Derwent Estuary Program

2010-11

STORMWATER & RIVULET MONITORING REPORT

Clarence... a brighter place

Brighton Council

Hobart City Council

Kingborough

Derwent Valley Council

Glenorchy City Where ideas happen.

Tasmania Explore the possibilities

The Derwent Estuary Program (DEP) is a regional partnership between local governments, the Tasmanian state government, commercial and industrial enterprises, and community-based groups to restore and promote our estuary. The DEP was established in 1999 and has been nationally recognised for excellence in coordinating initiatives to reduce water pollution, conserve habitats and species, monitor river health and promote greater use and enjoyment of the foreshore. Our major sponsors include: Brighton, Clarence, Derwent Valley, Glenorchy, Hobart and Kingborough councils, the Tasmanian State Government, Hobart Water, Tasmanian Ports Corporation, Norske Skog Boyer and Nyrstar Hobart Smelter.

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1. Abbreviations

ANZECC	Australian and New Zealand Environment Conservation Council
CFU	Colony-forming Unit
cm	Centimetre
DEP	Derwent Estuary Program
mg/L	Milligrams per Litre
ml	Millilitre
mm	Millimetre
NHMRC	National Health and Medical Research Council
NTU	Nephelometric Turbidity Unit
TSS	Total Suspended Solids
ug/L	Micrograms per Litre
WSUD	Water Sensitive Urban Design
WWTP	Waste Water Treatment Plant

2. Introduction

Stormwater is the water which flows across land following precipitation, carrying with it a range of pollutants that have been deposited on the land surface, including pathogens, nutrients, hydrocarbons and heavy metals. In most urban catchments around Hobart, this water enters the Derwent untreated, flowing through a system of kerbs, gutters and pipes. Where stormwater enters urban streams this may also result in downstream flooding and erosion. Stormwater pollutants can significantly degrade water quality and aquatic habitats in the Derwent estuary.

The Derwent estuary receives stormwater from 57 urban and sub-urban catchments by way of 13 major rivulets and several hundred large outlet pipes. Construction sites, roads, industrial sites, commercial areas, eroding stream banks and occasional sewer cross-connections are all sources of stormwater pollution in the catchments surrounding Hobart.

Between 2002 - 2005, the Derwent Estuary Program (DEP) coordinated a stormwater and rivulet monitoring program to assess the pollution levels in several major stormwater inputs to the Derwent estuary. This program was a joint effort between the DEP and the six Southern Tasmanian councils bordering the estuary (Kingborough, Hobart City, Glenorchy City, Derwent Valley, Brighton and Clarence City Councils). The program initially extended over a three year period from July 2002 to July 2005, with 34 monitoring sites in stormwater drains and rivulets around Hobart. The intent of the program was to monitor these sites during base flow conditions for a range of pollutants including sediment, faecal bacteria, nutrients and metals.

After July 2005 there was a five year hiatus before the DEP revised the stormwater and rivulet monitoring program, commencing in August 2010 and finishing in July 2011. The revised program followed the same protocol as the original program, with the same monitoring sites (table 1, figure 1) and identical parameters (table 2), so that results of the two programs could be compared. In total 25 sites were monitored, including upper and lower catchment sites, stormwater drains and dams (an additional four mid-catchment sites were monitored by Hobart and Kingborough Councils – these will be discussed separately). Most sites were identical to the previous monitoring program, however some sites were removed, as they were now considered unsuitable, and two sites (SW021 and SW034) were moved due to access and safety reasons.

Monitoring frequency differed from council to council. In accordance with the previous monitoring protocol, some councils monitored bi-annually, others quarterly and others monthly over the twelve month monitoring period. Monitoring frequency is also shown in table 1.

Table 1: 2010-11 monitoring sites and monitoring frequency.

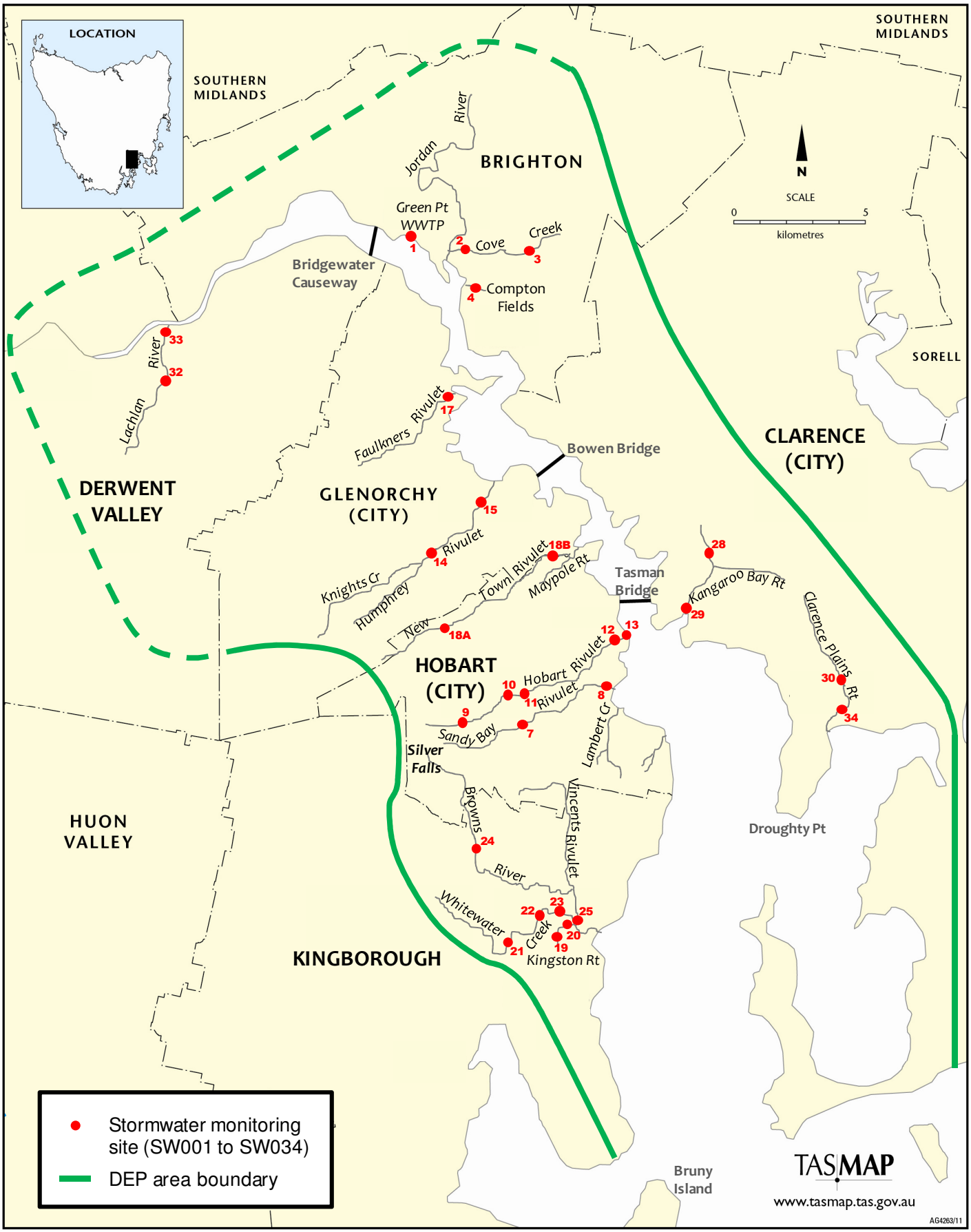
Council	Site ID	Site Location	Monitoring Frequency
Brighton Council	SW001	Green Point WWTP	Quarterly
	SW002	Cove Creek lower site	
	SW003	Cove Creek upper site	
	SW004	Compton Fields	
Hobart City Council	SW007	Sandy Bay Rivulet upper site	Monthly
	SW008	Sandy Bay Rivulet lower site	
	SW009	Hobart Rivulet upper site	
	SW012	Hobart Rivulet lower site	
	SW018A	New Town Rivulet upper site	
Glenorchy City Council	SW014	Humphreys Rivulet upper site	Monthly
	SW015	Humphreys Rivulet lower site	
	SW017	Faulkners Rivulet lower site	
	SW018B	New Town Rivulet lower site	
Kingborough Council	SW019	Kingston Rivulet upper site	Monthly
	SW020	Kingston Rivulet lower site	
	SW021	Whitewater Creek upper site	
	SW023	Whitewater Creek lower site	
	SW024	Browns River upper site	
	SW025	Browns River lower site	
Clarence City Council	SW028	Kangaroo Bay Rivulet upper site	Monthly
	SW029	Kangaroo Bay Rivulet lower site	
	SW030	Clarence Plains Rivulet upper site	
	SW034	Clarence Plains Rivulet lower site	
Derwent Valley Council	SW032	Lachlan River upper site	Bi-annually
	SW033	Lachlan River lower site	

Table 2: 2010-11 monitoring parameters.

Parameter	Units
Total Suspended Solids (TSS)	mg/L
Turbidity	NTU
Enterococci	cfu/100ml
Thermo-tolerant Coliforms	cfu/100ml
Total Nitrogen*	mg/L
Total Phosphorous*	mg/L
Copper*	µg/L
Lead*	µg/L
Zinc*	µg/L
Oil & Grease*	mg/L

*Nutrients, Metals and Oil & Grease samples were tested quarterly only.

Figure 1: 2010-11 monitoring sites.



As with the previous monitoring program, the intention was to monitor for pollutants under base flow conditions. However like the previous program, a range of different weather and rainfall conditions were captured within the twelve month monitoring period. Rainfall data from Ellerslie Road, Hobart has been used in this report to assess the potential impact of rainfall on pollutant levels. Rainfall data for the 24 hours prior to monitoring was used to determine the flow conditions under which sampling occurred. These are described below:

- Base flow – No rainfall in the 24 hours prior to monitoring
- Moderate flow – 0-10mm rainfall in the 24 hours prior to monitoring
- Storm event – More than 10mm rainfall in the 24 hours prior to monitoring

Of the twelve monitoring dates, six were taken during base flow conditions, five were taken during moderate flow conditions and one storm event was captured. The four quarterly sampling dates (which included testing for nutrients and metals) occurred during base flow conditions on three occasions, and during moderate flow conditions on one occasion. All monitoring results are included in the dataset for this report, regardless of weather/flow conditions. Storm event sampling also occurred on August 11th, 2010. The data from this event has not been included in the overall data set, but has been used in rainfall comparisons which are discussed later in the report.

Duplicate samples were taken at some sites throughout the monitoring program for quality assurance purposes, however these results have been omitted from this report. All other results have been included in the data set, including outliers. In most cases medians have been used to convey the central value of data sets and these have been compared to ANZECC (2000) "Trigger values" to gauge water quality performance against National standards. It should be noted that in many cases samples returned values that were less than the laboratory method detection limit. In these cases results were reported as equal to the detection limit for that parameter. This can potentially cause results to be reported as slightly higher than usual.

The objectives of this report are to analyse data from the 2010/11 Stormwater and Rivulet Monitoring Program in order to characterise pollutants entering the Derwent estuary via urban rivulets, identify specific stormwater issues in each municipality, assess the performance of stormwater management strategies and devise plans to improve water quality for the protection of rivulets and the estuary in the future. The results from this monitoring program can also be compared to the previous program to determine possible changes in pollutant concentrations over time.

3. 2010-11 Report Card

The results of the 2010-11 Stormwater and Rivulet Monitoring Program are summarised in figure 2. This 'report card' format was also used to report results from the 2002-05 monitoring program. The report card gives an indication of how sites performed in relation to ANZECC (2000) guidelines, but cannot be used to identify statistically significant changes in water quality. In the report card, each monitoring site was scored against ANZECC (2000) "Trigger values" for six different water quality parameters – TSS, Turbidity, Enterococci, Thermo-tolerant coliforms, total Nitrogen and total Phosphorous. Each site was awarded a point for each parameter that was within the ANZECC trigger value. Where a parameter was within +/- 10% of the trigger value, 0.5 points were awarded for that parameter. The maximum score available was 6/6 – indicating that all six parameters measured at that site were well within the ANZECC (2000) trigger value. This scoring system was identical to the previous report card for comparison purposes.

As can be expected, most upper sites scored fairly well, with the exception of Cove Creek, Whitewater Creek, Kangaroo Bay Rivulet and Clarence Plains Rivulet. On the other hand, most lower sites, stormwater drains and dams scored poorly, generally failing at least three out of the six parameters. Lachlan River, in the Derwent Valley, was an exception, passing all six parameters at both its upper and lower sites.

Many sites failed on three parameters in particular – Enterococci, total Nitrogen and total Phosphorous, indicating that background pollutant levels are unusually high in greater Hobart's rivulets or that the ANZECC trigger values are particularly tight for these parameters. In general water quality decreased from upper to lower sites, and was worse still in stormwater drains and dams.

Figure 2: 2010-11 Report Card.

Site	Site No.	Water clarity: Total suspended solids	Water clarity: Turbidity	Faecal bacteria: Enterococci	Faecal bacteria: Thermo-tolerant coliforms	Nutrients: Total nitrogen	Nutrients: Total phosphorous	Score	Change from 2002-2005 score
ANZECC (2000) 'Trigger value' guideline*		<5 mg/L	<25 (NTU)	<230 CFU/100ml	<1000 CFU/100ml	<0.5 mg/L	<0.05 mg/L		
UPPER RIVULET SITES									
Cove Creek	SW003	✗	✗	✗	✓	✗	✗	1/6	-1.5
Sandy Bay Rivulet	SW007	✓	✓	✓	✓	✗	✗	4/6	-1
Hobart Rivulet	SW009	✓	✓	✓	✓	✓	~	5.5/6	-0.5
Humphreys Rivulet	SW014	✓	✓	✓	✓	✓	✗	5/6	-1
New Town Rivulet	SW018A	✓	✓	✓	✓	✓	✓	6/6	-
Whitewater Creek	SW021	✗	✓	✓	✓	✗	✗	3/6	-1.5
Browns River	SW024	✓	✓	✓	✓	✓	✗	5/6	-1
Kangaroo Bay Rivulet	SW028	✗	✓	✗	✓	~	✗	2.5/6	-0.5
Clarence Plains Rivulet	SW030	✗	✓	✗	✓	✗	✗	2/6	-3
Lachlan River	SW032	✓	✓	✓	✓	✓	✓	6/6	-
LOWER RIVULET SITES									
Cove Creek	SW002	✗	✓	✗	✓	✗	✗	2/6	-
Sandy Bay Rivulet	SW008	✓	✓	✗	✓	✗	✗	3/6	-0.5
Hobart Rivulet	SW012	✓	✓	✗	✗	✗	✗	2/6	-
Humphreys Rivulet	SW015	✗	✓	✓	✓	✓	✗	4/6	-0.5
Faulkners Rivulet	SW017	~	✓	✗	✓	✗	✗	2.5/6	-0.5
New Town Rivulet	SW018B	✓	✓	✗	✓	✗	✗	3/6	-2.5
Whitewater Creek	SW023	✗	✗	✗	✓	✗	✗	1/6	-0.5
Browns River	SW025	✓	✓	✗	✗	✓	~	3.5/6	-1.5
Kangaroo Bay Rivulet	SW029	✗	~	✗	~	✗	✗	1/6	-1.5
Lachlan River	SW033	✓	✓	✓	✓	✓	✓	6/6	+1
Clarence Plains Rivulet	SW034	✗	✓	✓	✓	✗	✗	3/6	+1
STORMWATER DRAINS & COLLECTION DAMS									
Green Point WWTP	SW001	✗	~	✓	✓	✗	✗	2.5/6	+0.5
Compton Fields	SW004	✗	✗	✓	✓	✗	✗	2/6	-
Kingston Rivulet (upper)	SW019	✗	✗	✗	✗	✗	✗	0/6	-
Kingston Rivulet (lower)	SW020	✗	✗	✗	✓	✗	✗	1/6	+1

KEY	
✓	Median water quality value from site is less than ANZECC (2000) "Trigger Value" guideline
✗	Median water quality value from site exceeds ANZECC (2000) "Trigger Value" guideline
~	Median water quality value from site is within 10% of the ANZECC (2000) "Trigger Value" guideline

*TSS, Nitrogen and Phosphorous are measured against default trigger values for slightly disturbed ecosystems in Southeast Australian lowland rivers, detailed in ANZECC (2000).
*Turbidity is measured against default trigger value for slightly disturbed ecosystems in Southeast Australian upland rivers, detailed in ANZECC (2000).
*Faecal bacteria parameters are measured against secondary contact recreational guidelines detailed in ANZECC (2000).

3.1. Comparison with 2002-05 results

The report card can be used to compare results with those of the original 2002-05 monitoring program. In general it appears that water quality has decreased slightly since the original monitoring program. That is, more sites failed to meet ANZECC trigger values in the more recent program. This was particularly the case with the upper sites, which may indicate recent development of land and changing land uses higher in the catchments around the upper sites. Some lower sites had improved water quality including Lachlan River, Clarence Plains Rivulet, Green Point WWTP and Kingston Rivulet.

Clarence Plains Rivulet (upper site) and New Town Rivulet (lower site) had the greatest decreases in water quality, losing 3 points and 2.5 points respectively when compared to results from the 2002-05 monitoring program. This could potentially be due to development in those catchments. On the other hand, water quality improved by one point at Lachlan River (lower site), Clarence Plains Rivulet (lower site) and Kingston Rivulet (lower site). According to the table, Cove Creek and Clarence Plains Rivulet lower sites had better water quality than at their upper sites.

3.2. Summary of rainfall data for 2002-05 and 2010-11 monitoring programs

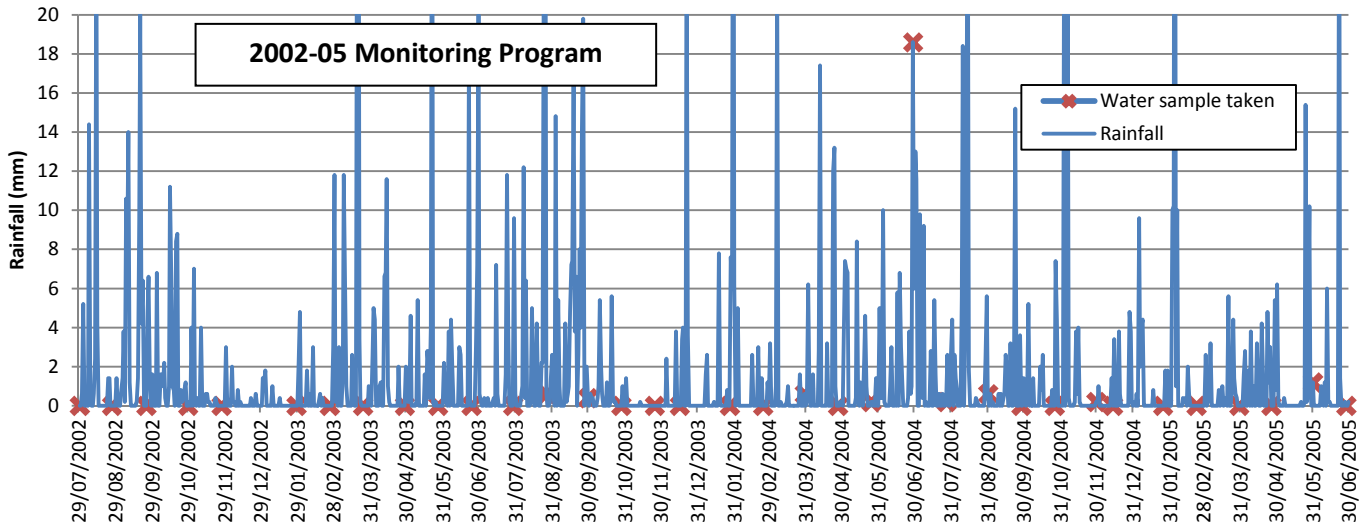
Pollutant concentrations in stormwater can increase significantly during periods of high rainfall, especially during the first few hours of a storm (known as the first flush). Therefore rainfall conditions should be considered when comparing the results of two stormwater monitoring programs over different time periods. As mentioned earlier, the intent of both monitoring programs was to monitor base flow conditions; however moderate flow and storm event conditions were captured in both programs. Table 3 compares stormwater flow conditions and rainfall measured in the 24 hours prior to sampling for each monitoring event in both programs.

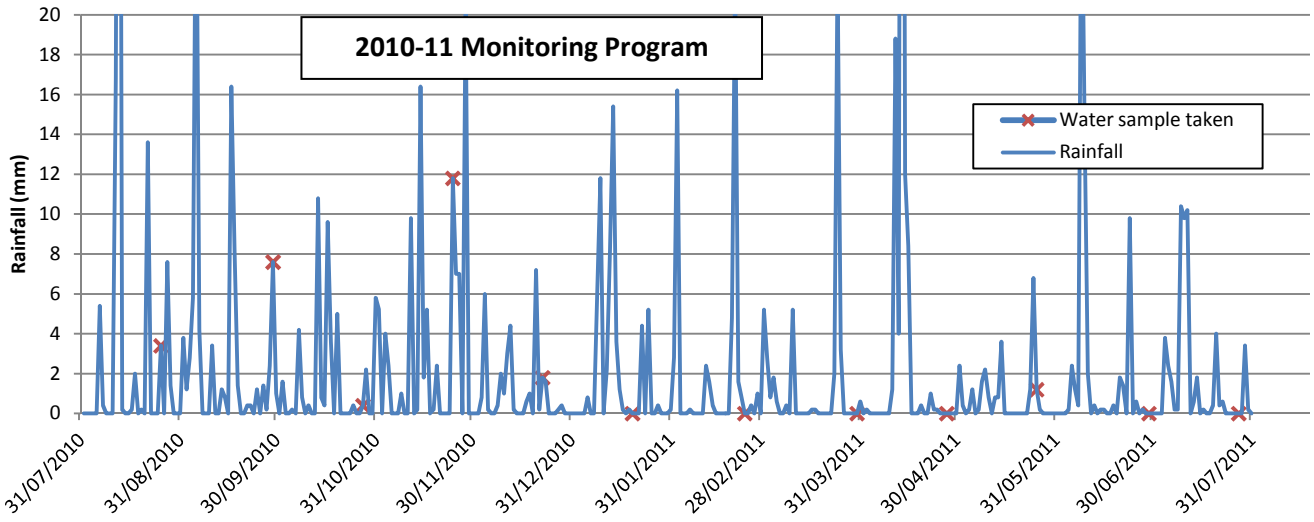
Table 3: Rainfall summary.

	2002-05 Monitoring Program	2010-11 Monitoring Program
Total number of sampling events	35	12
No. of events under base flow conditions	26	6
No. of events under moderate flow conditions	8	5
No. of events under storm conditions	1	1
Average rainfall in 24 hrs prior to sampling	0.6 mm	2.2 mm

Overall the 2002-05 monitoring program had a much higher proportion of dry weather conditions during sampling than occurred in the more recent program. The average rainfall measured in the 24 hrs prior to sampling was almost four times higher during the 2010-11 program. This difference in rainfall patterns may partly explain the decline in water quality observed over the two monitoring periods. Other weather patterns, for example the length of a dry spell before a rain event, may also influence pollutant concentrations, due to a build up of pollutants on hard surfaces prior to rainfall. Daily rainfall patterns for each monitoring program are shown in figure 3.

Figure 3: Comparison of rainfall in the 24 hours prior to sampling in both the 2002-05 and 2010-11 programs.

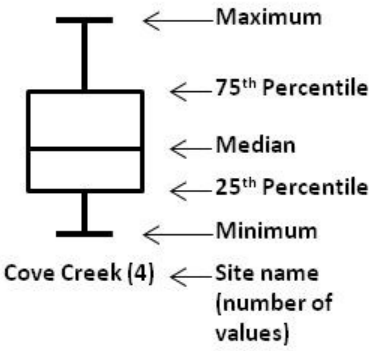




4. 2010-11 Stormwater and Rivulet Monitoring Results

The following chapter includes a series of graphs illustrating pollutant concentrations at each site. For each parameter there are three graphs. The first is a bar graph comparing median values for each parameter at upper and lower sites. The second is a box and whiskers plot demonstrating the spread of values in the data set for lower sites and stormwater drains. Figure 4 shows the features of the box and whiskers plots that are used in this report. The number of values for each site is shown in brackets after the site name, labelled on the x axis of the box and whiskers charts. The third graph compares median results from the 2010-11 monitoring program with results from the 2002-05 program. T-tests have been used to determine significant differences between data sets (for example upper and lower sites, old and new data, etc).

Figure 4: Box and whiskers charts



4.1. Water clarity

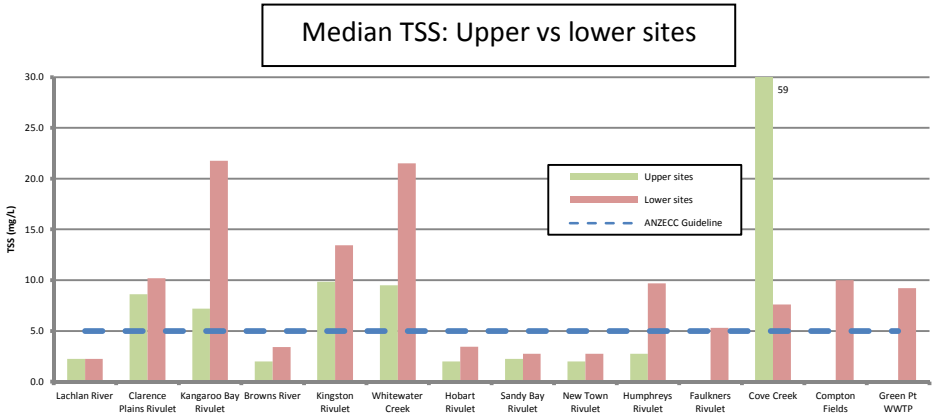
Water clarity results are shown in figure 5.

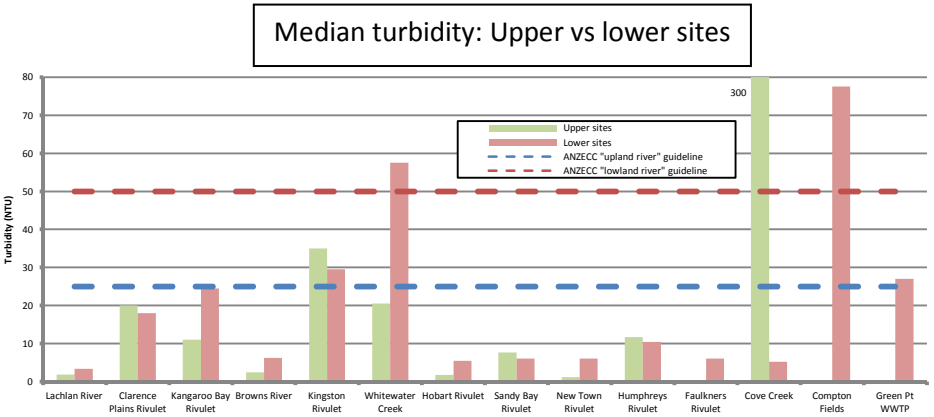
The indicators used to determine water clarity in this monitoring program were Total Suspended Solids (TSS) and turbidity. TSS and turbidity were tested monthly at most sites. TSS results have been compared to an arbitrary trigger value which has been used in previous Derwent Estuary Program (DEP) stormwater monitoring reports. The arbitrary trigger value is derived from TSS data in the ANZECC (2000) guidelines. Turbidity results have been compared to the ANZECC (2000) trigger values for turbidity in upland and lowland rivers in South-eastern Australia, with slightly disturbed ecosystems.

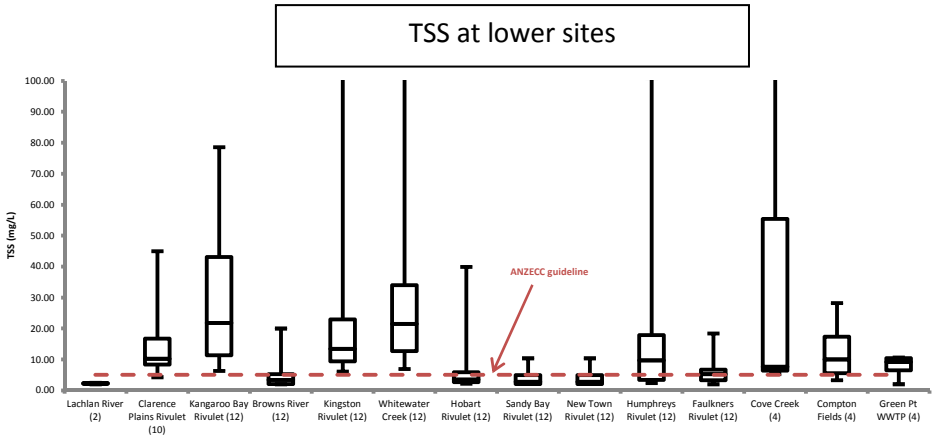
Approximately half of the sites tested for TSS were within the trigger value. This included some upper sites as well as some lower sites. TSS was elevated at three lower sites in particular – Kangaroo Bay Rivulet, Kingston Rivulet and Whitewater Creek. Cove Creek upper site had exceptionally high TSS values. In general lower sites had higher TSS values than upper sites, although these differences were not statistically significant. With the exception of Whitewater Creek, Cove Creek and Compton Fields stormwater pond, most turbidity results fell within the ANZECC (2000) trigger value for lowland rivers.

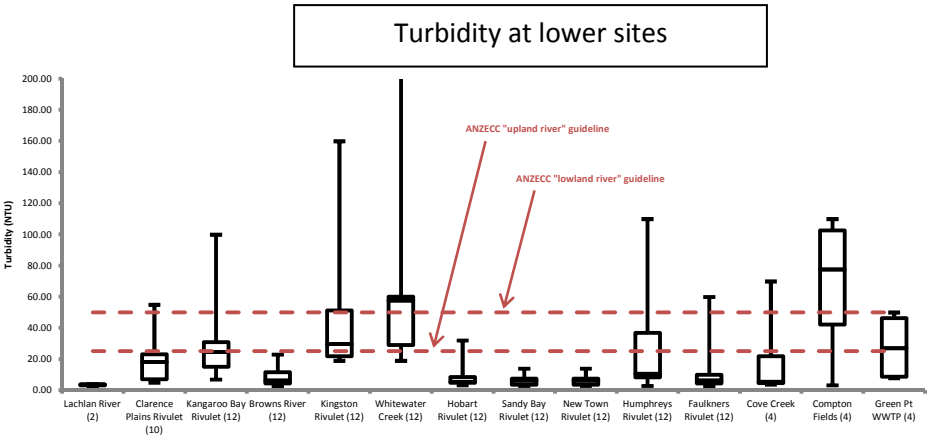
The turbidity and TSS box and whisker plots indicate a considerable amount of variability in the data for each site. However results at Browns River, Hobart Rivulet, Sandy Bay Rivulet and New Town Rivulet lower sites were relatively consistent and were all within the ANZECC (2000) trigger values.

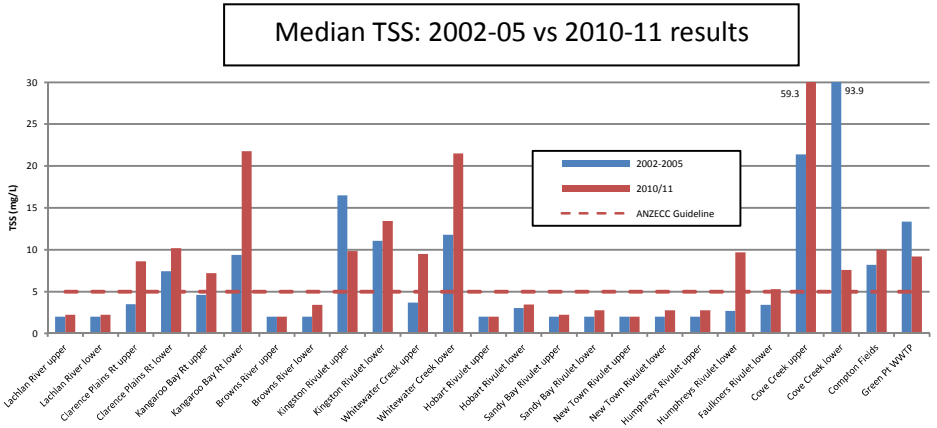
Figure 5: TSS and turbidity charts.

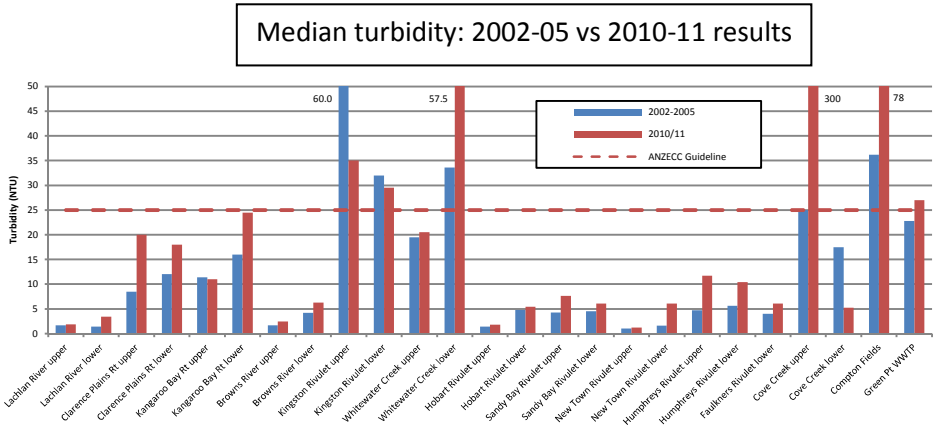








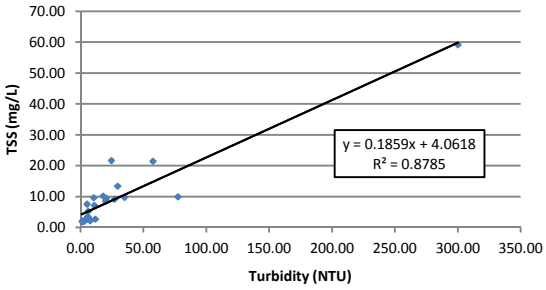




As could be expected, turbidity results correlated well with TSS results, with a correlation coefficient of 0.88. A correlation chart for these parameters is shown in figure 6. Potential relationships between TSS and other parameters were also tested, but no other correlations were found.

TSS results were not significantly different to those observed in the 2002-05 program. However there was a marked increase in TSS at Kangaroo Bay Rivulet (lower site), Whitewater Creek (lower site) and Cove Creek (upper site). Turbidity at Kingston Rivulet upper site has significantly improved since 2002-05.

Figure 6: TSS vs turbidity correlation chart.



4.2. Bacteriological water quality

Enterococci counts, as the preferred bacteriological indicator for recreational water quality, and thermo-tolerant coliforms have been used to assess water quality in this study. Enterococci and thermo-tolerant coliforms were tested monthly at most sites. Results of bacteriological testing are shown in figure 9. Thermo-tolerant coliform counts did not correlate well with Enterococci results. However several sites still reflected similar trends with both tests. Results have been compared with Enterococci and thermo-tolerant primary and secondary contact trigger values from the ANZECC (2000) guidelines for recreational water quality and aesthetics.

Seven out of eleven upper sites tested for Enterococci were within the ANZECC 'secondary contact' trigger value and four out of these seven sites had median values within the ANZECC 'primary contact' trigger value. Upper sites that were not within the ANZECC secondary contact trigger value included Clarence Plains Rivulet, Kangaroo Bay Rivulet, Kingston Rivulet and Cove Creek. The majority of sites tested for thermo-tolerant coliforms were within the ANZECC secondary contact trigger value. Browns River, Kangaroo Bay Rivulet and Hobart Rivulet were the only lower sites that exceeded the ANZECC secondary contact trigger value for thermo-tolerant coliforms.

As could be expected, Enterococci and thermo-tolerant coliform counts were generally higher at lower sites and stormwater drains than at upper rivulet sites. Enterococci and thermo-tolerant coliform counts were significantly higher at Browns River, Hobart Rivulet, Sandy Bay Rivulet and New Town Rivulet lower sites than at their upper sites.

Most lower sites were not within the ANZECC secondary contact trigger value and only two lower sites – Lachlan River and Green Point Waste Water Treatment Plant (WWTP) stormwater pond were within the ANZECC primary contact trigger value.

The Derwent Estuary Program (DEP) also uses the Australian National Health and Medical Research Council (NHMRC) Guidelines for Managing Risks in Recreational Water (2008) to assess bacteriological water quality in other monitoring programs. Rivulet and stormwater monitoring results have also been compared against these guidelines in order to gauge stormwater quality against recreational water quality at other sites monitored by the DEP.

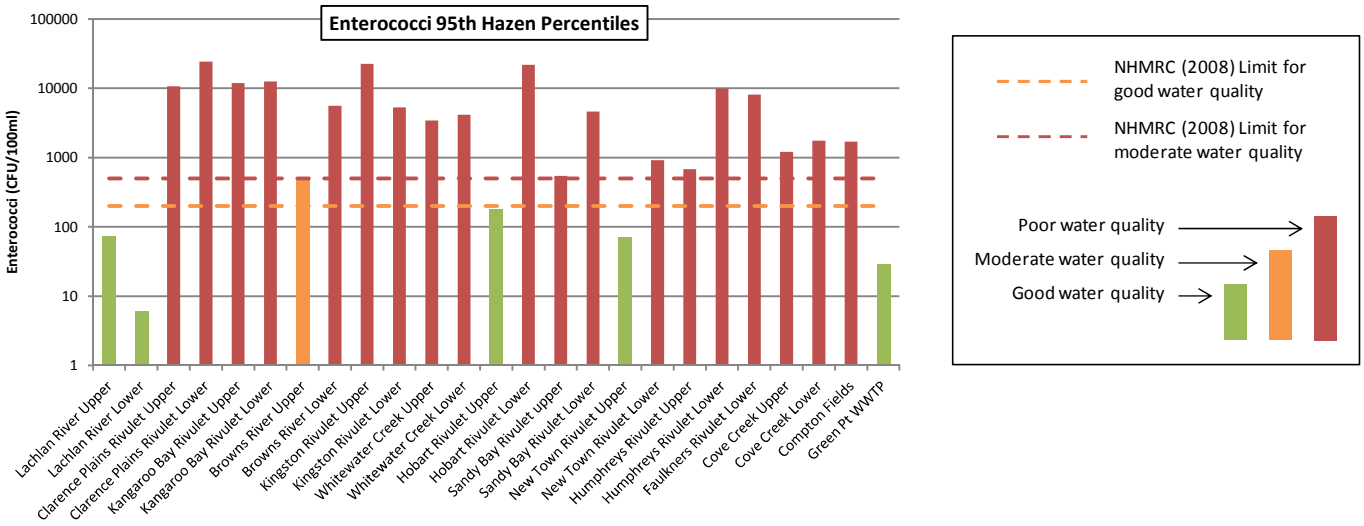
The NHMRC guidelines use 95th Hazen percentiles of Enterococci results to sort recreational water quality into the following three categories:

- <200 CFU/100ml – Good water quality
- 200-500 CFU/100ml – Moderate water quality
- >500 CFU/100ml – Poor water quality

According to the NHMRC Enterococci guidelines, Lachlan River upper and lower sites, Hobart Rivulet and New Town Rivulet upper sites, and Green Point WWTP stormwater pond all had 95th Hazen percentiles below 200 CFU/100ml, indicating good water quality at these sites. The 95th Hazen percentile for Browns River upper

site was between 200-500 CFU/100ml, indicating moderate water quality at this site. All other sites had 95th Hazen percentiles exceeding 500 CFU/100ml, indicating poor water quality at the remaining sites. 95th Hazen percentile chart is shown in figure 7.

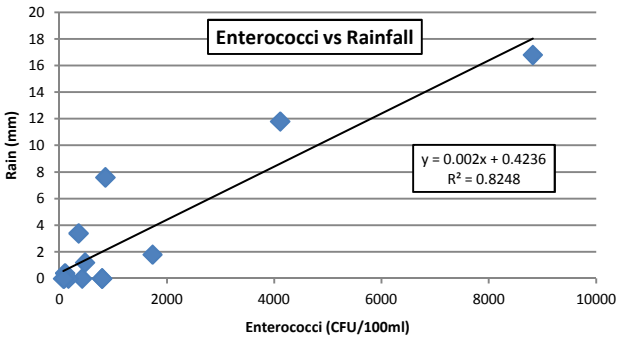
Figure 7: 95th Hazen percentiles for Enterococci at each site.



Bacteriological water quality has not changed significantly since the 2002-05 monitoring program, with the exception of one site – Green Point WWTP stormwater pond, which has significantly improved (Enterococci and thermo-tolerant coliforms).

Enterococci and thermo-tolerant coliforms were the only parameters to correlate with rainfall. This indicates that faecal pollutants generally increased in concentration with rainfall. Correlation charts for these parameters are shown in figure 8, below.

Figure 8: Correlation charts for Enterococci and thermo-tolerant coliforms with rainfall.



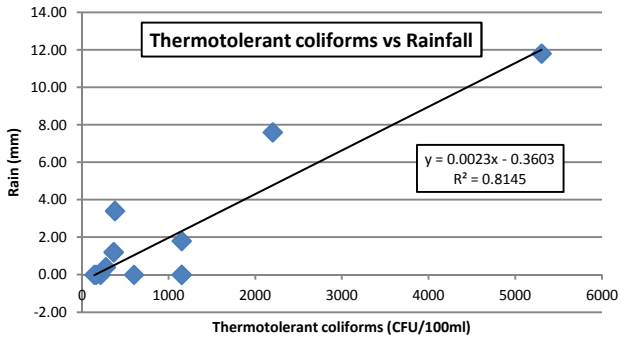
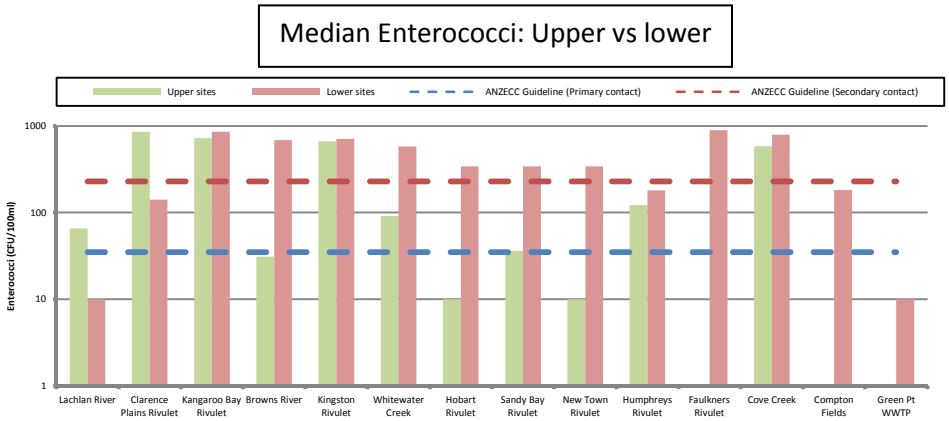
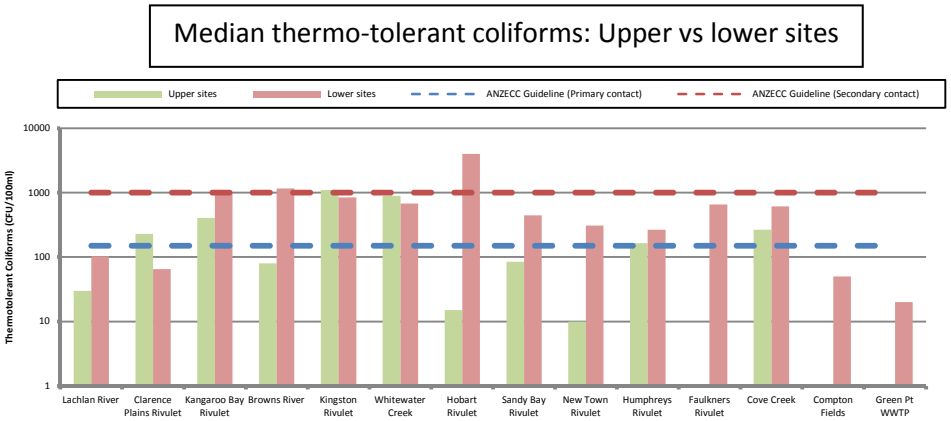
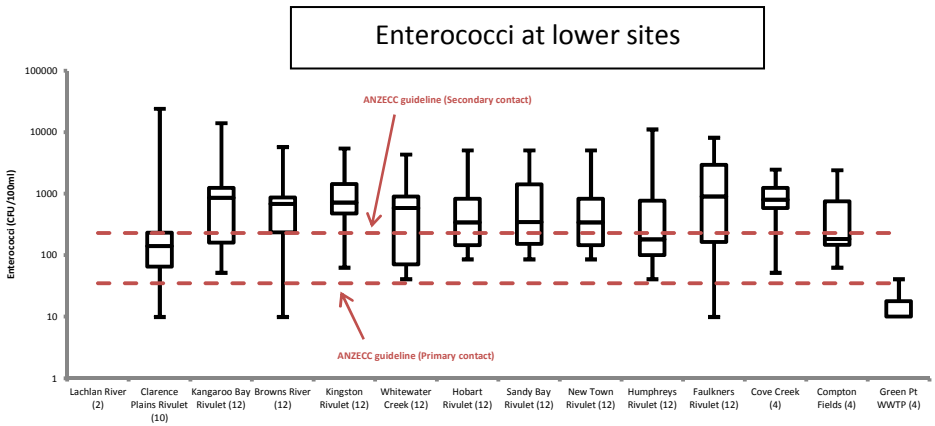
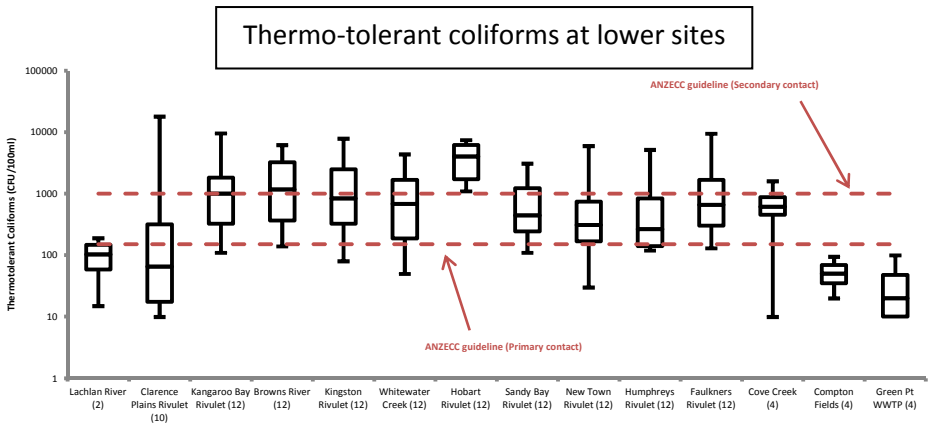


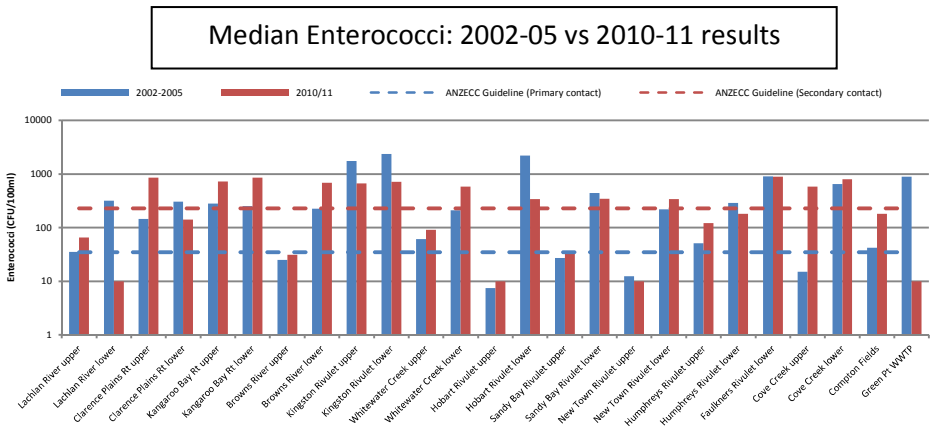
Figure 9: Enterococci and thermo-tolerant coliform charts.

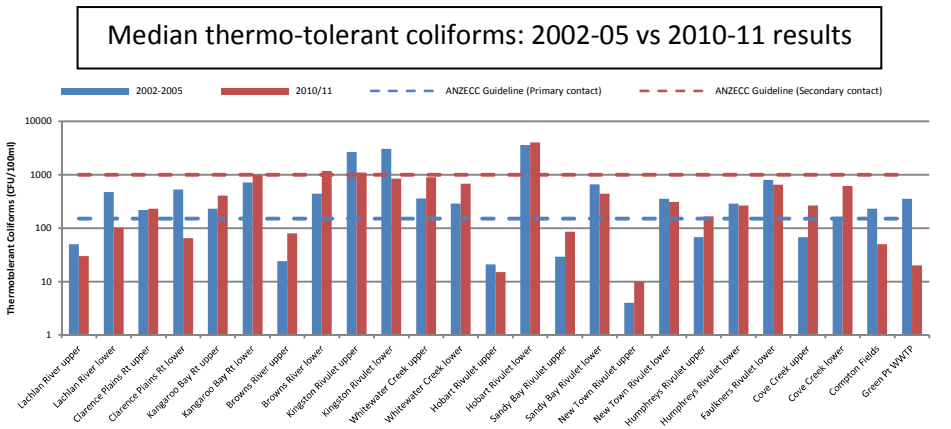












4.3. Nutrients

Total Nitrogen and total Phosphorous testing was completed quarterly at all sites except Lachlan River, which was tested twice over the twelve month monitoring period, according to the monitoring protocol. Nitrogen and Phosphorous results have been compared with ANZECC (2000) trigger values for lowland rivers in South-eastern Australia with slightly disturbed ecosystems. Results are shown in figure 11.

There were only four Nitrogen and Phosphorous results for each site resulting in a small data set with considerable variability between results. As with most other parameters, there was no correlation between Nitrogen and Phosphorous levels.

Three lower sites had Nitrogen levels below the ANZECC (2000) trigger value – Lachlan River, Browns River and Humphreys Rivulet. Nitrogen levels were particularly elevated in Kingston Rivulet (upper and lower sites), Cove Creek (upper and lower sites) and Compton Fields stormwater pond. In general Nitrogen levels were higher at lower sites. Kangaroo Bay Rivulet, Hobart Rivulet and Cove Creek lower sites had significantly higher levels of Nitrogen at lower sites compared to upper sites.

Interestingly, Phosphorous levels demonstrated a different trend to Nitrogen, with several rivulets having higher Phosphorous concentrations at upper sites compared to lower sites. Lachlan River, Clarence Plains Rivulet, Browns River, Whitewater Creek and Cove Creek all had higher Phosphorous levels at upper sites than at lower sites. Of the 25 sites monitored, Lachlan River (upper and lower sites) and New Town Rivulet (upper site) were the only sites to have Phosphorous levels within the ANZECC (2000) trigger value. Phosphorous levels were particularly high in Kingston Rivulet (upper and lower sites) and Cove Creek (upper and lower sites).

Although Phosphorous results did not correlate statistically with TSS results, there was an apparent relationship between these two parameters when comparing all results from both monitoring programs. This suggests that Phosphorous bonds well with sediment particles. Further testing and comparison of these two parameters could define this relationship more clearly. A correlation chart for Phosphorous and TSS is shown in figure 10.

When comparing nutrient levels over time, Nitrogen and Phosphorous concentrations displayed very different characteristics. Total Nitrogen levels were similar to those observed five years ago, although Kingston Rivulet, Whitewater Creek and New Town Rivulet (lower sites) had elevated levels, and Cove Creek lower site had a significant increase in TN levels. On the other hand, Phosphorous concentrations were elevated at most sites compared to the 2002-05 results. Phosphorous levels were significantly worse at several sites including Humphreys Rivulet (upper and lower sites), Whitewater Creek (upper site) and Compton Fields. Elevated Phosphorous levels could be due to a number of possibilities including sewage contamination, increased use of fertilisers in dense residential areas or higher rainfall/flow conditions.

Figure 10: Total Phosphorous vs TSS correlation chart.

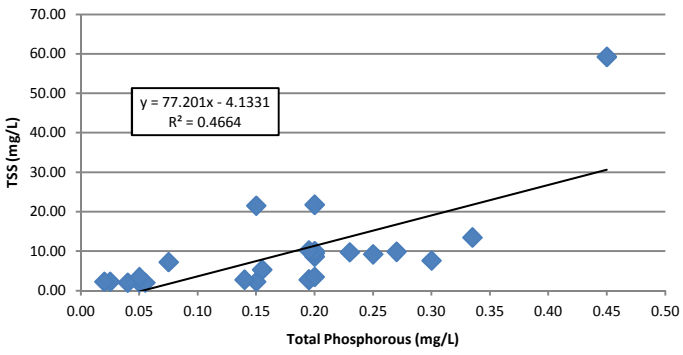
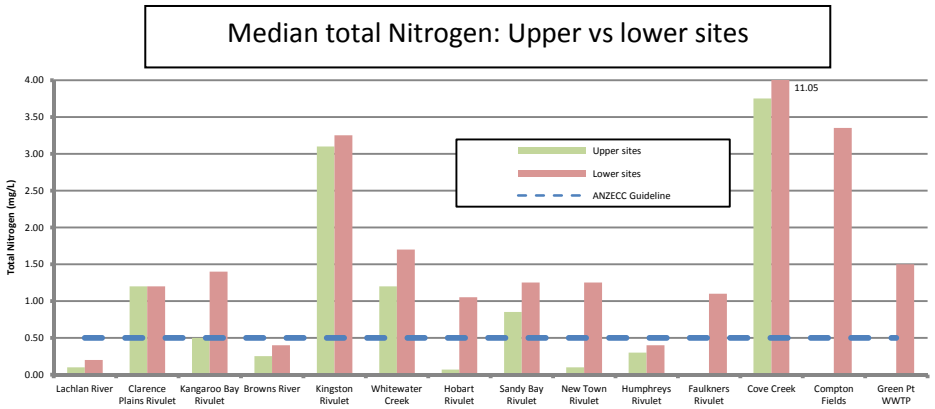
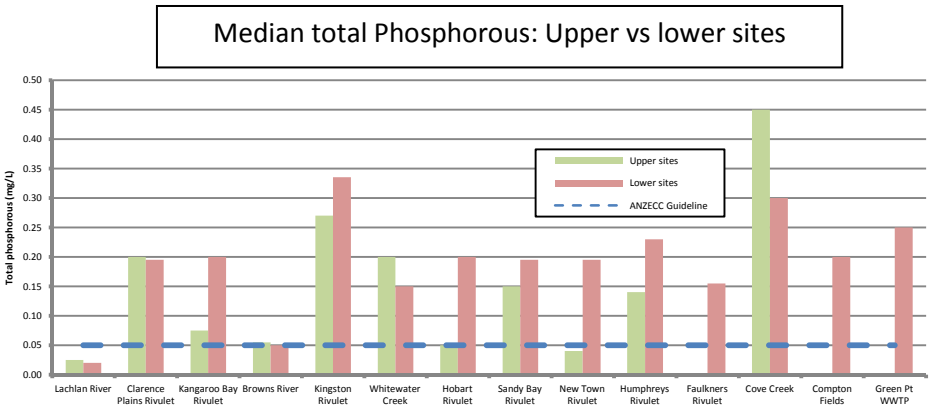
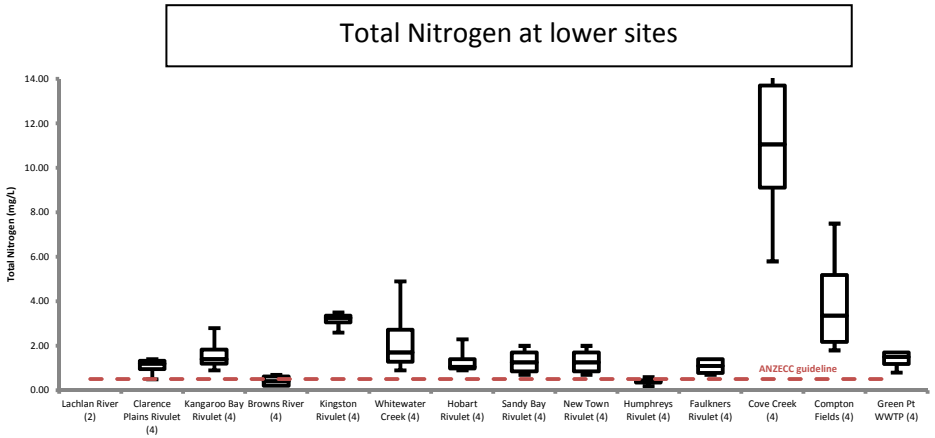
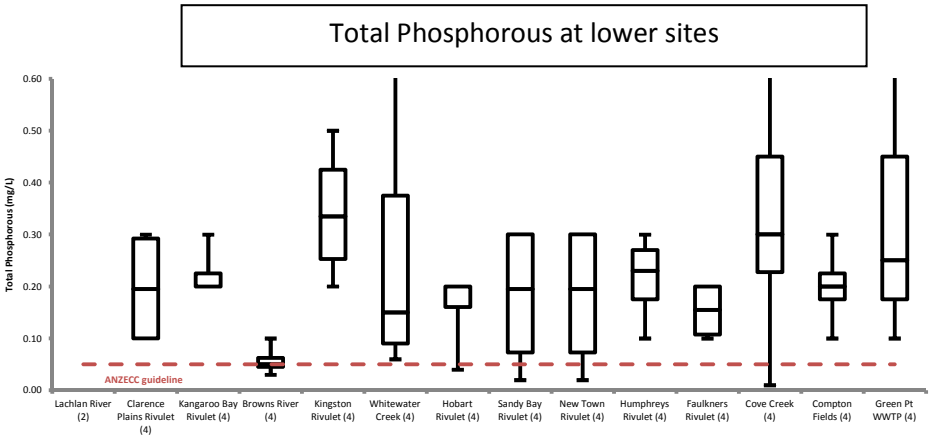


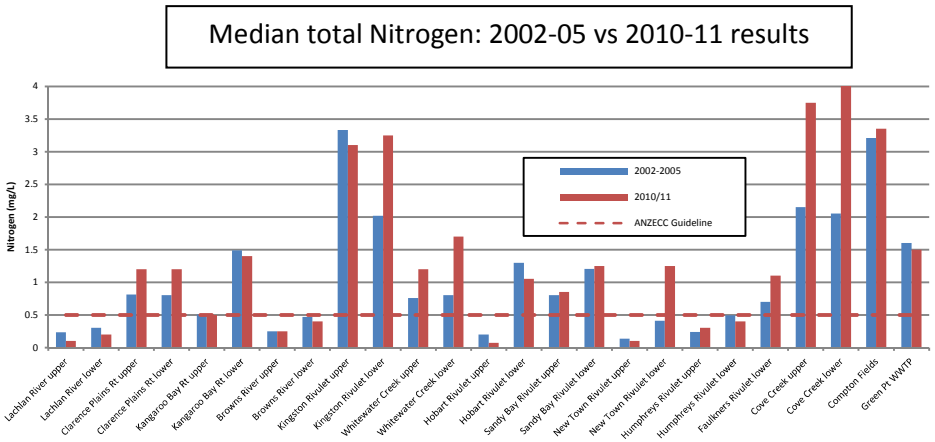
Figure 11: Total Nitrogen and total Phosphorous charts.

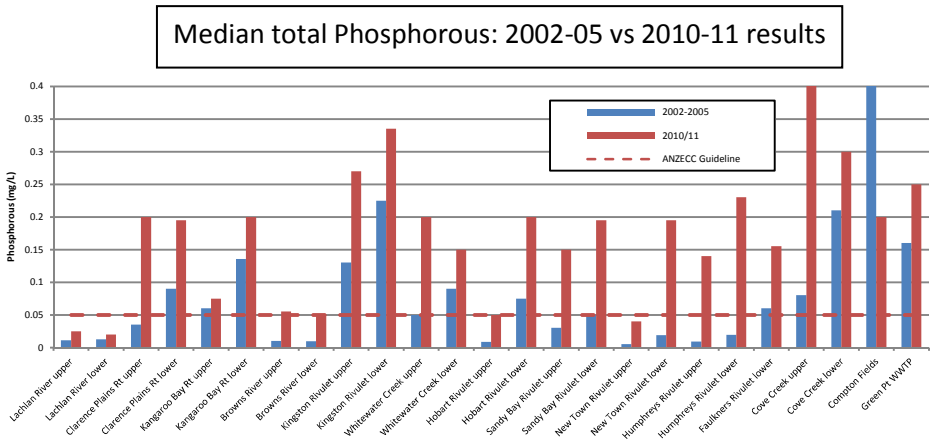












4.4. Metals

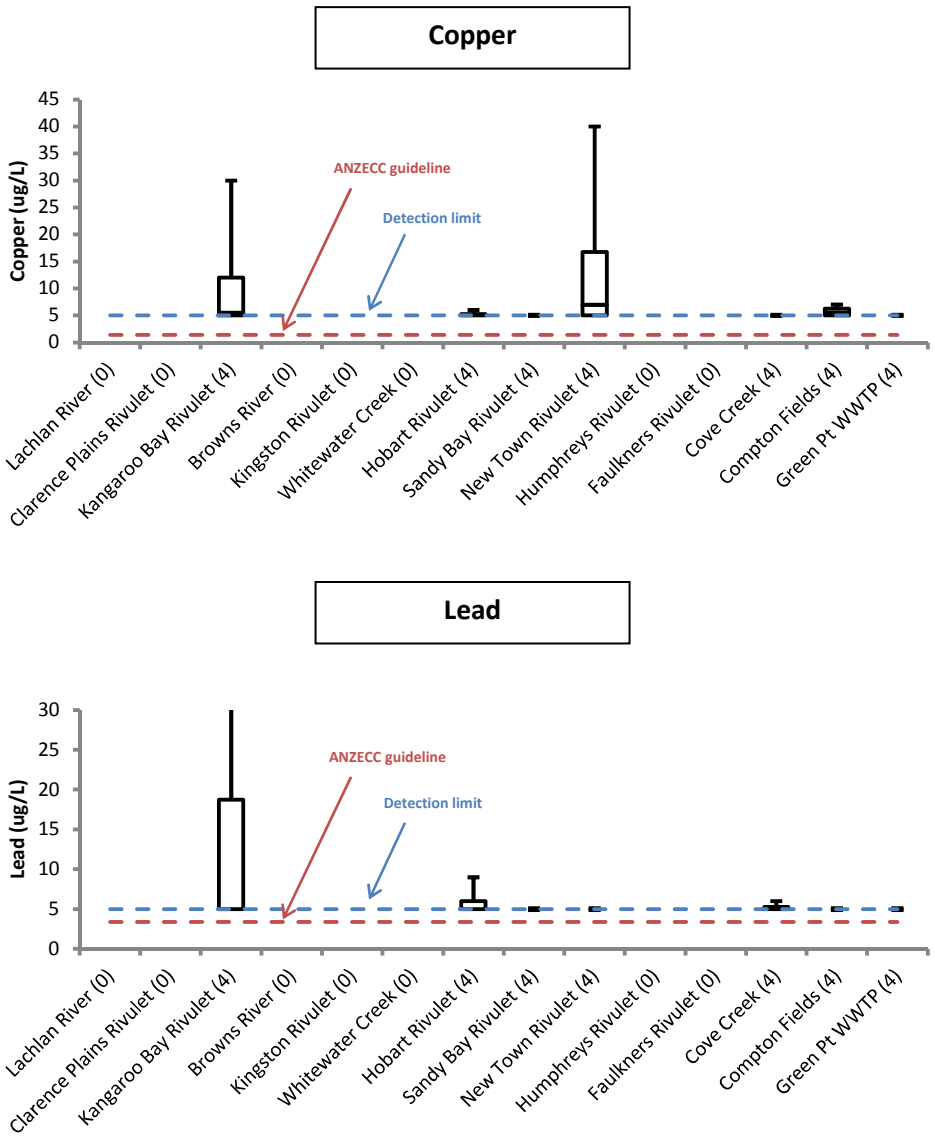
Copper, lead and zinc were tested at selected sites on a quarterly basis. Metals were only tested at lower sites in Kangaroo Bay Rivulet, Hobart Rivulet, Sandy Bay Rivulet, New Town Rivulet, Cove Creek, Compton Fields stormwater pond and Green Point WWTP stormwater pond. Metals results are shown in figure 12.

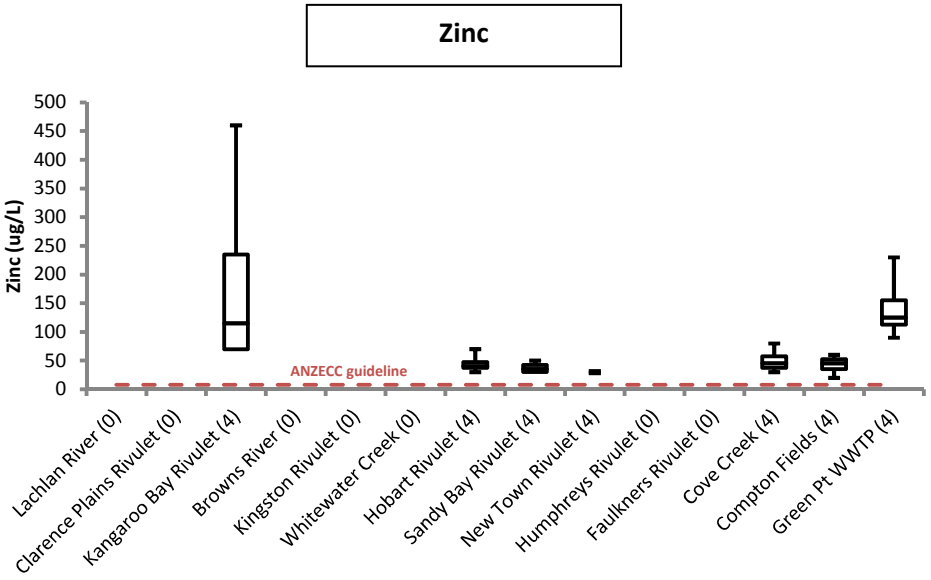
Due to the small data set and insufficient laboratory test sensitivities, metals results from this survey do not provide a reliable indication of water quality. Metals concentrations that were below the detection limit have been reported as equal to the detection limit. For copper, 20 out of 28 samples tested were less than the detection limit. For lead, 24 out of 28 samples tested were below the detection limit. Zinc results were all above the laboratory detection limit.

Metals results have been compared against ANZECC (2000) trigger values for the protection of 95% of freshwater species. Median results for copper, lead and zinc were all around 2-10 times higher than ANZECC (2000) trigger values. However, in some cases detection limits exceeded the ANZECC (2000) trigger value. Detection limits are also shown in figure 11.

There was insufficient data available to compare copper and lead results between the two monitoring programs. However, zinc results were similar in both monitoring programs.

Figure 12: Copper, lead and zinc charts.





4.5. Oil & Grease

Of the 48 samples that were tested for Oil and Grease, 46 results were less than the 1mg/L laboratory detection limit. Whitewater Creek and Cove Creek lower sites had one sample each that returned a result of 1mg/L – equal to the detection limit. These results are similar to those observed in the 2002-05 monitoring program, where oil and grease were detected at low levels at Compton Fields and Cove Creek lower site only. The current sampling methodology is not particularly well suited for oil and grease testing. Oil and grease samples should ideally be taken by 'skimming' the surface of the water, whereas all samples in this monitoring program were taken at a depth of 15-30cm below the surface.

5. Council Reports

The following chapters summarise results for each Council. Potential pollution sources are also identified in tables 4-9, as well as some comments on possible solutions to help reduce pollutant levels at sites with water quality issues.

5.1. Kingborough Council

Six sites were monitored by Kingborough Council during the 2010-11 stormwater and rivulet monitoring period. These included upper and lower sites in Browns River, Kingston Rivulet and Whitewater Creek, representing some of Kingborough's major urban catchments. Samples were taken monthly. Median results were similar to those obtained during the 2002-05 monitoring program. When rated against ANZECC (2000) guidelines, Browns River and Whitewater Creek results were worse than in the previous program, but Kingston Rivulet improved.

Kingborough Council also monitored an additional mid-catchment site on Whitewater Creek (SW022). Median TSS levels at this site were higher than at the lower site. Median Enterococci levels were similar to those observed at the lower site. Total Nitrogen levels were roughly in between the levels observed at Whitewater upper and lower sites, however total Nitrogen was higher at the mid-catchment site than at the upper and lower sites. Table 4 is a summary of notable water quality issues at Kingborough sites.

Table 4: Summary of stormwater quality issues observed at Kingborough Council monitoring sites.

KINGSTON RIVULET	COMMENTS
Elevated TSS at upper and lower sites, although upper site has improved since the 2002-05 program.	Decline in TSS could be due to completion of majority of residential development in upper catchment.
Enterococci levels exceed ANZECC (2000) and NHMRC (2008) guideline limits at both upper and lower sites.	Sewage overflows/cross-connections could be the cause of elevated Enterococci and nutrient levels. Further WSUD projects throughout the catchment could address nutrient issues. Performance of Kingston wetlands could also be monitored to determine removal rates for these pollutants.
Elevated nutrients at upper and lower sites. Consistent with 2002-05 results, but now is slightly worse.	
WHITEWATER CREEK	
TSS elevated at mid and lower sites. Higher at all sites now compared with 2002-05 results.	Elevated TSS at mid and lower sites is most likely due to roadworks and in-stream works during the monitoring program.
Enterococci levels exceed ANZECC and NHMRC guidelines.	Elevated nutrients and Enterococci could be a reflection of the agricultural nature of the upper catchment.
Nutrients slightly elevated at upper and lower sites and have increased since the 2002-05 program.	
BROWNS RIVER	
Overall water quality was quite good at upper and lower sites, but Enterococci levels exceeded ANZECC and NHMRC guidelines at the lower sites.	Possible sources of faecal contamination in Browns River mid and lower catchment should be investigated.

5.2. Hobart City Council

Hobart City Council monitored upper and lower sites in Hobart Rivulet and Sandy Bay Rivulet, as well as an upper site in New Town Rivulet. New Town Rivulet lower site was monitored by Glenorchy City Council. Samples were taken monthly. Overall water quality showed similar trends to other sites with a slight decrease in water quality since the 2002-05 monitoring program. When scored against ANZECC (2000) guidelines, New Town Rivulet lower site has had a particularly pronounced decrease in water quality since the last monitoring program. Water quality results were very similar for all three Rivulets, with good TSS results but elevated Enterococci levels and nutrients. All three Rivulets also have similar land uses in their catchments – a mix of urban and commercial with some light industrial. Therefore potential pollution sources and recommendations for improvements are similar for all three Rivulets.

Hobart City Council also monitored Enterococci levels at three additional Hobart Rivulet sites – directly upstream of the McRobies Gully outfall, directly downstream of the McRobies Gully outfall and at Macquarie Point, in the mouth of the Rivulet. Enterococci results were low on both sides of the McRobies Gully outfall, suggesting that Enterococci loads from McRobies Gully Rivulet are not high. Enterococci levels at Macquarie Point were higher than those observed at the Hobart Rivulet lower site.

Table 5: Summary of stormwater quality issues observed at Hobart City Council monitoring sites.

HOBART RIVULET	COMMENTS
TSS remained low at upper and lower sites.	None.
Enterococci levels were high at the lower site and Macquarie Point. Both sites failed to meet ANZECC and NHMRC guidelines for Enterococci.	High enterococci and nutrient levels at lower sites only indicates that there may be significant sources of faecal contamination entering the Rivulet in the mid and lower catchment. Possible sources of faecal contamination include cross connections between stormwater and sewer pipes and possible sewage overflows during high stormwater flows. Further implementation of WSUD projects in the Hobart Rivulet mid and lower catchment could potentially reduce nutrient loads to the Derwent estuary.
Nutrients were elevated at the lower site. The median Phosphorous level at the upper site increased slightly, but moved above the ANZECC trigger value, bringing the score down (-0.5 points) according to the score card.	
SANDY BAY RIVULET	
Median Phosphorous results for both the upper and lower sites moved above the ANZECC trigger value, accounting for a loss of 1 point for the upper site and 0.5 points for the lower site on the score card.	As above.
NEW TOWN RIVULET	
Median Enterococci, total Phosphorous and total Nitrogen results at the lower site all moved above the ANZECC trigger value – equating to a loss of 2.5 points on the score card.	As above.

5.3. Glenorchy City Council

Glenorchy City Council monitored upper and lower sites in Humphreys Rivulet, a lower site in New Town Rivulet and a lower site in Faulkners Rivulet. Hobart City Council monitored the upper site in New Town Rivulet. Samples were taken monthly. When measured against ANZECC (2000) guidelines, New Town and Faulkners Rivulet lower sites had average water quality, but Humphreys Rivulet had comparatively good water quality. Water quality at all sites was slightly worse than when monitored in the 2002-05 program.

Table 6: Summary of stormwater quality issues observed at Glenorchy City Council monitoring sites.

NEW TOWN RIVULET	COMMENTS
TSS remained low at upper and lower sites.	Results were similar to those observed in the 2002-05 program.
Enterococci levels exceeded ANZECC and NHMRC guidelines at the lower site.	High enterococci and nutrient levels at lower sites only indicates that there may be significant sources of faecal contamination entering the Rivulet in the mid and lower catchment. Possible sources of faecal contamination include cross connections between stormwater and sewer pipes and possible sewage overflows during high stormwater flows. Further implementation of WSUD projects in the New Town Rivulet mid and lower catchment could reduce nutrient loads to the Derwent estuary.
Nutrient levels were elevated, particularly compared to 2002-05 results.	
HUMPHREYS RIVULET	
TSS elevated at lower site, particularly compared to 2002-05 results.	Elevated TSS indicates possible sediment inputs from construction sites or stream bank erosion due to increased stormwater loads. Regulation of construction site sediment controls and implementation of WSUD features may help to address this issue.
Enterococci levels were within ANZECC secondary contact guidelines, but far exceeded NHMRC guidelines.	Elevated Enterococci levels indicate that sewage may be entering the stormwater system. Construction of a wetlands system at Grove reserve could further improve nutrient and bacteriological water quality in this catchment.
Total Nitrogen results were good for both the upper and lower site, but phosphorous levels increased significantly since the 2002-05 program.	
FAULKNERS RIVULET	
Enterococci levels exceeded ANZECC and NHMRC guidelines.	High enterococci levels may be due to overflows/leaks from sewage infrastructure. Construction of a wetland at Windermere Bay could help improve bacteriological water quality.

5.4. Derwent Valley Council

Derwent Valley Council monitored two sites – Lachlan River upper and lower, on a bi-annual basis. Lachlan River had the best overall water quality of all the sites monitored. All parameters were well within ANZECC (2000) and NHMRC (2008) guidelines. This was an improvement on the previous mentoring program, as Enterococci levels were not previously within the ANZECC guidelines at the lower site. According to the monitoring protocol only two samples were taken at each site over the twelve month monitoring period, so the data may not be representative of actual water quality.

Table 7: Summary of stormwater quality issues observed at Derwent Valley Council monitoring sites.

LACHLAN RIVER	COMMENTS
Good water quality in general at both upper and lower sites.	Alternative monitoring sites could be investigated in New Norfolk. A representative site should be used which captures stormwater drainage from the most urbanised area of New Norfolk, prior to discharge to either the Lachlan or Derwent Rivers. Monthly sampling should be considered.
Enterococci levels at the lower site have decreased since the 2002-05 program and are now within ANZECC primary contact guidelines.	Improved Enterococci results could potentially be a reflection of better sewage management and regulation of on-site waste water treatment systems.

5.5. Brighton Council

Brighton Council monitored four sites on a quarterly basis. These included upper and lower sites in Cove Creek, a stormwater pond near the Green Point WWTP and in a small creek running into a stormwater pond at Compton Fields. When compared against ANZECC (2000) guidelines, results were very similar to those observed in the 2002-05 program. However Green Point WWTP was one of the few sites that improved since the last monitoring program. Cove Creek seems to have significant issues which have continued since the last program. The data set for Cove Creek is relatively small with considerable variability between results. Further monitoring of Cove Creek should be conducted to better characterise pollutant levels and identify possible sources.

Table 8: Summary of stormwater quality issues observed at Brighton Council monitoring sites.

COVE CREEK	COMMENTS
All parameters elevated at both upper and lower sites. Probably the worst water quality of all sites, although data should be interpreted carefully due to the small data set and variability within the results.	Residential development in upper catchment on highly dispersive soil may be causing fluxes. This should be investigated. Possible inputs in upper catchment should also be investigated. Recent re-alignment and modification of the Creek may be affecting results.
COMPTON FIELDS	
Enterococci levels increased compared to 2002-05, but were still within ANZECC secondary contact guidelines.	Nutrient and Enterococci levels remain elevated. Catchment is fully rural, so Enterococci and nutrient levels may be due to stock and cropping practices. Further investigation of potential faecal contamination and nutrient sources should be investigated.
Nutrient levels remain elevated.	
GREEN POINT WWTP STORMWATER POND	
Enterococci levels were within ANZECC primary contact and NHMRC guidelines. This was a significant improvement on 2002-05 results.	Continuing good results at this site may be aided by the recent installation of an upstream gross pollutant trap. Further rehabilitation of the Creek running into the stormwater pond could ensure high water quality is maintained in the future, especially considering the stormwater is used in the Brighton re-use scheme.

5.6. Clarence City Council

Clarence Council monitored four sites – Clarence Plains Rivulet (upper and lower sites) and Kangaroo Bay Rivulet (upper and lower). Samples were taken monthly. Samples taken at Clarence Plains Rivulet lower site were within ANZECC guidelines more frequently than samples from the upper site. The opposite was true for Kangaroo Bay Rivulet results. This may be due to significant development of the Clarence Plains upper catchment.

Table 9: Summary of stormwater quality issues observed at Clarence City Council monitoring sites.

CLARENCE PLAINS RIVULET	COMMENTS
Increased TSS at both upper and lower sites, particularly since the 2002-05 program.	Poor water quality results at Clarence Plains upper site may be a reflection of the increased development in the upper catchment. Construction sites may be a potential source of sediment in the upper catchment. Appropriate rehabilitation of the Rivulet and installation of WSUD elements in the catchment could also help improve water quality. Elevated Enterococci levels at the upper site may be due to faecal contamination from wildlife living in the bushland in the upper catchment. Agricultural in the upper catchment may also be contributing to the elevated Enterococci and nutrient levels at the upper site, while composting on residential properties may be causing elevated nutrient levels in the lower catchment. Due to the amount of new development around the Clarence Plains Rivulet upper site, an alternative monitoring site should be investigated, in order to better gauge background pollutant levels.
Enterococci levels increased at the upper site, but decreased at the lower site. Lower site is now within ANZECC secondary contact guideline, but upper site now exceeds the ANZECC guideline.	
Elevated nutrients at both sites. Nutrient levels have increased at both sites since the 2002-05 program.	
KANGAROO BAY RIVULET	
TSS at both upper and lower sites has increased since the 2002-05 program.	Elevated Enterococci and nutrient levels may be due to sewage overflows or cross connection with stormwater. Domestic animals and composting units in the residential area in the mid-lower catchment may also be contributing to the elevated nutrient and Enterococci levels. Wild ducks, geese and native hens in the lower catchment may also be contributing to elevated Enterococci levels at the lower site. Wild animals in bushland in the upper catchment may also be contributing to Enterococci levels at the upper site. Implementation of WSUD could be investigated in order to improve Enterococci and nutrient levels. The ponds in Kangaroo Bay Rivulet located adjacent to the Council chambers could potentially be developed into a wetland system. Likewise, WSUD options near the mouth of the Rivulet and near Rosny Hill Road could also be investigated.
Enterococci levels exceed ANZECC and NHMRC guidelines at both sites.	
Nutrients elevated at lower site.	

6. Conclusion

Stormwater quality was monitored at 25 sites around the greater Hobart region over a twelve month period from August 2010 to July 2011. In general, water quality has not changed significantly since it was last monitored during 2002-05. While there has been a slight degradation of water quality at most sites monitored, others have seen significant improvements in certain parameters. Improvements at certain sites could be due to a range of factors:

- Changing land uses in catchments (for example, some catchments that previously had large amounts of residential construction work are now fully developed, resulting in improved TSS and turbidity results); or
- Different local weather/flow conditions during sampling.

Decreased water quality at other sites may be due to:

- Aging sewerage infrastructure resulting in higher levels of faecal contamination;
- In-stream creek works;
- Increased residential development/urbanisation; or
- Increased rainfall/flow conditions compared to the previous monitoring period.

Bacteriological water quality, particularly at most lower sites, was poor. This, combined with elevated nutrient levels suggests that sewage may be entering stormwater drains and rivulets. This could be due to cross connections between sewage and stormwater pipes or sewage overflows. TSS was also elevated at several sites indicating that further attention should be given to preventing sediment sources to stormwater including regulating sediment and erosion control on construction sites and promoting the use of WSUD features to minimise stormwater volumes and prevent stream bank erosion.

Stormwater drains and rivulets often flow to popular recreational waters around Hobart. Thus, ANZECC (2000) and NHMRC (2008) guidelines for recreational water quality have been used to gauge water quality at the 25 sites monitored in this program. When compared to ANZECC (2000) guidelines, it is clear that overall water quality has declined since 2005, with many sites dropping just below the ANZECC (2000) trigger values. While T-tests demonstrated that water quality did not decline significantly at the majority of sites, several results were slightly higher than those observed in the 2002-05 program and now exceed the ANZECC (2000) guidelines. Because the ANZECC (2000) guidelines were used to score each site in the score card, this explains the notable decline in water quality as represented in figure 2.

While there are undoubtedly issues in greater Hobart's catchments contributing to the elevated pollutant levels observed in this report, climatic factors may have also influenced these results as well as having a small data set. As mentioned in chapter 2.2, sampling days in the most recent monitoring program were almost four times 'wetter' on average than in the 2002-05 program.

Rainfall has an intrinsic link with pollutant levels especially relating to first flush stormwater flows with initial surface runoff of a rainstorm having more concentrated pollutant concentration or load than typical base flows or samples taken at the tail end of a rainfall event. The higher frequency of rainfall events within the 2010-11 program could explain the higher concentrations at many sites and on several occasions.

Storm event monitoring should be considered in the future in order to better characterise the impact of rainfall on pollutant levels in greater Hobart's stormwater drains and rivulets and ascertain the effects of first flush on water quality. This could be combined with an ongoing routine monitoring program in order to obtain a larger data set and allow better analysis of results. Other weather patterns (for example, the length of dry spells before storm events) may also be investigated in future programs.

Analysis of metals and oil and grease results was difficult due to the small data set and the number of results less than the laboratory detection limit. Also, the method used - collecting grab samples from the middle of the water column maybe not the best methodology to capture these pollutants. Concentrations of contaminants such as metals in sediments can be more than 100,000 times higher than in the overlying water (Horowitz 1991). Likewise oil and grease and other petroleum hydrocarbons tend to float so these samples should be collected at the air/water interface.

Alternative methods for monitoring metals and oil and grease should be investigated including solid-media method whereby adsorptive solid media secured in stormwater drains is deployed for a standard period of exposure and analysed for accumulated pollutant concentrations. This method has been successfully used by the City of Kingston, Melbourne to track pollutants and to evaluate the impact of changes in stormwater management practices as a consequence of their education and enforcement program (Marshall, S. et al, 2010).

The analysis of thermo-tolerant coliform counts had limited value, as Enterococci counts are currently used in most standards. TSS and turbidity were found to correlate well, so it is not necessary to monitor both parameters. Therefore it is recommended that these parameters be omitted from future stormwater monitoring programs. The savings on analytical laboratory costs could be directed towards a storm event monitoring or other program. Suggested parameters for a future program could include the following:

- TSS
- Enterococci
- Total Nitrogen
- Total Phosphorous

Several Water Sensitive Urban Design (WSUD) features have also been installed in catchments in the greater Hobart region. The performance of these WSUD elements could also be assessed as an option for future monitoring programs.

Sampling frequency is another critical issue identified in this monitoring program. Some analytes and sites were monitored quarterly and one council, Derwent Valley Council monitored bi-annually. Consequently, data set for these analytes and sites was too small to properly analyse results. Where possible, all sites should be monitored uniformly using the same protocols. Future programs should aim to monitor all sites at the same frequency, on the same day (in order to be able to compare with rainfall data).

While ANZECC (2000) trigger values have been useful as a guide for water quality, more appropriate standards for stormwater quality could be developed. These could be tailored to rivulets and stormwater infrastructure in the greater Hobart region, allow for fluxes due to varying weather conditions, and would provide a more realistic target for achieving compliance. These standards could be integrated into regional water quality objectives and be used for new developments.

Overall, the 2010-11 Stormwater and Rivulet Monitoring Program has been a useful tool for characterising pollutant concentrations from greater Hobart's catchments, revising the same program that previously ran from July 2002- June 2005 and providing regional stormwater quality data which had been absent over the last five years. The recent program has been effective in monitoring overall water quality, characterising pollutants entering the Derwent Estuary via urban rivulets, identifying particular issues and potential sources of contaminants that could be successfully compared with the 2002-2005 program's results.

Issues with the 2010-11 Stormwater and Rivulet Monitoring Program have been identified in this report and will help inform the development of a future monitoring program. A new and ongoing stormwater monitoring program will ensure that a larger data set is built up, allowing for the further assessment of results and isolation of potential pollution sources allowing councils to:

- Identify specific stormwater issues in each municipality so that councils can prioritise areas for stormwater management and better focus funding.
- Indicate the performance of stormwater management strategies in improving water quality.
- Devise strategies and management plans based on the information collected to improve water quality for the protection of the rivulets and the estuary

The DEP will work with council partners to develop and initiate a revised stormwater program and reporting in early 2012.

7. Reference:

Marshall, S., Pettigrove, V., Potter, M., Barrett, T. and Pfitzner, M. (2010). *Bagging Industrial Drains: A Solid Media Survey of Stormwater Contamination.* University of Melbourne, Victoria, Australia.