mg/L) (2)	12	2	1	1	4	1	3	1
Ammonium-Nitrogen (mg/L) (0.01)	12	0.010	0.010	0.005	0.030	0.005	0.010	0.007
Oxidised Nitrogen (mg/L) (0.01)	12	0.01	0.01	0.01	0.02	0.01	0.01	0.01
Total Nitrogen (mg/L) (0.05)	12	0.10	0.09	0.06	0.22	0.08	0.12	0.04
Total Phosphorus(mg/L) (0.002)	12	0.003	0.004	0.001	0.006	0.001	0.005	0.002
Faecal Coliforms (CFU/100ml) (1)	11	13	5	0.0	62	0.5	18	19
Bicarbonate Alkalinity (mg/CaCO3/L) (2)	5	1	1	1	1	1	1	0
Chloride (mg/L) (0.1)	5	90	89	53	121	62	119	29
Sulphate as SO42-(mg/L) (0.1)	5	7	9	4	9	4	9	3
Fluoride (mg/L) (0.05)	5	0.07	0.06	0.06	0.08	0.06	0.08	0.01
Sodium (mg/L) (0.05)	5	40.9	46.6	25.2	51.1	29.9	49.1	10.8
Potassium (mg/L) (0.05)	5	1.9	1.8	1.6	2.2	1.7	2.1	0.2
Magnesium (mg/L) (0.01)	5	6.8	7.5	4.4	8.4	4.9	8.3	1.8
Calcium (mg/L) (0.01)	5	1.9	2.1	1.4	2.5	1.4	2.4	0.5
Aluminium (ug/L) (10)	5	281	259	240	334	247	327	42
Arsenic (ug/L) (1)	5	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L) (1)	5	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L) (1)	5	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Copper (ug/L) (1)	5	1.0	1.0	1.0	1.0	1.0	1.0	0.0
Lead (ug/L) (1)	5	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Manganese (ug/L) (1)	5	313	304	92	489	156	476	167
Molybdenum (ug/L) (1)	5	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Nickel (ug/L) (1)	5	3.4	4.0	2.0	4.0	2.5	4.0	0.9
Selenium (ug/L) (3)	5	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L) (1)	5	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L) (1)	5	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L) (10)	5	24	20	15	45	16	34	12
Boron (ug/L) (5)	5	22	22	8	31	15	29	9
Iron (ug/L) (20)	5	663	495	222	1410	254	1155	495
Mercury (ug/L) (0.1 to 0.01)	5	0.04	0.05	0.01	0.05	0.03	0.05	0.02
Total Organic Carbon(mg/L) (0.2)	2	3	3	3	4			

Table A.157. Summary Statistics for Site 157 Deep Bay Creek in Crown Land below Berowra Heights. (Reference Creek) for July 2010 to Oct 2011

Site 157 Deep Bay Ck (Reference)	Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)	4	404	55	5	1500	5	1500	731
Temperature (oC)	4	16.8	16.4	13.4	21.0	13.4	21.0	3.1
Electrical Conductivity (mS/cm)	4	0.17	0.18	0.12	0.21	0.12	0.21	0.04
Electrical Conductivity (µS/cm)	4	154	145	119	206	119	206	38
Turbidity (NTU)	4	1.3	0.1	0.0	4.8	0.0	4.8	2.4
Dissolved oxygen (mg/L)	4	9.3	9.6	6.6	11.1	6.6	11.1	2.0
Dissolved oxygen (%sat)	4	69	82	11	103	11	103	41
pH	4	4.6	4.5	4.5	4.9	4.5	4.9	0.2
Salinity (ppt)	4	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Suspended Solids (mg/L) (2)	3	1	1	1	1	1	1	0
Ammonium-Nitrogen (mg/L) (0.01)	3	0.005	0.005	0.005	0.005	0.005	0.005	0.000
Oxidised Nitrogen (mg/L) (0.01)	3	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Total Nitrogen (mg/L) (0.05)	3	0.14	0.12	0.06	0.24	0.06	0.24	0.09
Total Phosphorus(mg/L) (0.002)	3	0.003	0.003	0.002	0.004	0.002	0.004	0.001
Soluble Reactive Phosphorus (mg/L)(0.002)	1	0.001						
Faecal Coliforms (CFU/100ml) (1)	3	125	150	6.0	220	6.0	220	109
Bicarbonate Alkalinity (mg/CaCO3/L) (2)	2	1	1	1	1			
Chloride (mg/L) (0.1)	2	44	44	43	45			
Sulphate as SO42-(mg/L) (0.1)	2	6	6	5	6			
Fluoride (mg/L) (0.05)	2	0.05	0.05	0.03	0.07			
Sodium (mg/L) (0.05)	2	21.4	21.4	21.2	21.6			
Potassium (mg/L) (0.05)	2	1.8	1.8	1.1	2.5			
Magnesium (mg/L) (0.01)	2	3.3	3.3	3.2	3.4			
Calcium (mg/L) (0.01)	2	0.7	0.7	0.7	0.7			
Aluminium (ug/L) (10)	2	178	178	158	197			
Arsenic (ug/L) (1)	2	0.5	0.5	0.5	0.5			
Cadmium (ug/L) (1)	2	0.50	0.50	0.50	0.50			
Chromium (ug/L) (1)	2	0.5	0.5	0.5	0.5			
Copper (ug/L) (1)	2	1.5	1.5	1.0	2.0			
Lead (ug/L) (1)	2	0.5	0.5	0.5	0.5			
Manganese (ug/L) (1)	2	38	38	33	42			
Molybdenum (ug/L) (1)	2	0.5	0.5	0.5	0.5			
Nickel (ug/L) (1)	2	0.8	0.8	0.5	1.0			
Selenium (ug/L) (3)	2	1.5	1.5	1.5	1.5			
Silver (ug/L) (1)	2	0.5	0.5	0.5	0.5			
Uranium (ug/L) (1)	2	0.5	0.5	0.5	0.5			
Zinc (ug/L) (10)	2	12	12	5	19			
Boron (ug/L) (5)	2	15	15	13	17			
Iron (ug/L) (20)	2	110	110	106	113			
Mercury (ug/L) (0.1 to 0.01)	2	0.03	0.03	0.01	0.05			

Table A.160. Summary Statistics for Site 160 Joes Saddle Creek in Berowra valley regional Park near Hornsby (Reference Creek) for July 2010 to Oct 2011

Site 160 Joes Saddle Ck (Reference)		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		8	83	6	0	600	1	30	209
Temperature (oC)		8	13.9	13.1	11.1	20.4	12.2	15.3	2.9
Electrical Conductivity (mS/cm)		8	0.17	0.17	0.12	0.27	0.13	0.20	0.05
Electrical Conductivity (µS/cm)		8	161	164	114	215	130	188	35
Turbidity (NTU)		8	3.2	0.0	-0.2	21.0	0.0	3.9	7.3
Dissolved oxygen (mg/L)		8	7.2	6.9	5.0	10.1	5.1	9.3	2.0
Dissolved oxygen (%sat)		8	69	66	48	95	50	89	18
pH		7	4.3	4.3	4.1	4.7	4.2	4.4	0.2
Salinity (ppt)		8	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Suspended Solids (mg/L)	(2)	3	1	1	1	1	1	1	0
Ammonium-Nitrogen (mg/L)	(0.01)	4	0.006	0.005	0.005	0.010	0.005	0.010	0.003
Oxidised Nitrogen (mg/L)	(0.01)	4	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Total Nitrogen (mg/L)	(0.05)	4	0.14	0.14	0.12	0.16	0.12	0.16	0.02
Total Phosphorus(mg/L)	(0.002)	4	0.003	0.002	0.001	0.005	0.001	0.005	0.002
Faecal Coliforms (CFU/100ml)	(1)	4	3	2	0.5	5	0.5	5	2
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	2	1	1	1	1			
Chloride (mg/L)	(0.1)	2	46	46	41	50			
Sulphate as SO42-(mg/L)	(0.1)	2	7	7	7	7			
Fluoride (mg/L)	(0.05)	2	0.07	0.07	0.06	0.07			
Sodium (mg/L)	(0.05)	2	24.5	24.5	22.9	26.0			
Potassium (mg/L)	(0.05)	2	1.3	1.3	1.2	1.5			
Magnesium (mg/L)	(0.01)	2	3.9	3.9	3.4	4.5			
Calcium (mg/L)	(0.01)	2	1.0	1.0	0.9	1.1			
Aluminium (ug/L)	(10)	2	404	404	389	418			
Arsenic (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Cadmium (ug/L)	(1)	2	0.50	0.50	0.50	0.50			
Chromium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Copper (ug/L)	(1)	2	1.0	1.0	1.0	1.0			
Lead (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Manganese (ug/L)	(1)	2	17	17	15	18			
Molybdenum (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Nickel (ug/L)	(1)	2	1.0	1.0	1.0	1.0			
Selenium (ug/L)	(3)	2	1.5	1.5	1.5	1.5			
Silver (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Uranium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Zinc (ug/L)	(10)	2	16	16	13	19			
Boron (ug/L)	(5)	2	30	30	20	39			
Iron (ug/L)	(20)	2	108	108	93	123			
Mercury (ug/L)	(0.1 to 0.01)	2	0.01	0.01	0.01	0.01			

Table A.161. Summary Statistics for Site 161 Canoelands Creek in Marramarra national Park near Canoelands (Reference Creek) for July 2010 to Oct 2011

Site 161 Canoelands Ck (Reference)		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		3	167	200	100	200	100	200	58
Temperature (oC)		3	13.0	14.2	9.5	15.3	9.5	15.3	3.1
Electrical Conductivity (mS/cm)		3	0.17	0.18	0.14	0.19	0.14	0.19	0.03
Electrical Conductivity (µS/cm)		3	161	161	146	175	146	175	15
Turbidity (NTU)		3	1.6	1.0	0.8	3.0	0.8	3.0	1.2
Dissolved oxygen (mg/L)		3	9.6	9.5	6.9	12.3	6.9	12.3	2.7
Dissolved oxygen (%sat)		3	89	95	67	106	67	106	20
pH		3	5.4	5.5	5.2	5.6	5.2	5.6	0.2
Salinity (ppt)		3	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Suspended Solids (mg/L)	(2)	3	1	1	1	1	1	1	0
Ammonium-Nitrogen (mg/L)	(0.01)	3	0.005	0.005	0.005	0.005	0.005	0.005	0.000
Oxidised Nitrogen (mg/L)	(0.01)	3	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Total Nitrogen (mg/L)	(0.05)	3	0.11	0.10	0.09	0.14	0.09	0.14	0.03
Total Phosphorus(mg/L)	(0.002)	3	0.004	0.004	0.003	0.006	0.003	0.006	0.002
Faecal Coliforms (CFU/100ml)	(1)	3	11	1	0.5	31	0.5	31	17
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	2	1	1	1	1			
Chloride (mg/L)	(0.1)	2	48	48	39	56			
Sulphate as SO42-(mg/L)	(0.1)	2	8	8	8	9			
Fluoride (mg/L)	(0.05)	2	0.04	0.04	0.03	0.06			
Sodium (mg/L)	(0.05)	2	22.6	22.6	20.9	24.3			
Potassium (mg/L)	(0.05)	2	1.5	1.5	1.3	1.8			
Magnesium (mg/L)	(0.01)	2	3.9	3.9	3.4	4.4			
Calcium (mg/L)	(0.01)	2	1.5	1.5	1.1	2.0			
Aluminium (ug/L)	(10)	2	141	141	84	198			
Arsenic (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Cadmium (ug/L)	(1)	2	0.50	0.50	0.50	0.50			
Chromium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Copper (ug/L)	(1)	2	3.5	3.5	1.0	6.0			
Lead (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Manganese (ug/L)	(1)	2	52	52	40	63			
Molybdenum (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Nickel (ug/L)	(1)	2	1.5	1.5	1.0	2.0			
Selenium (ug/L)	(3)	2	1.5	1.5	1.5	1.5			
Silver (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Uranium (ug/L)	(1)	2	0.5	0.5	0.5	0.5			
Zinc (ug/L)	(10)	2	19	19	11	26			
Boron (ug/L)	(5)	2	13	13	10	15			
Iron (ug/L)	(20)	2	229	229	207	251			
Mercury (ug/L)	(0.1 to 0.01)	2	0.03	0.03	0.01	0.05			

Table A.164. Summary Statistics for Site 164 Djarra Crossing north arm of Joe Crafts Creek in Muogamarra Nature Reserve (Reference Creek) for July 2010 to Oct 2011

Site 164 Djara Crossing (Reference)		Valid N	Mean	Median	Min	Max	20th%ile	80th%ile	Std.Dev.
Estimated Flow rate (L/min)		7	967	100	10	4000	80	1800	1484
Temperature (oC)		7	13.2	13.1	9.9	18.3	10.3	14.5	2.8
Electrical Conductivity (mS/cm)		7	0.12	0.12	0.06	0.14	0.11	0.14	0.03
Electrical Conductivity (µS/cm)		7	99	100	69	123	73	116	21
Turbidity (NTU)		7	3.4	1.2	0.0	10.0	0.0	9.9	4.6
Dissolved oxygen (mg/L)		7	10.2	10.6	9.2	11.1	9.3	10.8	0.7
Dissolved oxygen (%sat)		7	97	99	86	105	94	101	6
pH		7	5.1	5.0	4.5	6.2	4.5	5.2	0.6
Salinity (ppt)		7	0.1	0.1	0.0	0.6	0.1	0.1	0.2
Suspended Solids (mg/L)	(2)	7	2	1	1	3	1	3	1
Ammonium-Nitrogen (mg/L)	(0.01)	7	0.005	0.005	0.002	0.010	0.005	0.005	0.002
Oxidised Nitrogen (mg/L)	(0.01)	7	0.01	0.01	0.01	0.02	0.01	0.01	0.01
Total Nitrogen (mg/L)	(0.05)	7	0.11	0.08	0.06	0.24	0.08	0.17	0.07
Total Phosphorus(mg/L)	(0.002)	7	0.003	0.003	0.001	0.006	0.002	0.004	0.002
Faecal Coliforms (CFU/100ml)	(1)	7	137	12	2.0	650	6.0	270	246
Bicarbonate Alkalinity (mg/CaCO3/L)	(2)	3	2	1	1	5	1	5	2
Chloride (mg/L)	(0.1)	4	30	30	27	33	27	33	3
Sulphate as SO42-(mg/L)	(0.1)	4	6	6	6	7	6	7	1
Fluoride (mg/L)	(0.05)	4	0.03	0.03	0.03	0.05	0.03	0.05	0.01
Sodium (mg/L)	(0.05)	4	18.6	18.9	16.5	20.3	16.5	20.3	1.6
Potassium (mg/L)	(0.05)	4	0.9	0.9	0.6	1.2	0.6	1.2	0.3
Magnesium (mg/L)	(0.01)	4	2.8	2.9	2.4	3.1	2.4	3.1	0.3
Calcium (mg/L)	(0.01)	4	0.4	0.3	0.2	0.5	0.2	0.5	0.1
Aluminium (ug/L)	(10)	3	468	316	287	801	287	801	289
Arsenic (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cadmium (ug/L)	(1)	3	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Chromium (ug/L)	(1)	3	0.7	0.5	0.5	1.0	0.5	1.0	0.3
Copper (ug/L)	(1)	3	1.0	1.0	1.0	1.0	1.0	1.0	0.0
Lead (ug/L)	(1)	3	0.7	0.5	0.5	1.0	0.5	1.0	0.3
Manganese (ug/L)	(1)	3	11	11	8	13	8	13	3
Molybdenum (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Nickel (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Selenium (ug/L)	(3)	3	1.5	1.5	1.5	1.5	1.5	1.5	0.0
Silver (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Uranium (ug/L)	(1)	3	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Zinc (ug/L)	(10)	3	9	5	5	16	5	16	6
Boron (ug/L)	(5)	3	23	16	15	37	15	37	12
Iron (ug/L)	(20)	3	334	195	154	652	154	652	276
Mercury (ug/L)	(0.1 to 0.01)	3	0.19	0.05	0.01	0.50	0.01	0.50	0.27
Total Organic Carbon(mg/L)	(0.2)	1	3						

12 Appendix B. Summary for SOE Report 2010-2011

Water Quality Summary

Health Ratings of 36 sites in Creeks and Estuary.

Prepared for use in Council's

Statement of Environment Report 2010-2011

SOE REPORTING 2010-2011 YEAR. HEALTH RATINGS OF 36 SITES IN CREEKS AND ESTUARY.

GUIDELINE PARAMETERS
Freshwater: Suspended Solids < 10mg/L; Total Nitrogen <0.35mg/L; Total Phorphorus <0.025 mg/L
Estuarine: Chlorphyll <4 ug/L; Total Nitrogen <0.3 mg/l; Total Phosphorus <0.03 mg/L

RANKING: Three key water parameters were used for ranking the water quality at a site: At freshwater sites - suspended solids, total nitrogen and total phosphorus; and at estuarine sites - chlorophyll, total nitrogen and total phosphorus. The rating was considered to be "good" at a site if the ANZECC Guideline values for the three parameters are **simultaneously** satisfied more than 50% of the time, a "fair" rating for 25 to 50%; and a "poor" rating for under 25% of the time.
Based on this methodology the measured ratings for 2010-2011 were "Good" at 36% of our 36 sampling sites, "Fair" at 8% and "Poor" at 56% of sites

	SUMMARY 2010-2011 Ranking	Number	Percent	Criteria	SUMMARY 2009-2010 Ranking	Number	Percent
	good	**13**	**36**	Satisfy 3 key parameters simult over 50% of time	**good**	**14**	**39**
	fair	**3**	**8**	Satisfy 3 key parameters simult over 25to 50% of time	**fair**	**5**	**14**
	poor	**20**	**56**	Satisfy 3 key parameters simult. less than 25% of time	**poor**	**17**	**47**
total sites		36				36	

site	2010-2011 Rank	2010-2011 % of time the 3 key guidelines passed simultaneously	2010-2011 Problem?	Site (Creek -where)	Site Identification	2009-2010 Rank	% of time the 3 key guidelines passed simultaneously
FRESHWATER CREEKS							
36	good	100	-	Murray Anderson - Reference	36	good	100
37	good	100	-	Smugglers - Reference	37	good	100
1	poor	0	V Hi TN; Hi TP	Berowra - Gorge	1	poor	0
2	good	50	Hi TN	Tunks - Gorge	2	good	92
4	poor	8	Hi TN, TP	Berowra - Westleigh	4	fair	42
5	poor	0	Hi TN, TP	Pyes - Cherrybrook	5	poor	0
6	poor	0	Hi TN, TP	Georges - Cherrybrook	6	poor	8
8	poor	0	Hi TN, TP	Devlins - Epping	8	poor	0
10	poor	0	Hi SS, TN, TP	Larool - Thornleigh	10	poor	0
12	poor	0	Hi SS, TN, TP	Hornsby - Hornsby	12	poor	0
13	poor	0	Hi SS, TN, TP	Sams - Mt Kuring-gai	13	poor	15
23	poor	0	Hi TN, TP	Waitara - U/S STP	23	poor	0
39	good	58	Hi TN	Joe Crafts - Berowra Hts	39	good	100
42	poor	0	Hi TN, TP	Colah - Glenorie	42	fair	25
43	poor	0	V Hi TN; Hi TP	Calna - D/S STP	43	poor	8
45	poor	0	V Hi TN; Hi TP	Berowra - Fishponds	45	poor	0
46	fair	25	Hi TN	Trib of Terrys - Epping	46	good	33
49	fair	25	Hi TN, TP	Still - Galston	49	fair	25
52	good	50	Hi TN, TP	Calna - U/S STP	52	good	83
62	poor	0	Hi TN, TP	Kimmerikong - Cowan	62	poor	0
63	poor	18	Hi TN, TP	Colah - Ben Bullen	63	fair	42
64	poor	0	Hi TN, TP	Sallaway - Galston	64	poor	0
77	poor	0	V Hi TN, Hi TP	Gleeson - Mt Colah	77	poor	0
80	poor	0	V Hi TN, Hi SS, TP	Glenorie - Glenorie	80	poor	0
ESTUARY SITES							
38	good	58	Hi Chloro	Sandbrook Inlet - Brooklyn	38	good	60
48	fair	33	Hi Chloro, TN, TP	Marramarra - Orchard	48	fair	33
55	good	67	Hi TN	Hawkesbury- Brooklyn Baths	55	good	67
60	poor	25	Hi Chloro, TN, TP	Berowra - Car ferry	60	poor	25
61	poor	7	Hi Chloro, TN, TP	Berowra - Calabash	61	poor	7
100	poor	0	Hi Chloro, TN, TP	Berowra - Crosslands	100	poor	4
103	good	75	Hi Chloro, TN, TP	Hawkesbury - Milsons Passage	103	good	67
104	good	75	Hi Chloro, TN, TP	Hawkesbury - Peat Island	104	good	75
105	good	83	Hi TN	Hawkesbury - at STP outlet	105	good	83
106	good	66	Hi Chloro, TN	Hawkesbury - entrance Sandbrook	106	good	74
107	good	58	Hi Chloro, TN	Hawkesbury - off Long Isl	107	good	75
108	good	92	Hi Chloro, TN	Hawkesbury - Dangar Isl	108	good	92
total =	36				total =	36	
Good=	13				Good=	14	
Fair	3				Fair	5	
Poor	20				Poor	17	

Why ranking is different in 2010-2011 than in 2009-2010

- Estuarine sites essentially the same as 2009-2010
- Freshwater sites generally more failures for SS, TN and TP than in 2009-2010 (Possibly due to more storms in 2010-2011). Sites 4, 42, 46 and 63 ranked lower this year.