Assessment of Water, Sediment and Fish Quality in the Bayswater drains and adjacent Swan River, April/May 2003

September 2003

Department of Environment

Acknowledgments

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Water, sediment and fish field data was collected by officers of the Department of Environment, Swan River Trust and Department of Fisheries.

Special thanks to Dr Ed Butler (CSIRO Marine Research), Dr Grant Douglas (CSIRO Land and Water), Dr Brian Jones (Department of Fisheries), Gabrielle Nowara (Department of Fisheries), Dr Fran Stephens (Department of Fisheries), Martin Matisons (Department of Health), Kim Leighton (Department of Health), Brian Loughton (Water Corporation), Dr Jane Latchford (Swan River Trust), Stephen Wong (Department of Environment), Brad Degens (Department of Environment) and Dr Tom Rose (Department of Environment) for their valuable comments and feedback on the report.

Funding for this assessment was provided by the Department of Environment, Swan River Trust, Department of Health, Department of Fisheries and the Water Corporation.

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Recommended reference

The recommended reference for this publication is:

Department of Environment (2003). *Assessment of Water, Sediment and Fish Quality in the Bayswater drains and adjacent Swan River, April/May 2003*. Department of Environment.

ISBN 1-920849-30-0

Executive summary

This assessment of the Bayswater drains and adjacent Swan River was in response to concerns about heavy metal contamination and acidic groundwater identified along the south-western boundary of the CSBP Cresco site in Bayswater. The prime objective of the assessment was therefore to determine the extent to which the drains in Bayswater and the adjacent Swan River might be affected by those contaminants. However, although the assessment was focused on drains in the vicinity of the CSBP Cresco site, the assessment also recognised and took into account that there are multiple sources of industrial contaminants in the Bayswater Main Drain catchment.

It should be stressed that this assessment is based on one-off sampling of water quality, nutrients and other contaminants in sediment and biota in April/May 2003. The effect of seasonal and flow variations on the water, sediment and biota quality in the drain and river were therefore not a part of this investigation. Consequently, the results represent the condition of the Bayswater drains and adjacent Swan River at the time of sampling only.

Water quality was sampled at seventeen sites in nine different drains and at ten sites in the adjacent Swan River. Sediments were sampled in the drains at generally the same sites used to collect water quality samples. Biota was sampled at three locations in the Swan River corresponding to three of the water quality sites (BWR2, BWR4 and BWR10).

Environmental values for the drains and river have not yet been determined and agreed upon between all key stakeholders as envisaged in the *National Water Quality Management Strategy* (ANZECC & ARMCANZ, 2000) and associated Guidelines. To provide a general frame of reference as to the state of water quality in the drains this report compares the result of sampling with trigger levels in those Guidelines which the Department of Environment considers may be seen by some as applicable to these water bodies. Exceedances of the referenced trigger levels therefore do not indicate that "standards" are not being met, but are only an indication that further consideration should be given to the situation.

Key Findings

- The assessment did not show that the CSBP site was affecting the Swan River at the time of the study.
- Contaminant concentrations were typical of drains in metropolitan areas - and generally either better or no worse than those reported in similar studies in the 1980's and 1990's in Perth.
- One sampling location at the Railway Parade Branch Drain adjacent to the CSBP site showed evidence of contamination from the CSBP site. The fluoride level was higher at this location, and the water was more acidic than at other sampling points.
- Heavy metal levels in black bream and yellow tailed trumpeter fish taken from the Swan River between Maylands and Bassendean during this study were well within those set in the Food Standards Code and the fish would be safe to eat.
- Water quality in the Swan River at the time of the study was safe for fishing and recreational use.
- Nutrient levels in the river were high.
- Some environmental trigger levels for sediment and water quality were exceeded in a number of drain and river samples. More work is needed to determine whether metals above trigger levels pose a risk to the environment.

Details of the findings are contained in the *Results and Discussion* section at page 13 and are summarised in the following two Summary Comparison tables for water quality, drain sediment and biota results against guidelines and trigger values.

Summary comparison of drain and river water quality results against guideline and trigger values

	DRAINS			RIVER		
	ANZECC Water Quality Trigger value – Freshwater, 95%ile (2000)	ANZECC Water Quality Trigger value – lowland river (2000)	ANZECC Water Quality Guidelines – Recreational (2000)	ANZECC Water Quality Trigger value – Marine, 95%ile (2000)	ANZECC Water Quality Trigger value – estuaries (2000)	ANZECC Water Quality Guidelines – Recreational (2000)
DO % sat		6	6		10	10
pH		6	6		10	
SpCond		17				
Temp °C						
TN		15			10	
NH_4-N		15			10	
NOx-N		14			10	
TP		6			10	
FRP		2			10	
Al	5					
As						
Cd	1					
Co				1		
Cr						
Cu	11			10		
Fe			16			
Hg						
Mn			10			10
Mo						
Ni	5					
Pb	1		4			
Se						
U						
Zn	17			7		
SO_4			1			10
F						

3	Number of drain sites exceeding guideline or trigger value
	All 17 drain sites less than guideline or trigger value
5	Number of river sites exceeding guideline or trigger value
	All 10 river sites less than guideline or trigger value
	No guideline or trigger value available

Summary comparison of drain sediment and river Fish results against guideline and trigger values

	SEDIMENTS		FISH		
	ANZECC Interim Sediment Quality Guidelines - Low trigger value (2000)	ANZECC Interim Sediment Quality Guidelines - High trigger value (2000)	Australia New Zealand Food Standards Code Maximum Levels (2003)	Australia New Zealand Food Standards Code - Generally Expected Levels, 50% below (2003)	Australia New Zealand Food Standards Code - Generally Expected Levels, 90% below (2003)
TN					
TP					
Al					
As (inorganic)	1				
Cd	3				
Co					
Cr	1				
Cu	6				
Fe					
Hg					
Mn					
Mo					
Ni	1	1			
Pb	7	1			
Se				3	
U					
Zn	8	5		2	

3	Number of drain sites with sediment exceeding guideline or trigger value
	All 16 drain sites with sediment less than guideline or trigger value
5	Number of river sites with fish flesh above the maximum level or generally expected levels
	All 3 locations with fish flesh less than maximum level or generally expected levels
	No guideline or trigger value available (sediment), no maximum or generally expected levels (fish)
	Sample not analysed for parameter

Contents

Background

An assessment of the water, sediment and Fish quality in drains in the Bayswater area and in the adjacent section of the Swan River was undertaken between April and May 2003. The objective of the assessment was to determine the extent to which the drains in Bayswater and the adjacent Swan River are affected by industrial and other contaminants. The assessment was triggered in response to concerns about high levels of heavy metal contamination and very acidic groundwater identified along the south-western boundary of the CSBP Cresco site in Bayswater.

The assessment comprised one-off sampling of water, sediment and Fish quality. Water and sediments were sampled at various sites in the Bayswater drain system. Water and Fish were sampled at several sites in the adjacent Swan River between the Garratt Road Bridge and the Sandy Beach Reserve.

The assessment was focused on, but not limited to, drains proximate to the CSBP Cresco site. It was recognised that there are multiple sources of industrial contaminants in the Bayswater Main Drain catchment.

A previous investigation of water quality in the Bayswater Main Drain was conducted in 1990/91 to define and apportion the pollutant load from different land uses and soil type mixes within the catchment. At the same time an investigation of water, sediment and fish quality in the adjacent Swan River was conducted in 1990 to assess the possible human health risks and environmental damage resulting from the discharge of drainage waters into the river. The sampling and analysis techniques and sampling sites chosen in the previous investigations vary from those used in the current assessment but will be discussed in relation to the study.

Information from a more recent study in the Mills Street drain between April 2000 and April 2002 is also presented to place this current study into context with other metropolitan drains. The Mills Street Main Drain catchment is highly urbanised and comprises a network of drains and compensating basins flowing through predominantly Bassendean Sands.

Bayswater Main Drain just upstream of confluence with Beechboro Branch Drain

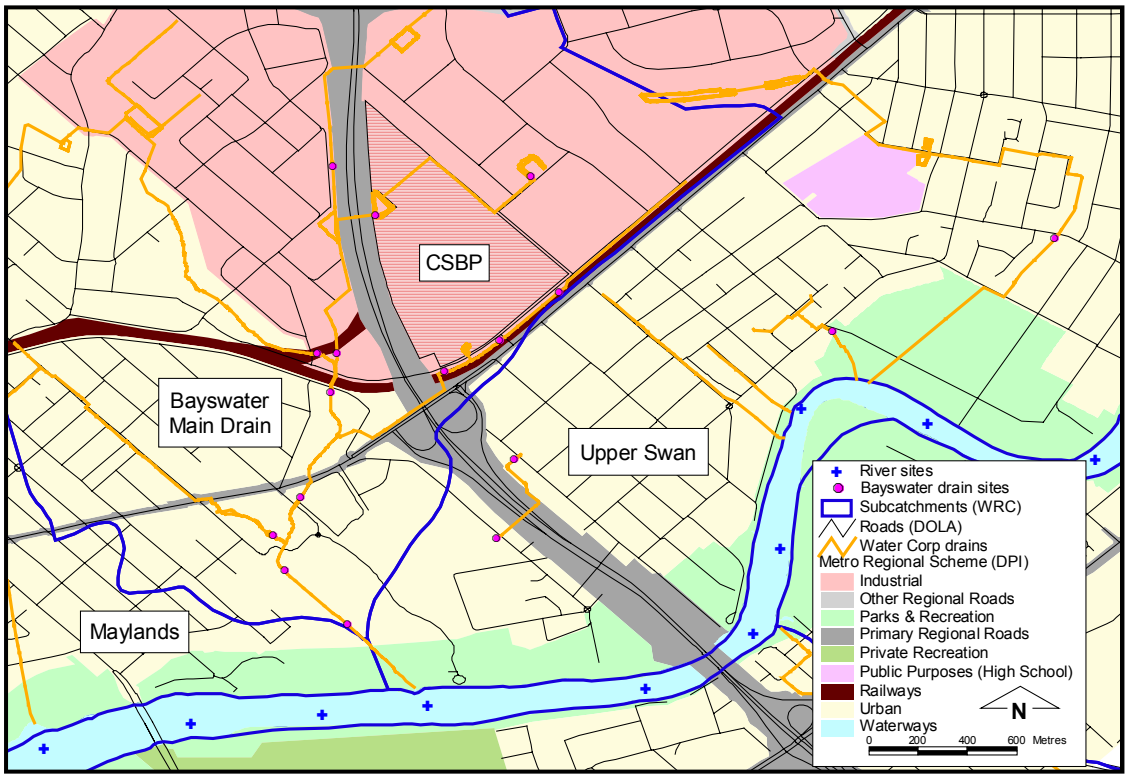
Bayswater Main Drain and Upper Swan catchments

Bayswater Main Drain is the largest urban catchment in the Perth metropolitan area. It collects groundwater and surface runoff from a 26.2 km^2 catchment. The average annual discharge from the Bayswater Main Drain into the Swan River Estuary is $12x10^6m^3$. The eastern boundary of the Bayswater Main Drain catchment joins the southern section of the Upper Swan catchment.

Land uses in the Bayswater Main Drain catchment comprise urban (high density residential), commercial areas and light to medium industry. Land use in the southern section of the Upper Swan catchment is predominantly urban.

The Bayswater Main Drain catchment is characterised by sandy soils (Bassendean sands) which have a high water table and a limited ability to adsorb and retain pollutants. A network of drains has been constructed in the catchment to drain winter, waterlogged soils. An efficient drainage network combined with a large number of septic tanks in the catchment used for the disposal of domestic and industrial wastes means that the Bayswater Main Drain has contributed significantly to the total pollutant load entering the Swan River.

The southern section of the Upper Swan catchment has similar soils to the Bayswater Main Drain catchment and comprises a network of minor drains most of which discharge directly into the Swan River near Ron Courtney Island.



Map of land uses in the Bayswater area

Methods

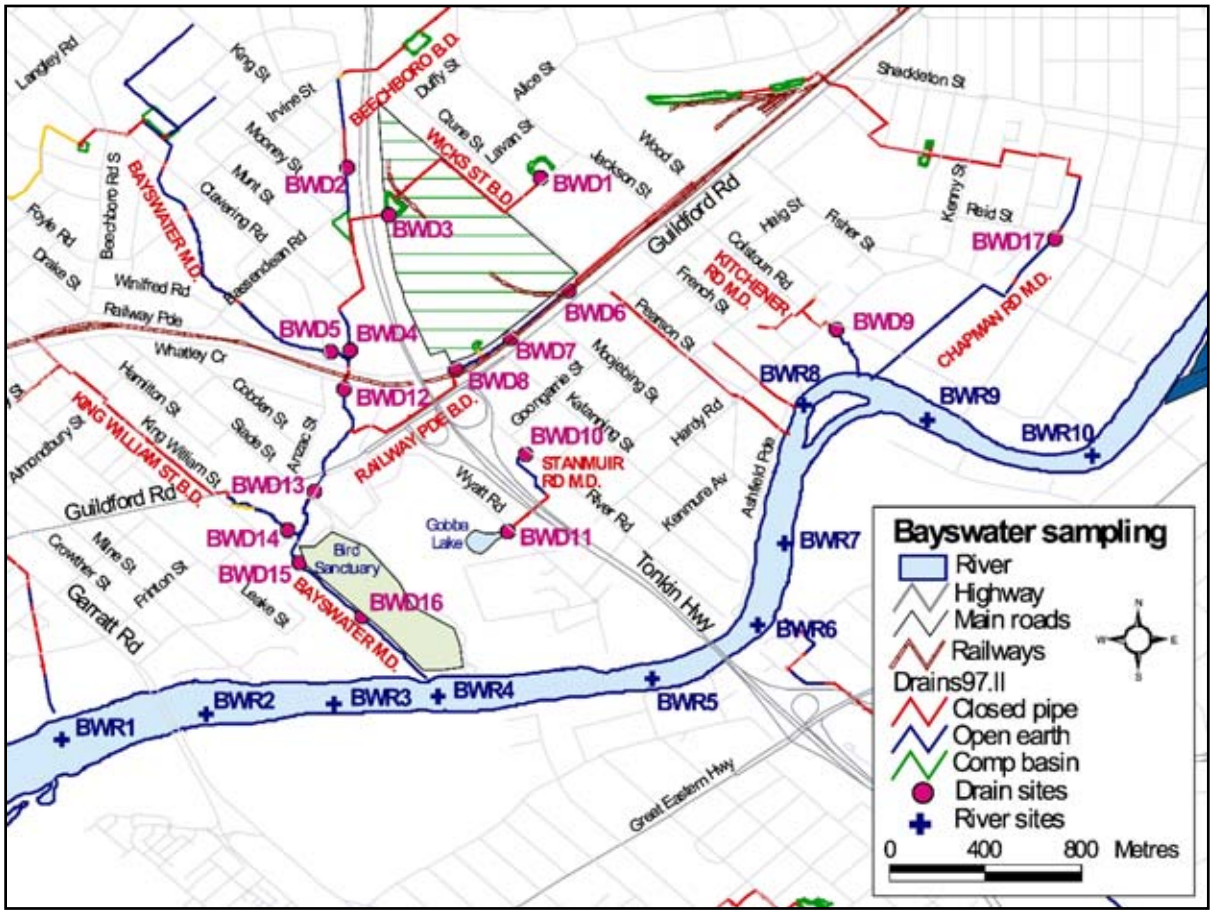
Site location

Water quality was sampled at seventeen sites in nine different drains and ten sites in the adjacent Swan River. Sediments were sampled in the drains at the same sites used to collect water quality samples (except BWD3). Fish was sampled at three locations in the Swan River that corresponded with water quality sites BWR2, BWR4 and BWR10.

The drain sample sites were selected such that they might contribute to the water and fish quality in the adjacent Swan River. Water and sediment quality in drains is often highly variable and specific to individual drain segments. Consequently, drain sample sites were selected such that:

- they were representative of a particular segment of a drain;
- the relative contributions of branch drains could be determined; or
- they were in locations up and downstream of likely contaminant sources.

The Swan River water quality sampling sites were selected on the basis of enabling identification of contaminated flow entering the river from individual drains or from outcropping groundwater.



Map of sampling sites in the drains of the Bayswater area and adjacent Swan River

Sampling

The assessment was primarily focused on water quality. Due to difficulties associated with drawing robust conclusions from snapshot water quality sampling, sediment and fish samples were collected to provide information on possible longer-term impacts on the Bayswater drains and Swan River.

Field observation forms were filled out for each water and sediment sample. All water, sediment and Fish samples were transported under "chain of custody" to the laboratory and analysed in accordance with the laboratory methods. All samples collected from the Bayswater drains and Swan River were analysed by the Australian Government Analytical Laboratories at Cottesloe.[1]

Water

Water quality in the drains and the Swan River was sampled on 16 April 2003. Water at each drain and Swan River sample site was measured *in situ* for physical properties (dissolved oxygen, pH, conductivity and temperature) samples were collected and analysed for a range of contaminants likely to be present in industrial and urban catchments. Water quality samples were analysed for nutrients (total nitrogen, total phosphorus, ammonium, oxides of nitrogen and filterable reactive phosphorus), sulfate, fluoride and dissolved heavy metals (aluminium, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, uranium, zinc, arsenic, mercury and selenium). Drain water samples were also analysed for dissolved calcium and magnesium for determining water hardness.

Sediments

Sediment samples were collected at each drain site (except BWD3) between 2 May and 15 May 2003. Sediment samples were analysed for a range of contaminants likely to be present in industrial and urban catchments. Sediment quality samples were analysed for nutrients (total nitrogen and total phosphorus), total heavy metals (aluminium, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, uranium, zinc, arsenic, mercury and selenium), total organic carbon and moisture.

Drain sediment samples comprised four sediment cores, which were composited from each drain site. A 15–25cm sediment core was collected using a 50mm diameter polycarbonate sediment corer. The sediment core was then transferred to a clean stainless steel bowl. At each site the four sediment cores were mixed in the bowl with a clean wooden spoon until homogeneous. A clean 250mL glass jar was filled to the top with the composited sediment sample.

The entire sediment core was composited into the sample to provide the maximum integration of contaminant concentrations in the drain over time.

Fish (fish flesh)

Fish flesh samples were collected at three locations in the Swan River on 30 April and 6 May 2003. The fish flesh samples were analysed for a range of contaminants likely to be present in industrial and urban catchments. Fish flesh samples were analysed for heavy metals (aluminium, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, uranium, zinc, arsenic, mercury and selenium).

Fish were collected at each location in the Swan River using a beach seine net. Yellowtail trumpeter (*Amniataba caudavittata*) and Black bream (*Acanthopagrus butcheri*) were separated from the catch, wrapped in aluminium foil, packed in airtight plastic bags and placed on ice. Samples of flesh were removed from the fish samples by the laboratory prior to analysis.

Black bream are an edible fish species and Yellowtail trumpeters are highly site attached in estuaries.

[1] A detailed sampling and analysis plan including a description of quality assurance and quality control procedures was prepared for this investigation. The sampling and analysis plan can be obtained from the Water and Rivers Commission.

Summary of water, sediment and fish sampling details and chemical analysis

Parameters tested	Sample collection	Sampling preparation	AGAL method code	Limit of reporting[2]
Water				**mg/L**
Total nitrogen (TN)	250mL plastic bottle	None	WL239	0.025
Total phosphorus (TP)				0.005
Ammonium (NH_4-N)		Filtration: 0.45µm cellulose nitrate		0.01
Total oxidised nitrogen (NO_x-N)				0.01
Filterable reactive phosphorus (FRP)				0.005
Sulfate (SO_4)			WL119	5
Fluoride (F)			WL218	0.2
Aluminium (Al)	125mL plastic bottle	Filtration: 0.45µm cellulose nitrate Preserved with HNO_3	NT2_47	0.005
Arsenic (As)			NT2_47_251	0.001
Calcium (Ca)			NT2_47	0.005
Cadmium (Cd)				0.0001
Chromium (Cr)				0.001
Cobalt (Co)				0.001
Copper (Cu)				0.001
Iron (Fe)				0.05
Mercury (Hg)			NT2_47_244	0.0001
Magnesium (Mg)			NT2_47	0.005
Manganese (Mn)				0.05
Molybdenum (Mo)				0.001
Lead (Pb)				0.001
Nickel (Ni)				0.001
Selenium (Se)			NT2_47_251	0.001
Uranium (U)			NT2_47	0.001
Zinc (Zn)				0.001
Sediment				**mg/kg dry weight**
Moisture	250mL glass bottle	None	WL170	-
Total organic carbon (TOC)			NW_S15	-
TN			WL132WL119	5
TP			WL195	50
Al			NT2_49	0.2
As				0.5
Cd				0.5
Cr				0.2
Co				0.5
Cu				0.2
Fe				0.2
Hg				0.2
Mn				0.2
Mo				0.5
Pb				0.2
Ni				0.2
Se				0.5
U				0.5
Zn				0.2

[2] Limit of reporting (LOR) is the lowest level of detection achievable amongst laboratories, i.e. the level that another laboratory should reach given the same instrument, method and sample matrices.

Parameters tested	Sample collection	Sampling preparation	AGAL method code	Limit of reporting
Fish flesh				**mg/kg**
Al	Foil wrapped in airtight plastic bag	Fillets removed from both sides of fish under laboratory conditions	NT2_46	0.01
As				0.01
Cd				0.01
Cr				0.01
Co				0.01
Cu				0.005
Fe				0.1
Hg				0.005
Mn				0.005
Mo				0.01
Pb				0.01
Ni				0.005
Se				0.025
U				0.01
Zn				0.005

Black bream *Acanthopagrus butcheri*

Yellowtail Trumpeter *Amniataba caudavittata*

Results and discussion

Comparison of results with guidelines

Environmental values for the drains and river have not yet been determined and agreed upon between all key stakeholders as envisaged in the *National Water Quality Management Strategy* (ANZECC & ARMCANZ, 2000) and associated Guidelines. To provide a general frame of reference as to the state of water quality in the drains this report compares the result of sampling with trigger levels in those Guidelines which the Department of Environment considers may be seen by some as applicable to these water bodies. Exceedances of the referenced trigger levels therefore do not indicate that "standards" are not being met, but are only an indication that further consideration should be given to the situation.

It is common in these types of studies to compare sample concentrations to recognised standards or guidelines. The *National Water Quality Management Strategy* (ANZECC & ARMCANZ, 2000, papers 4 and 7) provides current guidance on both ecosystem and human health protection. To select which set of guidelines to use the environmental value and level of protection of a water resource (including its receiving environment) needs to be determined and agreed upon between all key stakeholders. Water quality guidelines are provided for a range of environmental values including aquatic ecosystems, primary industries, drinking water, recreation and aesthetics (ANZECC & ARMCANZ 2000). The Guidelines recognise three levels of protection for aquatic ecosystems being areas with high conservation value, slightly to moderately disturbed ecosystems and highly disturbed ecosystems. To assess the level of toxicant contamination in aquatic ecosystems, trigger values were developed from data using toxicity testing on a range of test species (ANZECC & ARMCANZ 2000). The trigger values (99%, 95%, 90% and 80%) approximately correspond to the levels of protection described above. Exceedance of the trigger value indicates that there is the potential for an impact to occur and should therefore trigger a management response such as further investigation or adaptation of the guidelines according to local conditions (ANZECC & ARMCANZ 2000).

The drains in the Bayswater area are highly modified ecosystems in an industrial and urban catchment where the risk of toxicant contamination is high and current environmental value is low. On that basis the drains in the Bayswater area would be compared to the 80% level based on ANZECC guidance. However, the drains in the Bayswater area ultimately discharge into the Swan River where environmental values are high and for this reason, the toxicant results are compared to the trigger values for a 95% protection level applicable to slightly to moderately disturbed ecosystems. Nutrient concentrations and physical results are compared to the statistically derived default trigger values for slightly disturbed ecosystems of southwest Australia (baseflow only) (ANZECC & ARMCANZ 2000). The Swan-Canning Cleanup-Program has set five year targets for TN and TP, specific to Swan-Canning catchments (SRT, 1999). The Cleanup-Program targets are generally compared to long-term datasets (3 years) and consequently the TN and TP results from this assessment have not been compared to these targets.

From a human use perspective, urban drains are not a source of drinking water but may be accessed by the public and therefore it is reasonable to compare the toxicant results to recreational guidelines, which take into account risks to public health. Some parts of Bayswater drainage systems are accessible to the public, either as unfenced sections or a water body in parkland, and downstream portions may be used for various degrees of recreation including swimming. Toxicant concentrations should not exceed the recreational guidelines, to ensure that recreational users are not at risk (ANZECC & ARMCANZ 2000). The ANZECC & ARMCANZ 2000 recreational guidelines are based on the assumption that no more than 100 millilitres of water will be ingested, compared to the standard 2 litres of water per day for drinking water guidelines (NHMRC & ARMCANZ 1996).

The concentrations of heavy metals in the drain sediments are compared to the Interim Sediment Quality Guidelines, where both low and high trigger values are reported (ANZECC & ARMCANZ, 2000). Where concentrations are between the low and high values background concentrations should be investigated. If the results exceed the high guidelines or are above the background concentrations a further assessment of the bioavailability of the metal is required. The concentrations of heavy metals in the fish flesh are compared to General Food Standards, where both maximum levels and generally expected levels are reported (ANZFA, Food Standards Code). All foods listed in the standard must comply with the maximum levels. Generally expected levels are contaminant levels that would normally be expected in particular foods.

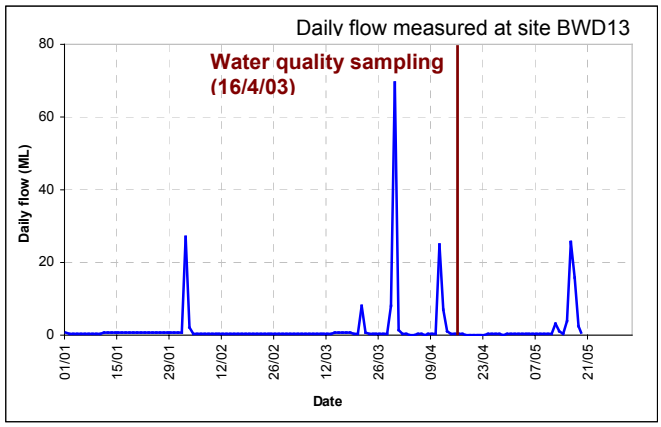
Water quality

Flow and water depth

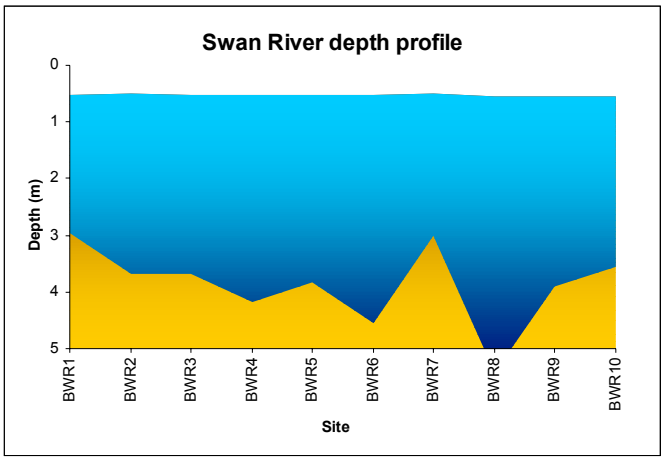
Freshwater flow into the Swan River from the catchment is strongly seasonal. The majority of rain and consequently flow into the Swan River occurs in winter between May and September. Rainfall events during summer and early autumn sometimes result in freshwater inflows otherwise there is no or minimal tributary flow during this period.

A rainfall event occurred in April 2003 resulting in a significant increase in flow in the Bayswater Main Drain between 11-12 April 2003[3]. The depth of most sites sampled in the Bayswater drains was less than 50cm. Rapid flow increase combined with the minimal water depth in the Bayswater drains is likely to have resulted in a significant flushing of the drain water. Water quality sampling for this investigation was conducted on 16 April 2003 following the flow event and is most likely representative of base flow water quality in the Bayswater drains. At the time of water quality sampling the flow recorded in the Bayswater Main Drain was minimal (0.2ML).

Daily flow in the Bayswater Main Drain during 2003



The increase in tributary inflow as a result of the rainfall event may have affected the water quality in the Swan River. The section of the Swan River between the Garratt Road Bridge and Sandy Beach Reserve is part of the marine dominated estuary. The average depth in this section of the Swan River was just over 3 metres the deepest section being near Ron Courtney Island (4.9m).



[3] Flow in the Bayswater Main Drain was measured at the Water and Rivers Commission gauging station (SWS10) which was equivalent to drain site BWD13.

Physical properties

The pH levels in the Bayswater drains were generally low with some very low pH levels being recorded (page 17). The lowest pH (3.0) was recorded in the Railway Parade Branch Drain (BWD8). Low pH levels were also recorded upstream of this site (BWD7), in the Beechboro Branch Drain (BWD2, BWD4) and in the Cresco Compensating Basin (BWD3). The low pH levels in these drains are most likely due to the proximity of the sample sites to the CSBP Cresco site. Soils associated with old wetlands in the Bayswater Main Drain and Upper Swan catchments have the potential to generate acid sulfate soil conditions. Drains frequently intercept these soils and may have contributed to the low pH levels in the drain water.

Swan River pH levels ranged between 7.1 and 7.34 and were reasonably consistent throughout the length of the River sampled. Approximately one third of the drain sites had pH values below the recreational guideline (6.5) and aquatic ecosystem trigger value (lower limit - 6.5). The pH levels at all sites in the Swan River were just below the aquatic ecosystem trigger value for estuaries (7.5) but were all within recreational guidelines (ANZECC & ARMCANZ, 2000). Current pH levels in the Bayswater drains and adjacent Swan River were generally similar to, or greater (better), than those recorded in 1990/91. In contrast to the low pH levels in the Bayswater drains, the Mills Street Main Drain pH levels were all above 6.

Several drain and all river sites had dissolved oxygen concentrations below the aquatic ecosystem trigger value – lower limit (page 18). Low dissolved oxygen concentrations occurred in the Wicks Street Branch Drain (BWD1, BWD3), the Railway Parade Branch Drain (BWD6, BWD7 and BWD8) and in the King William Street Branch Drain (BWD14). The toxicity of several heavy metals increases with reduction in dissolved oxygen. Consequently, low dissolved oxygen concentrations are of concern in the Bayswater drains.

Surface dissolved oxygen concentrations in the Swan River ranged between 35 and 55% saturation whilst bottom concentrations ranged between 3 and 10% saturation. Low dissolved oxygen concentrations in the Swan River are of concern but are not uncommon during summer and are often the result of algal bloom collapse. At the time of sampling an algal (dinoflagellate) bloom was present in the area of the Swan River sampled as part of this investigation. The dissolved oxygen concentrations at several drain sites and all River sites were below the recreational guidelines and the aquatic ecosystem trigger values – lower limit (ANZECC & ARMCANZ, 2000).[4]

The specific conductivity[5] of water in the Bayswater drains was generally between 0.6 and 1.2mS/cm (page 18). Elevated specific conductivity was recorded in the Beechboro Branch Drain (BWD4) and in the Bayswater Main Drain downstream of the confluence with the Beechboro Branch Drain (BWD12). The elevated specific conductivity in these drain segments are most likely due to the proximity of the sample sites to a plaster manufacturing/gypsum processing premises and the CSBP Cresco site. Specific conductivity was greater than the aquatic ecosystem trigger value – upper limit at all drain sites (ANZECC & ARMCANZ, 2000). Specific conductivity in the Swan River was far greater in the bottom water (39 – 44mS/cm) than in the surface water (4 – 18mS/cm) indicating vertical stratification. This stratification is caused by the denser salt-water layer pushing upstream underneath a surface layer of fresh water and is often referred to as a salt wedge.

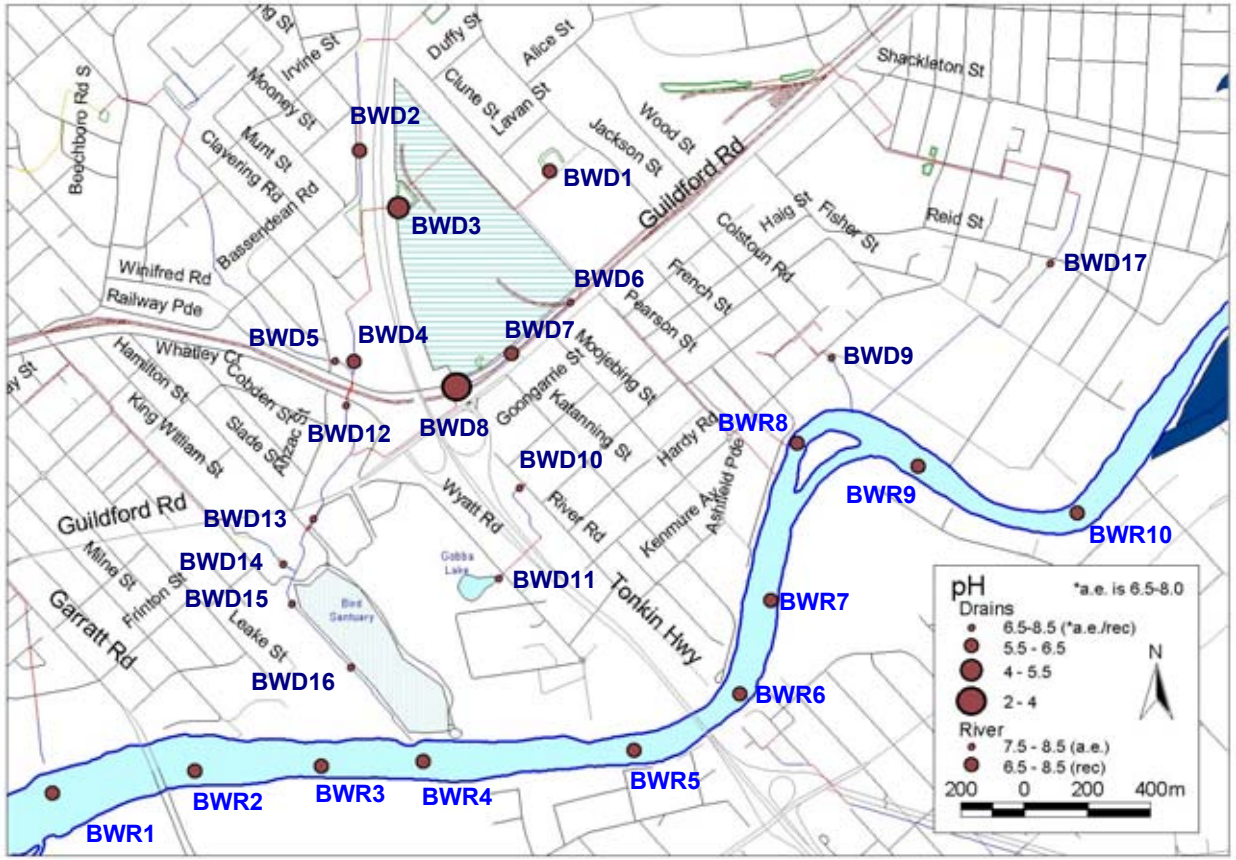
Summary

The pH levels in the Bayswater drains were generally between pH 6-7 however a very low pH of 3 was recorded in the Railway Parade Branch Drain. Approximately a third of the drain sites had pH values below the recreational guideline and aquatic ecosystem trigger value - lower limit. Several drain and all river sites had dissolved oxygen concentrations below the recreational guidelines and aquatic ecosystem trigger value – lower limit. Elevated specific conductivity was recorded in the Beechboro Branch Drain and the Bayswater Main Drain. Specific conductivity was greater than the aquatic ecosystem trigger value – upper limit at all drain sites.

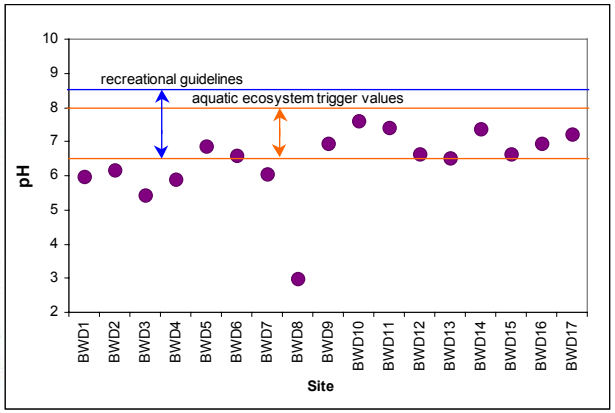
[4] As dissolved oxygen can fluctuate greatly over a diurnal cycle, it is preferable to measure DO over a full diurnal cycle for a few days (ANZECC & ARMCANZ, 2000). This type of dissolved oxygen monitoring was not conducted as part of this water quality assessment.

[5] Specific conductivity is a measure of the total concentration of inorganic ions in water and relates closely to salinity where chloride is the dominant ion.

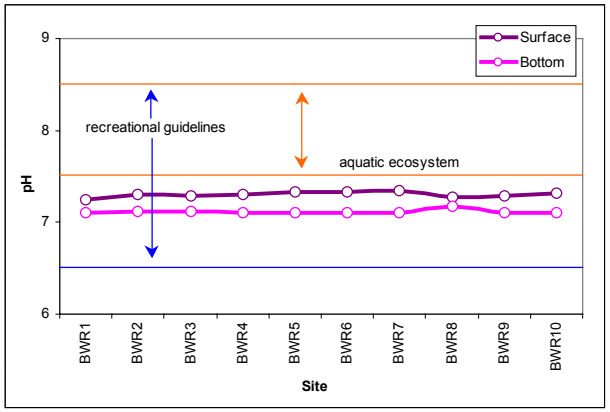
pH levels in Bayswater drains and the adjacent Swan River on 16 April 2003



Bayswater drains

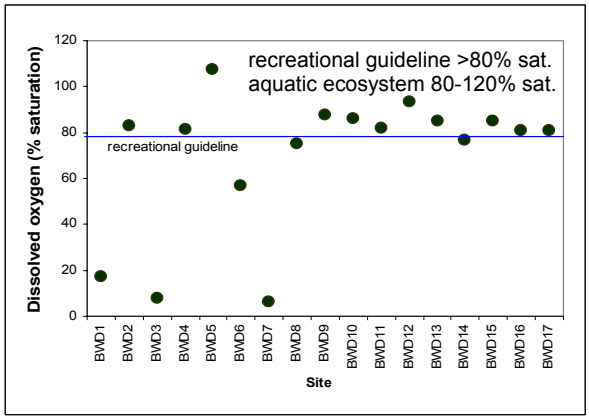


Swan River

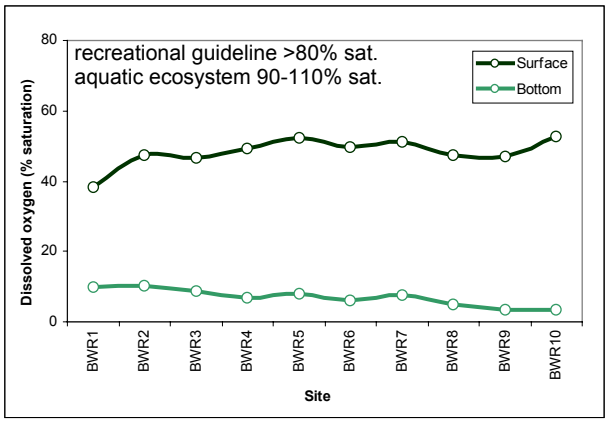


Physical properties in the Bayswater drains and in the Swan River on 16 April 2003

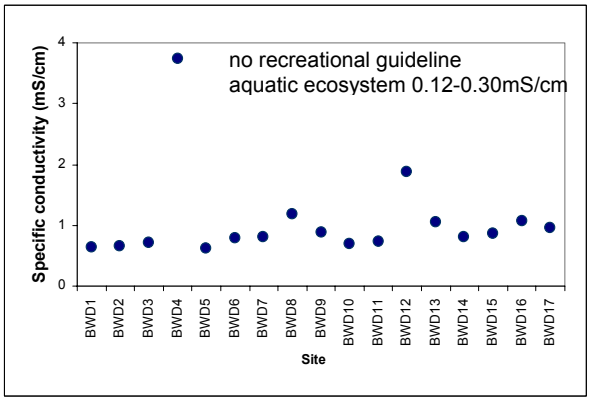
Bayswater drains



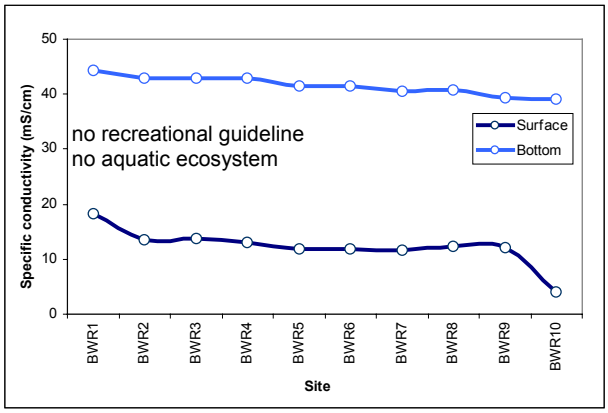
Swan River



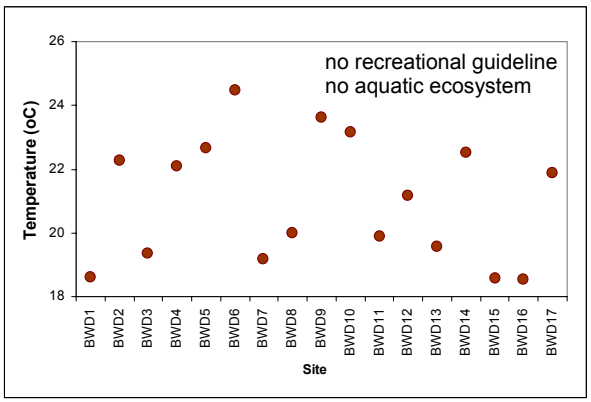
Bayswater drains



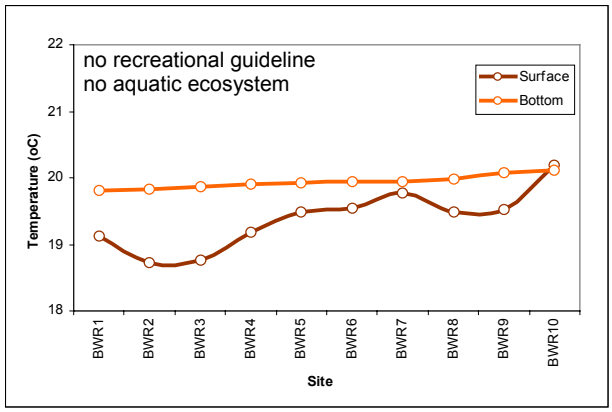
Swan River



Bayswater drains



Swan River



Nutrients

Nutrient concentrations varied spatially throughout the Bayswater drains (page 20). Elevated nutrient concentrations were localised generally being restricted to one section of drain or single site.

Total nitrogen, ammonium and total phosphorus concentrations were elevated in the Railway Parade Branch Drain just east of the Tonkin Highway (BWD6, BWD7 and BWD8). The greatest concentration of total phosphorus (0.18mg/L) and filterable reactive phosphorus (0.082mg/L) was recorded in the Cresco Compensating Basin (BWD3). The elevated nutrient concentrations in the Railway Parade Branch Drain and the Cresco Compensating Basin are most likely due to the proximity of the drain and compensating basin to the CSBP Cresco site. The highest total oxidised nitrogen concentration (1.4mg/L) was recorded in the upper section of the Stanmuir Road Main Drain (BWD10).

Total nitrogen and total phosphorus concentrations were elevated in the Bayswater Main Drain just upstream of the confluence with the Swan River. This is probably due to nutrient-rich water from the Eric Singleton Bird Sanctuary and inflow from the Swan River. Total nitrogen, ammonium and total oxidised nitrogen concentrations in the Bayswater drains generally exceeded the aquatic ecosystem trigger values for lowland rivers. Total phosphorus and filterable reactive phosphorus exceeded the aquatic ecosystem trigger values for lowland rivers in the Cresco Compensating Basin, the King William Street Branch Drain and in the Bayswater Main Drain just upstream of the confluence with the Swan River. Filterable reactive phosphorus also exceeded the aquatic ecosystem trigger values for lowland rivers in the Railway Parade Branch Drain and Gobba Lake (ANZECC & ARMCANZ, 2000).

Nutrient concentrations in the Swan River varied little between the Garratt Road Bridge and the Sandy Beach Reserve (page 21). Nitrogen and phosphorus concentrations in the River were elevated at all sites and were generally greater than the concentrations recorded in the drains. There was no evidence of an increase in nutrient concentrations in the Swan River estuary at the confluence with the Bayswater Main Drain (BWR4). Nitrogen and phosphorus concentrations at all Swan River sites were above the aquatic ecosystem trigger values for estuaries and were generally greater than that recorded in the drains (ANZECC & ARMCANZ, 2000).

Nutrient concentrations in the Bayswater drains may have been low due to the flow event that occurred several days prior to sampling. The nutrients detected are most likely derived from low flow sources such as groundwater discharges, point source discharges and nutrient release from decomposing organic material in the drains and compensating basins.

Some limited comparison can be drawn with the nutrient concentrations recorded in the Bayswater Main Drain and King William Street Branch Drain in 1990/91. The current nutrient concentrations were reasonably similar to those recorded in 1990/91 however, the total phosphorus concentration in the Bayswater Main Drain, and the total oxidised nitrogen concentration in the King William Street Branch Drain, were below the range of concentrations recorded in 1990/91.

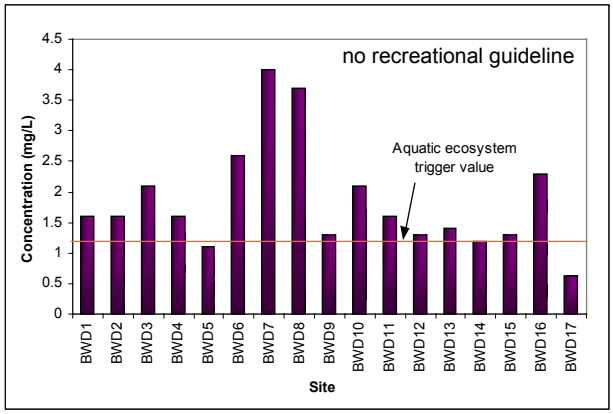
In comparison, the range of nutrient concentrations in the Mills Street Main Drain catchment was far greater than that recorded in the Bayswater drains. The maximum total nitrogen and total phosphorus concentrations in the Mills Street Main Drain catchment (TN - 36mg/L, TP - 3.1mg/L) were greater then the maximum recorded in the Bayswater drains (TN - 4mg/L, TP – 0.18mg/L). The greater range in nutrient concentrations in the Mills Street Main Drain catchment is probably due to sampling runs being conducted during low and high flow periods over 2 years.

Summary

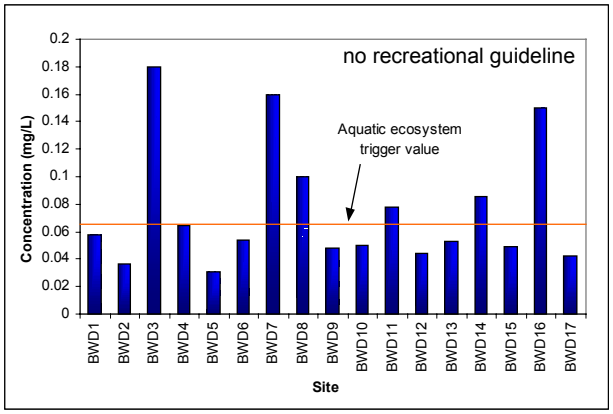
Nitrogen concentrations in the Bayswater drains generally exceeded the aquatic ecosystem trigger values for lowland rivers. Phosphorus concentrations exceeded the aquatic ecosystem trigger values for lowland rivers in several drain segments including the Cresco Compensating Basin, the King William Street Branch Drain and the Bayswater Main Drain. Nitrogen and phosphorus concentrations in the river were elevated at all sites and exceeded the aquatic ecosystem trigger values for estuaries.

Nutrient concentrations in Bayswater drains on 16 April 2003

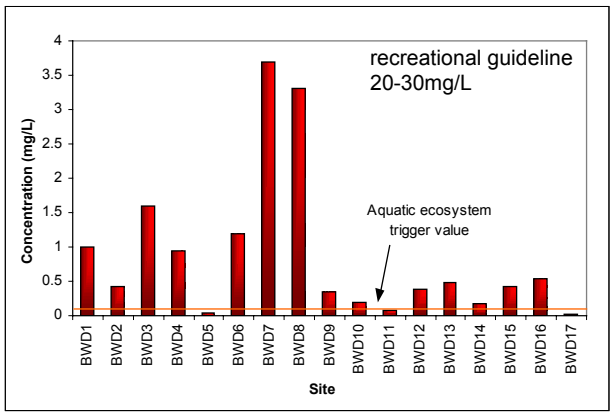
Total nitrogen (TN)



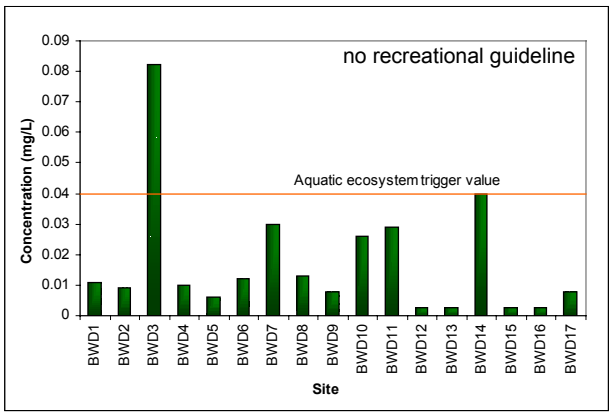
Total phosphorus (TP)



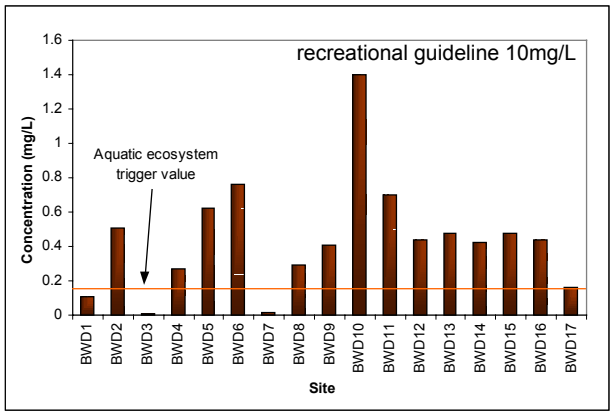
Ammonium (NH4)



Filterable reactive phosphorus (FRP)

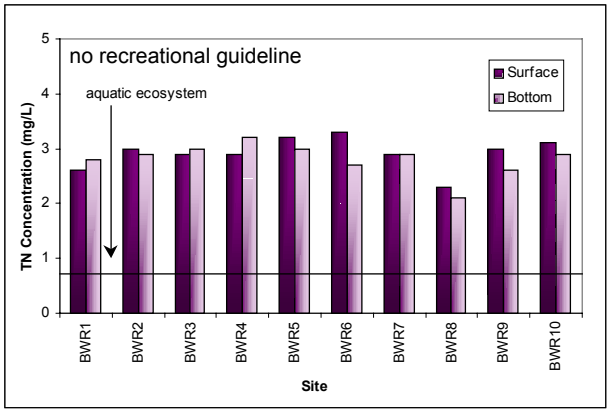


Total oxidised nitrogen (TON)

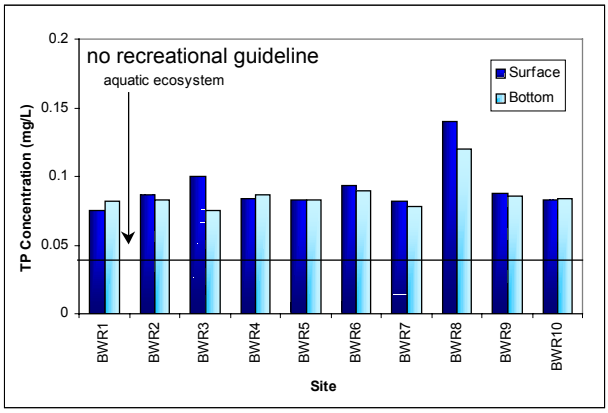


Nutrient concentrations in the Swan River on 16 April 2003

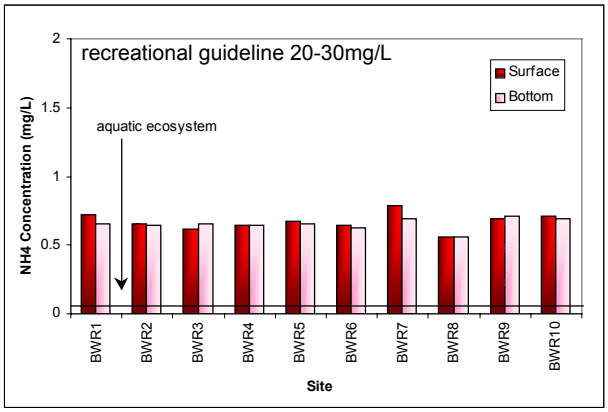
Total nitrogen (TN)



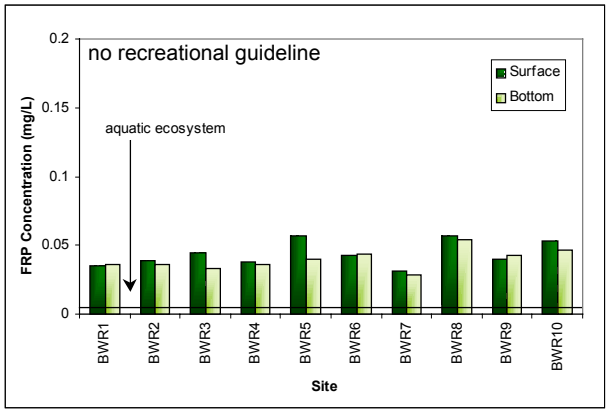
Total phosphorus (TP)



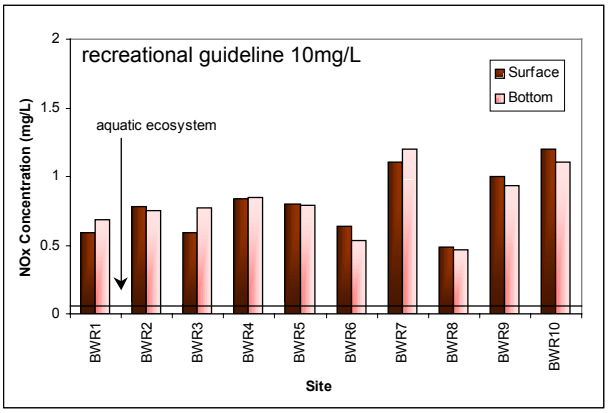
Ammonium (NH4)



Filterable reactive phosphorus (FRP)



Total oxidised nitrogen (TON)



Heavy metals

Dissolved heavy metal concentrations in the Bayswater drains exhibited significant spatial variation. Elevated concentrations of heavy metals were localised and generally limited to a section of drain or a single site. Swan River heavy metal concentrations were generally lower than concentrations in the drains and reasonably consistent throughout the length of the river sampled (pages 24-32).

The Railway Parade Branch Drain east of the Tonkin Highway (BWD8) recorded the maximum concentration of half the dissolved heavy metals analysed for in the Bayswater drains. Site BWD8 recorded the maximum concentration of aluminium (14mg/L), cadmium (0.004mg/L), cobalt (0.056mg/L), iron (24mg/L), manganese (0.44mg/L), nickel (0.062mg/L) and lead (0.008mg/L). The elevated heavy metal concentrations in the Railway Parade Branch Drain are most likely due to the low pH and proximity of the drain to the CSBP Cresco site.

Concentrations of aluminium, copper, nickel and zinc were above aquatic ecosystem trigger values at several sites in the Bayswater drains (ANZECC & ARMCANZ, 2000). Nickel and lead concentrations were below the hardness-corrected aquatic ecosystem trigger values at all Bayswater drain sites (see Hardness, page 23). The zinc concentrations at one site (BWD14) and copper concentrations at several sites (BWD1, BWD2, BWD4, BWD8 and BWD10) in the Bayswater drains exceeded the hardness corrected aquatic ecosystem trigger values.

Iron, manganese and lead concentrations at several sites in the Bayswater drains exceeded the recreational guidelines.

The heavy metal concentrations in the Bayswater drains were generally greater than those detected in the adjacent Swan River.

The maximum concentration of most heavy metals in the Swan River estuary occurred near Ron Courtney Island (BWR8). Site BWR8 had the highest concentrations of cobalt (0.002mg/L), chromium (0.002mg/L), copper (0.021mg/L), manganese (0.26mg/L) and molybdenum (0.005mg/L) in the Swan River. The elevated heavy metal concentrations near Ron Courtney Island may be due to the proximate inflow of four drains including the Kitchener Road Main Drain and the Chapman Road Main Drain. This site (BWR8) was also the deepest of the River sites, which may also have some impact on heavy metal concentrations in the water column.

Only dissolved aluminium and zinc concentrations in the Swan River were consistently greater downstream of the confluence with the Bayswater Main Drain.

Concentrations of copper in the river, and to a certain extent zinc, consistently exceeded the aquatic ecosystem trigger values (ANZECC & ARMCANZ, 2000). Manganese concentrations were consistently elevated in the Swan River and exceeded the recreational guidelines (ANZECC & ARMCANZ, 2000). Flux of manganese from the sediment into the Swan River water column may be occurring due to low dissolved oxygen concentrations in the bottom waters.

Arsenic, cadmium, cobalt, chromium, lead, mercury, molybdenum, selenium and uranium concentrations in the Bayswater drains and adjacent Swan River were generally low. The chromium, mercury and selenium concentrations in the drains and arsenic, cadmium, mercury, lead and selenium concentrations in the river were all below the limit of reporting.

Heavy metal concentrations in the Bayswater drains may have been comparatively low due to the flow event that occurred several days prior to sampling. The heavy metals detected are most likely derived from low flow sources such as dissolution from sediments, industrial discharges and groundwater inputs. The flow event in combination with the minimal depth of the Bayswater drains was likely to cause flushing of the drains water. Consequently, high flow sources of heavy metal contamination such as paved surfaces, roofs and roads were likely to be minimal.

Heavy metal concentrations in the Bayswater drains and adjacent Swan River have generally either remained similar or decreased since 1990/91. Only zinc concentrations in the drains are greater now than concentrations recorded in 1990 and 1991. Comparison of heavy metal concentrations in the Swan River with those recorded in 1990/91 was difficult as most of the results were below the limit of reporting.

Zinc, copper and mercury concentrations in the Bayswater drains were comparable with Mills Street Main Drain concentrations. Arsenic, cadmium, chromium, lead and nutrient concentrations were generally greater in the Mills Street Main Drain than in the Bayswater drains. Only nickel concentrations were higher in the Bayswater drains than in the Mills Street Main Drain catchment. Sampling in the Mills Street Main Drain catchment was conducted during low and high flow periods over 2 years contrasting with snapshot sampling of the Bayswater drains reported here.

Summary

The maximum concentration of half the dissolved heavy metals in the Bayswater drain samples occurred in the Railway Parade Branch Drain. Concentrations of aluminium, copper, nickel and zinc were above aquatic ecosystem trigger values at several sites in the Bayswater drains. Nickel concentrations were below the hardness corrected aquatic ecosystem trigger values at all Bayswater drain sites however the zinc concentration in the King William Street Branch Drain and copper concentrations in several drain segments exceeded the hardness corrected aquatic ecosystem trigger values. Iron, manganese and lead concentrations at several sites in the Bayswater drains exceeded the recreational guidelines.

The maximum concentration of most heavy metals in the Swan River occurred near Ron Courtney Island. Concentrations of copper in the river, and to a certain extent zinc, consistently exceeded the aquatic ecosystem trigger values. Manganese concentrations were consistently elevated in the Swan River and exceeded the recreational guidelines. The results did not indicate an obvious increase in contaminant concentrations in the Swan River at the confluence with the Bayswater Main Drain based on this single sampling occasion. Only dissolved aluminium and zinc concentrations in the Swan River were consistently greater downstream of the confluence with the Bayswater Main Drain.

Concentrations of nutrients and heavy metals in the Bayswater drains and adjacent Swan River have generally either remained similar or decreased since 1990/91. Only zinc concentrations in the drains and river and dissolved inorganic nitrogen concentrations in the river are greater now than the concentrations recorded in the early 1990s. The range of nutrient concentrations in the Mills Street Main Drain catchment was far greater than that recorded in the Bayswater drains. Only nickel concentrations were higher in the Bayswater drains than in the Mills Street Main Drain catchment.

Hardness

Correction of trigger values for hardness is recommended for certain heavy metals in freshwater where the concentration has exceeded the standard trigger value (ANZECC & ARMCANZ, 2000). Depending on the hardness and freshness of the water, heavy metal trigger values could be increased by a factor of 2 to 20 with increasing hardness.

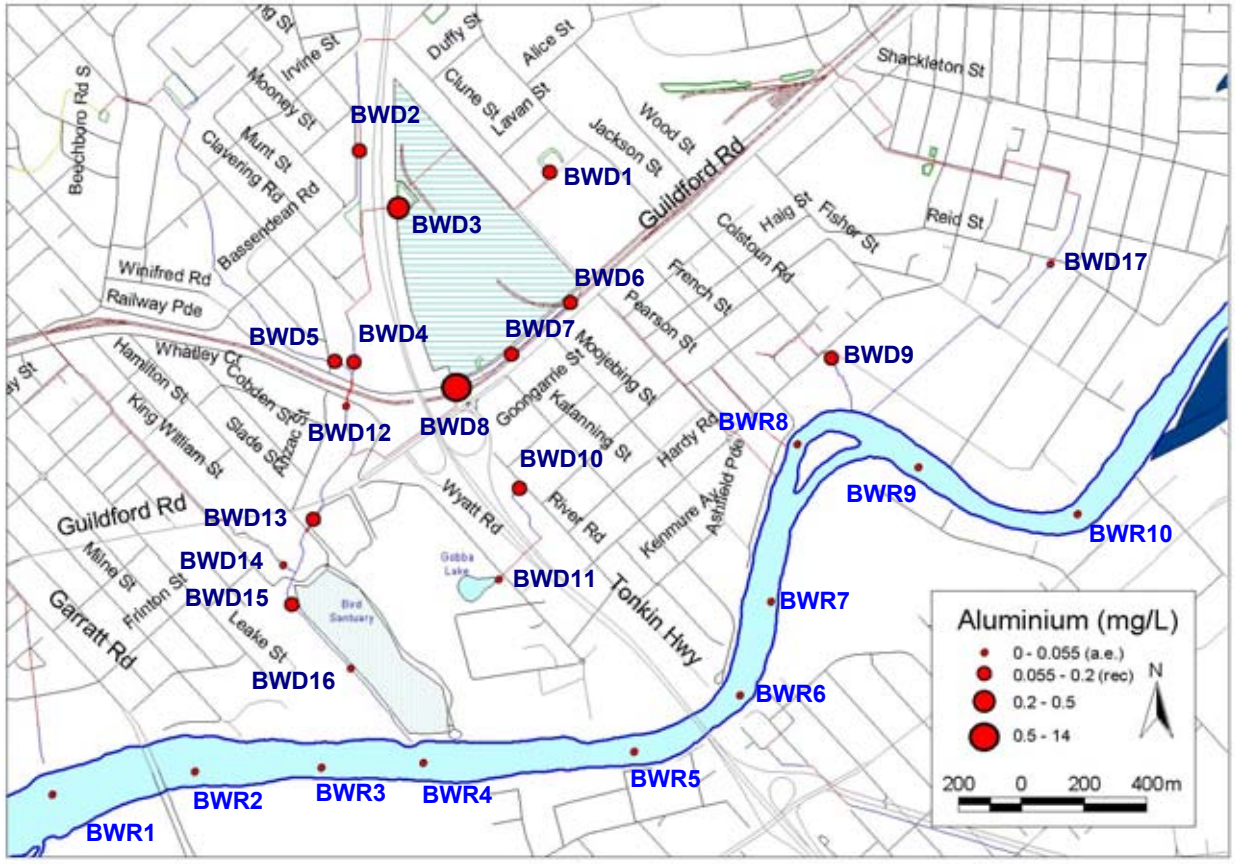
The concentration of cadmium, copper, lead, nickel and zinc in the Bayswater drains exceeded the aquatic ecosystem trigger value at one or more sites. The concentrations of these heavy metals were subsequently compared to the hardness corrected aquatic ecosystem trigger values[6].

Where heavy metal concentrations exceed hardness corrected trigger values a more complex estimate of metal bioavailability or the institution of management actions is recommended (ANZECC & ARMCANZ, 2000).

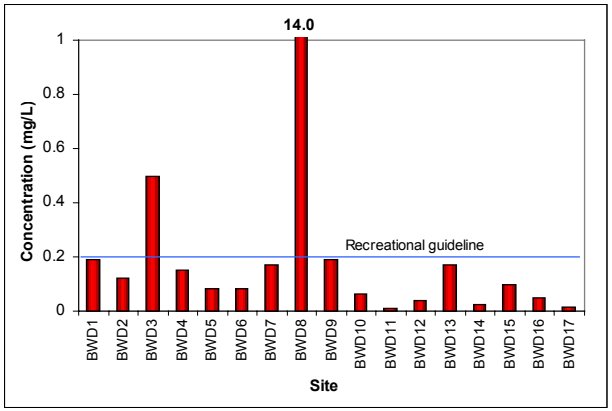
[6] Ecosystem protection trigger values were corrected for hardness using the hardness-dependent algorithim provided in ANZECC & ARMCANZ, 2000 (table 3.4.3).

Dissolved aluminium concentrations in Bayswater drains and the adjacent Swan River on 16 April 2003

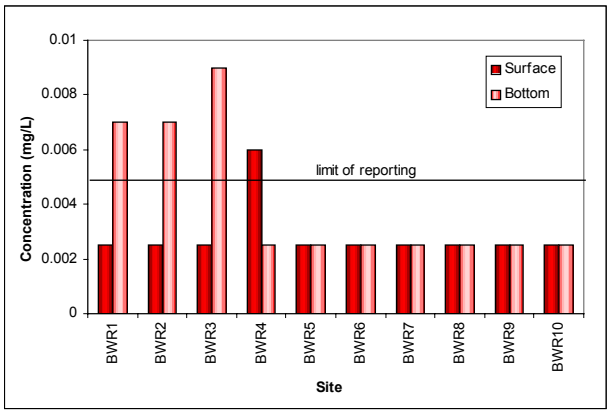
Aquatic ecosystem trigger value (freshwater) 0.055mg/L (pH >6.5)
No aquatic ecosystem trigger value (marine)
Recreational guideline 0.2mg/L)



Bayswater drains



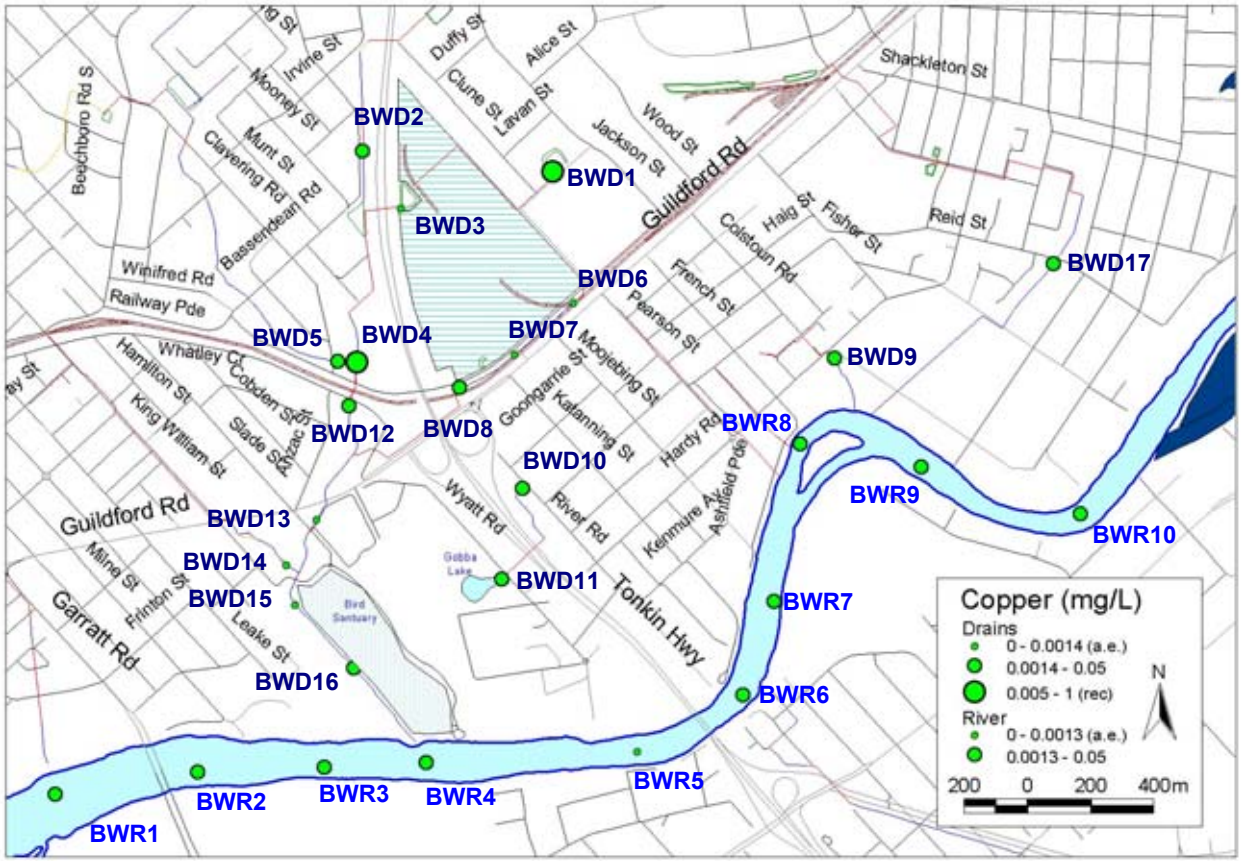
Swan River



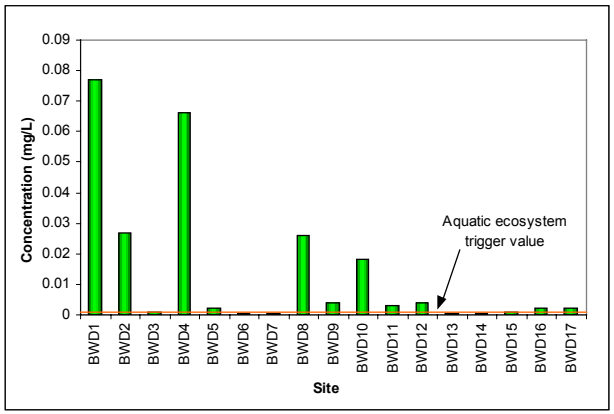
Limit of reporting
A concentration half the limit of reporting has been substituted for all concentrations reported as below the 'limit of reporting' to enable graphing of the results.

Dissolved copper concentrations in Bayswater drains and the adjacent Swan River on 16 April 2003

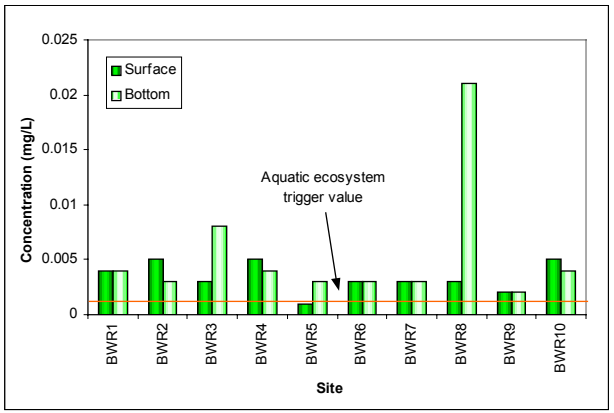
Aquatic ecosystem trigger value (freshwater) 0.0014mg/L
Aquatic ecosystem trigger value (marine) 0.0013mg/L
Recreational guideline 1mg/L



Bayswater drains



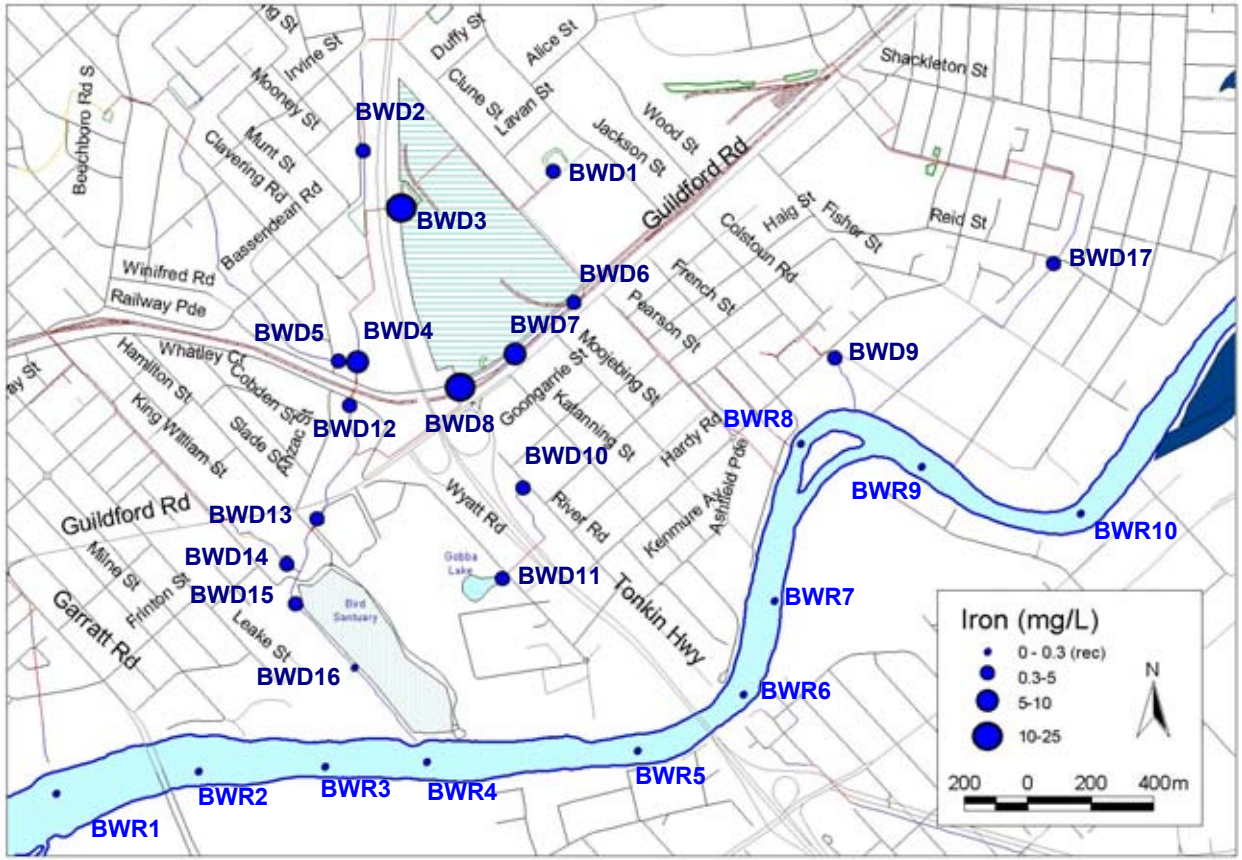
Swan River



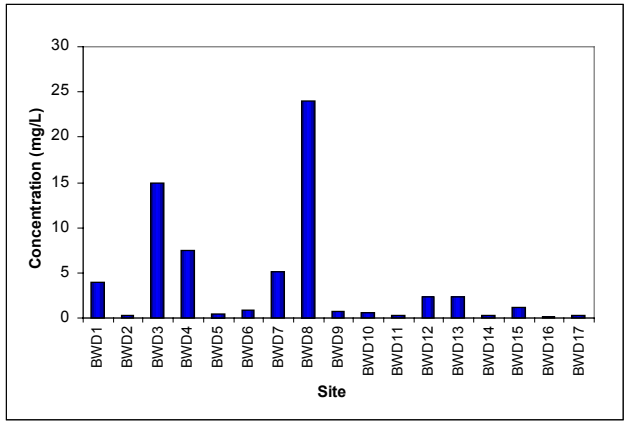
Limit of reporting
A concentration half the limit of reporting has been substituted for all concentrations reported as below the 'limit of reporting' to enable graphing of the results.

Dissolved iron concentrations in Bayswater drains and the adjacent Swan River on 16 April 2003

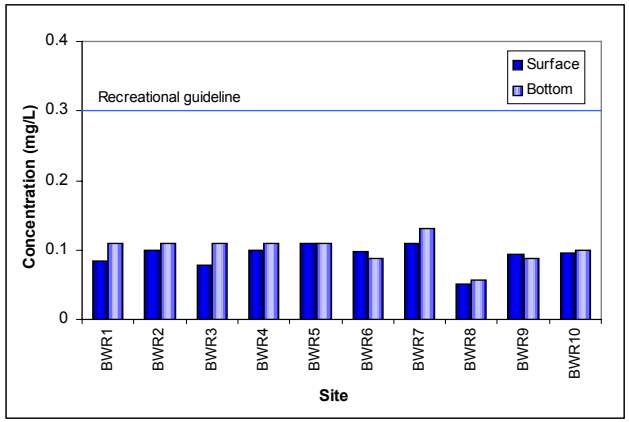
No aquatic ecosystem trigger value (freshwater)
No aquatic ecosystem trigger value (marine)
Recreational guideline 0.3mg/L



Bayswater drains

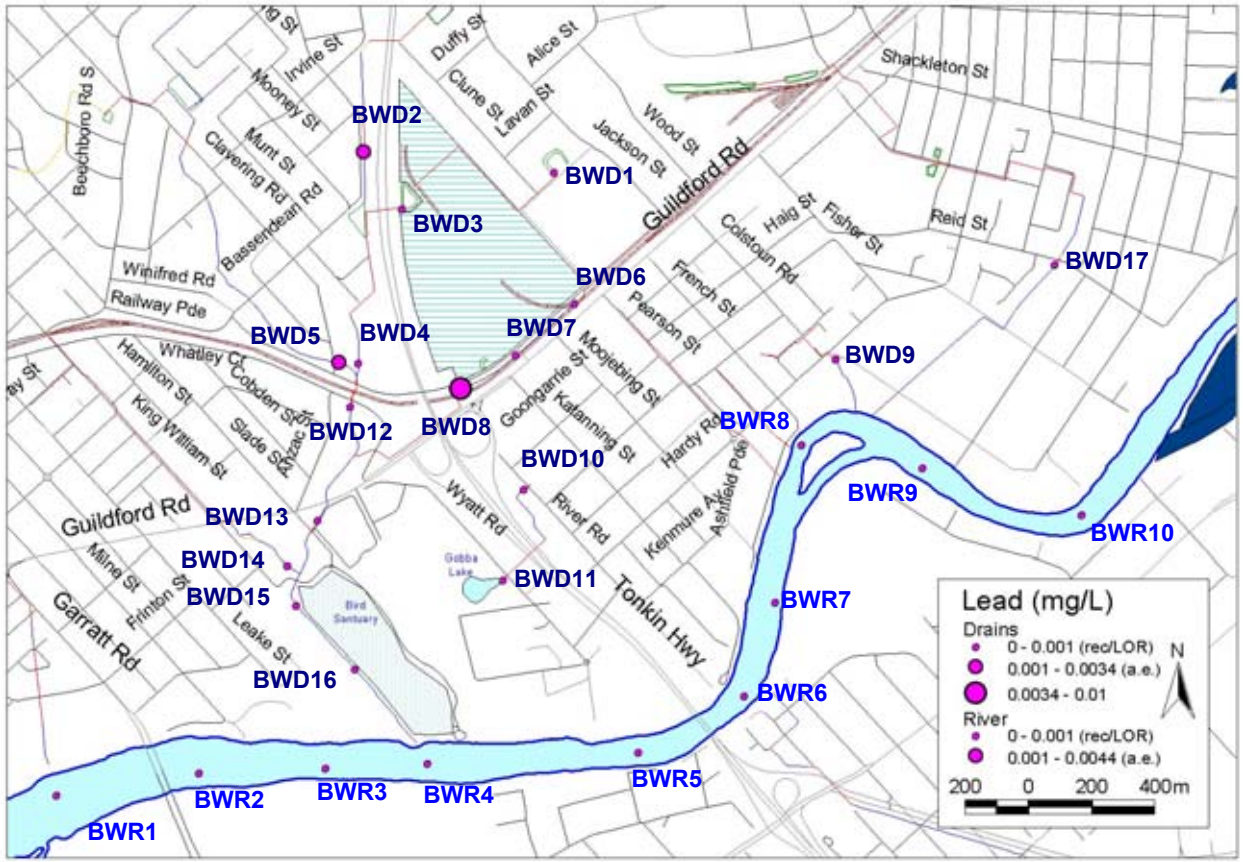


Swan River

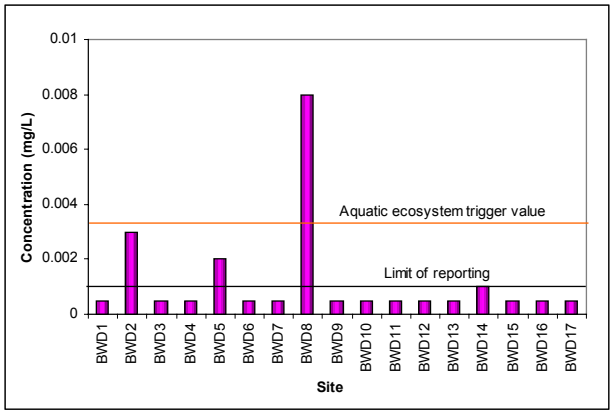


Dissolved lead concentrations in Bayswater drains and the adjacent Swan River on 16 April 2003

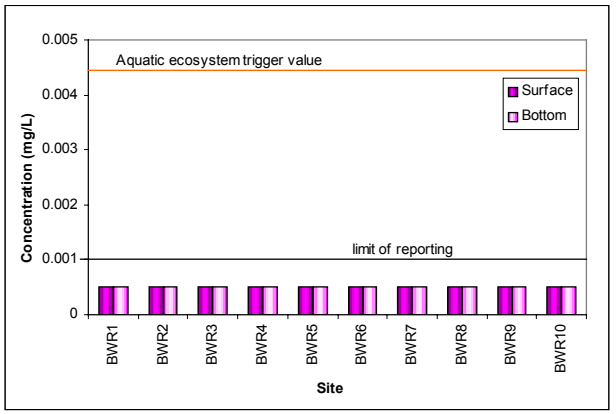
Aquatic ecosystem trigger value (freshwater) 0.0034mg/L
Aquatic ecosystem trigger value (marine) 0.0044mg/L
Recreational guideline 0.05mg/L



Bayswater drains



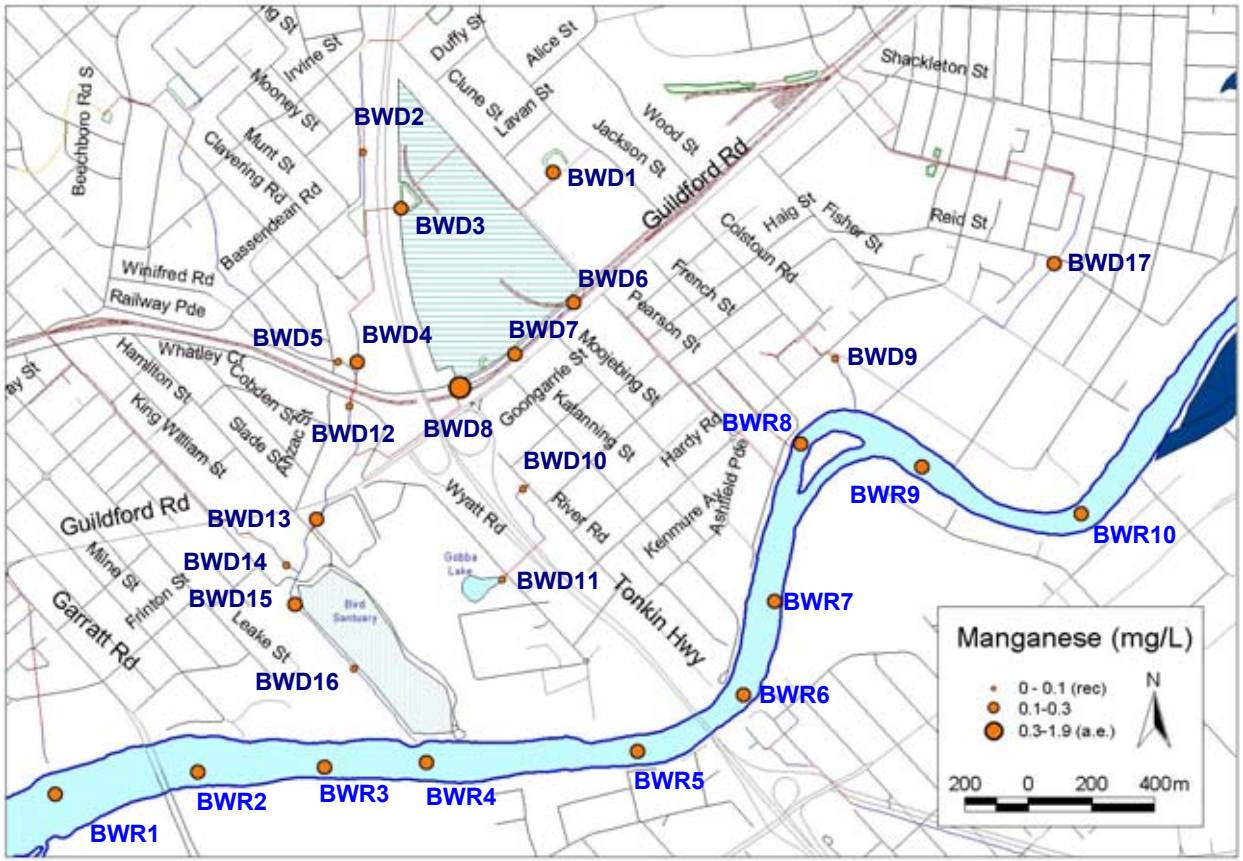
Swan River



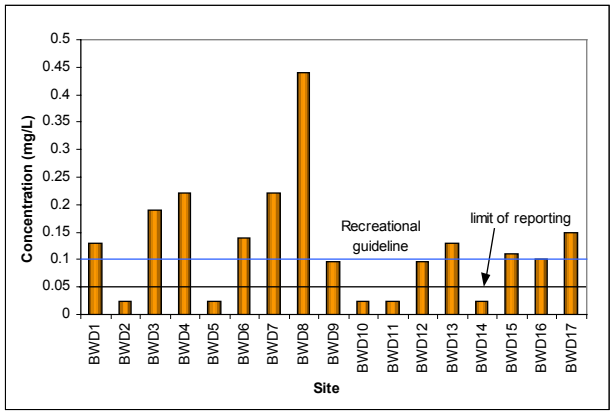
Limit of reporting
A concentration half the limit of reporting has been substituted for all concentrations reported as below the 'limit of reporting' to enable graphing of the results.

Dissolved manganese concentrations in Bayswater drains and the adjacent Swan River on 16 April 2003

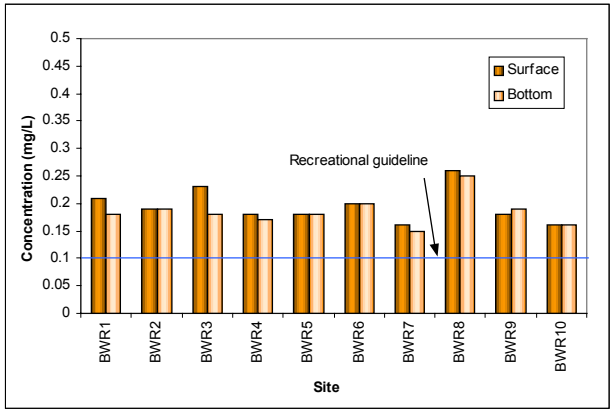
Aquatic ecosystem trigger value (freshwater) 1.9mg/L
No aquatic ecosystem trigger value (marine)
Recreational guideline 0.1mg/L



Bayswater drains



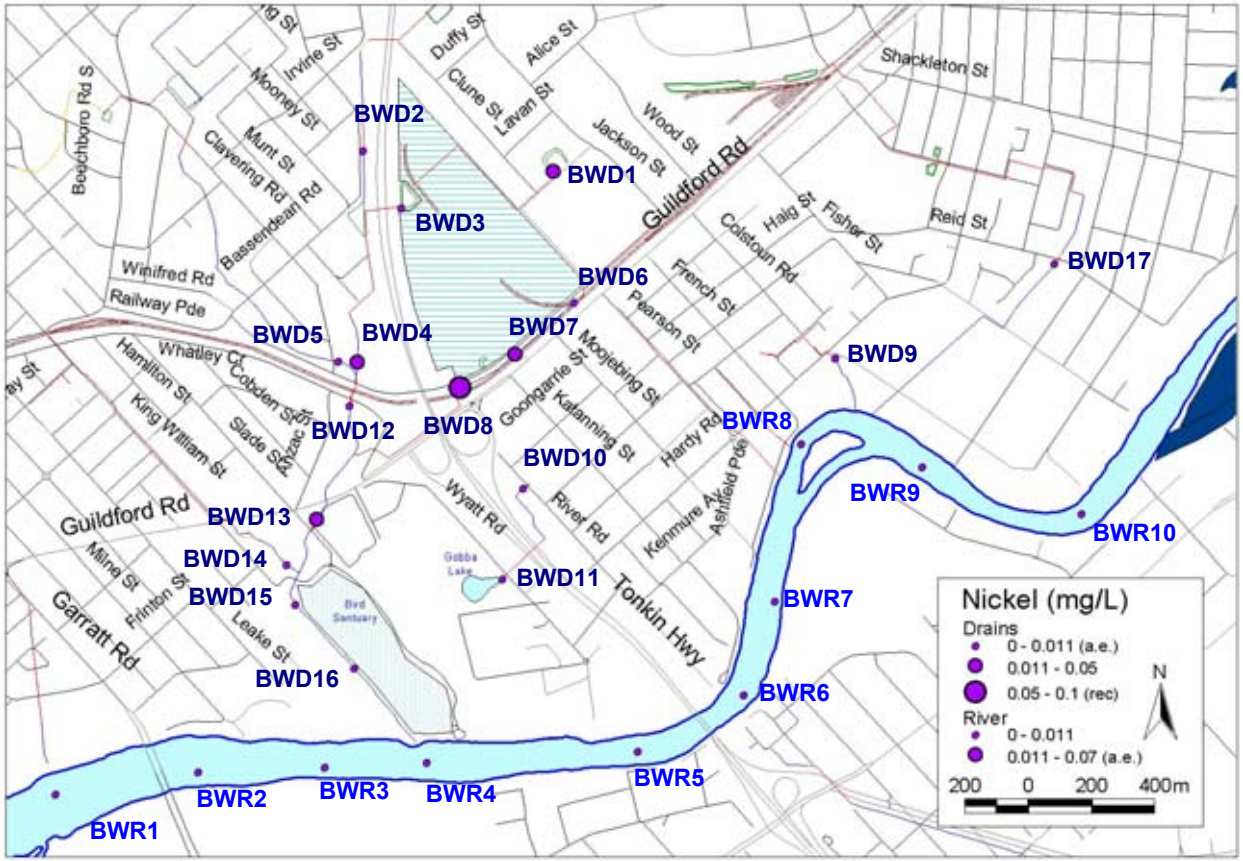
Swan River



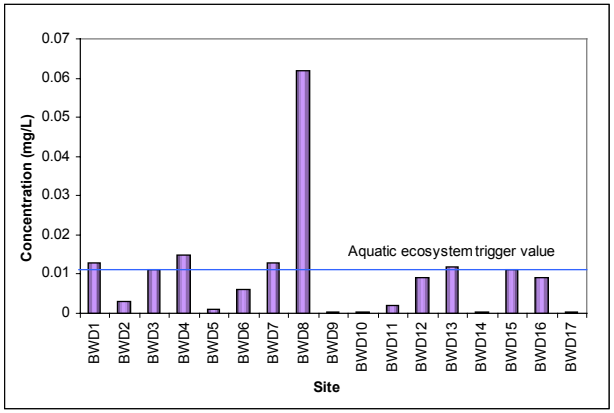
Limit of reporting
A concentration half the limit of reporting has been substituted for all concentrations reported as below the 'limit of reporting' to enable graphing of the results.

Dissolved nickel concentrations in Bayswater drains and the adjacent Swan River on 16 April 2003

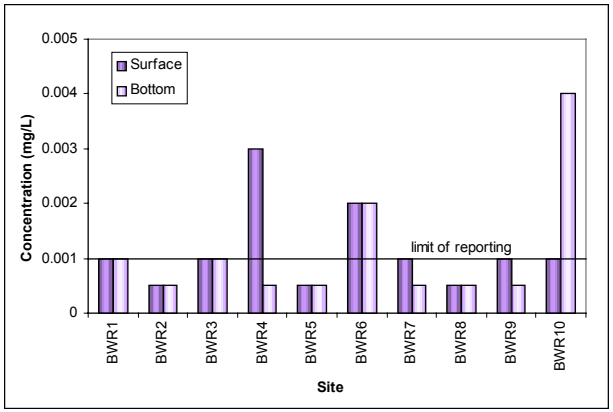
Aquatic ecosystem trigger value (freshwater) 0.011mg/L
Aquatic ecosystem trigger value (marine) 0.070mg/L
Recreational guideline 0.1mg/L



Bayswater drains



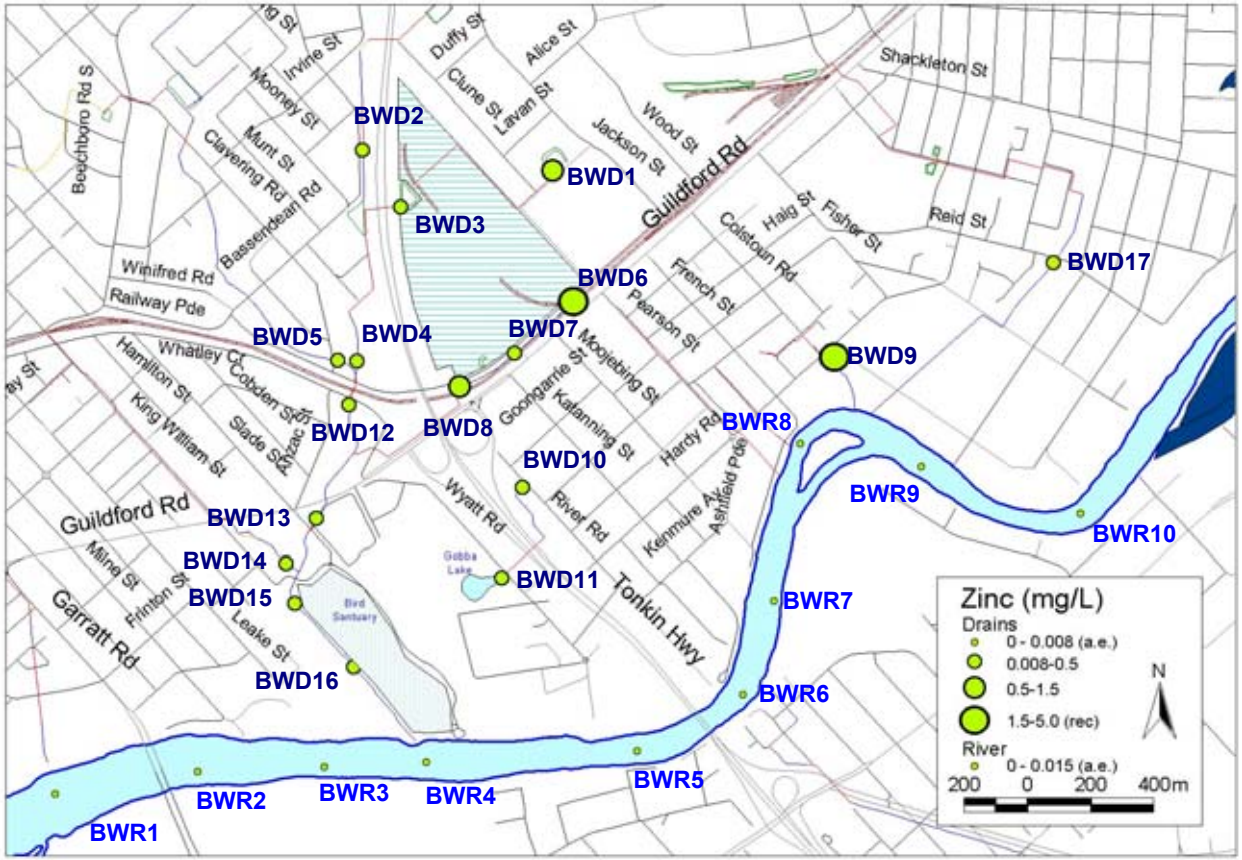
Swan River



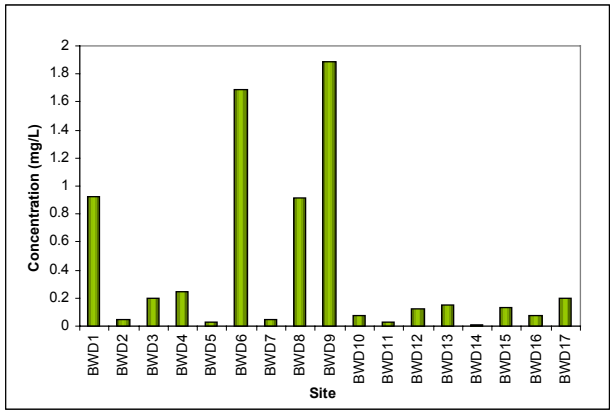
Limit of reporting
A concentration half the limit of reporting has been substituted for all concentrations reported as below the 'limit of reporting' to enable graphing of the results.

Dissolved zinc concentrations in Bayswater drains and the adjacent Swan River on 16 April 2003

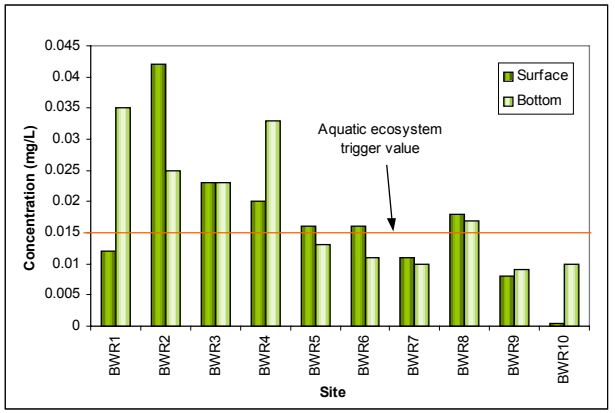
Aquatic ecosystem trigger value (freshwater) 0.008mg/L
Aquatic ecosystem trigger value (marine) 0.015mg/L
Recreational guideline 5mg/L



Bayswater drains

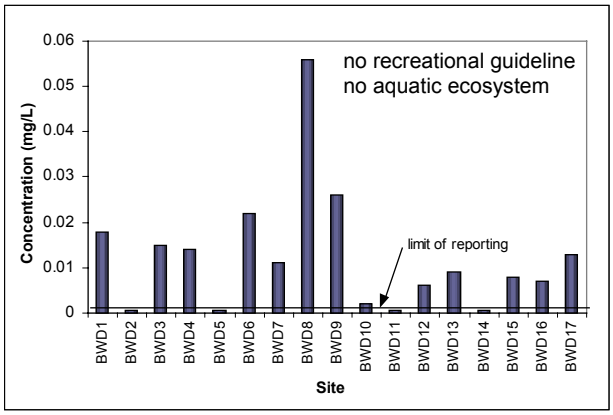


Swan River

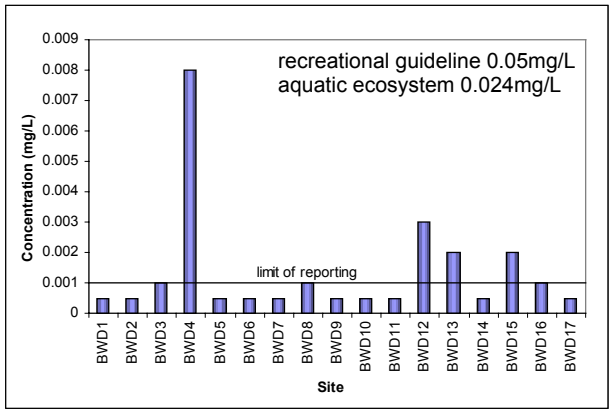


Dissolved heavy metal concentrations in the Bayswater drains on 16 April 2003

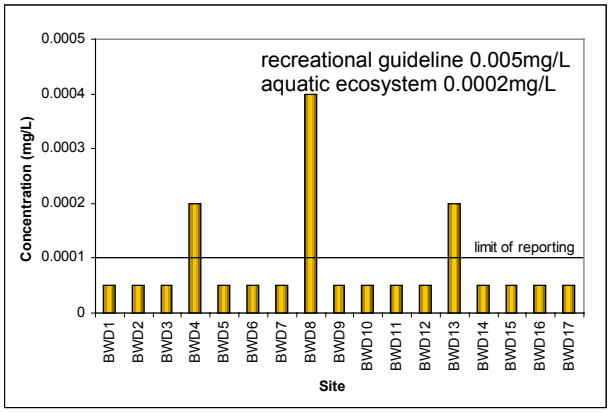
Cobalt



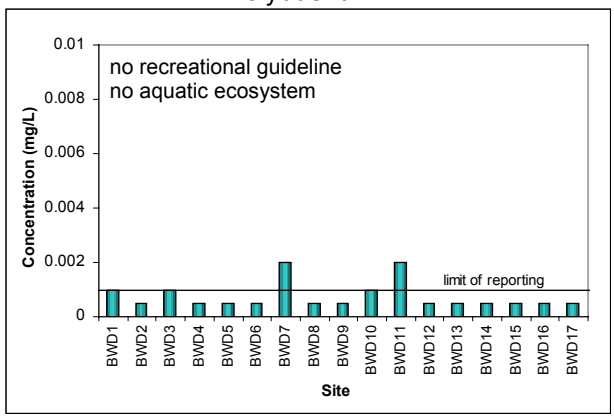
Arsenic



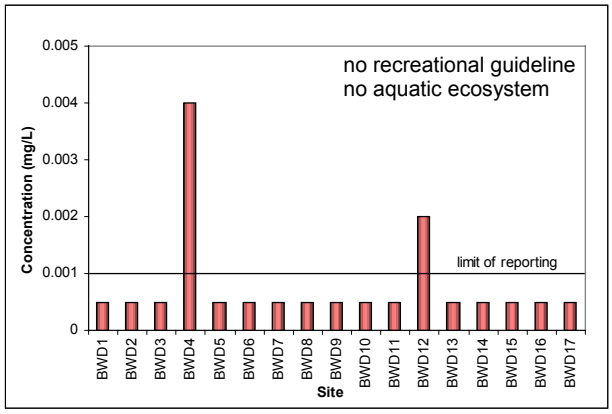
Cadmium



Molybdenum



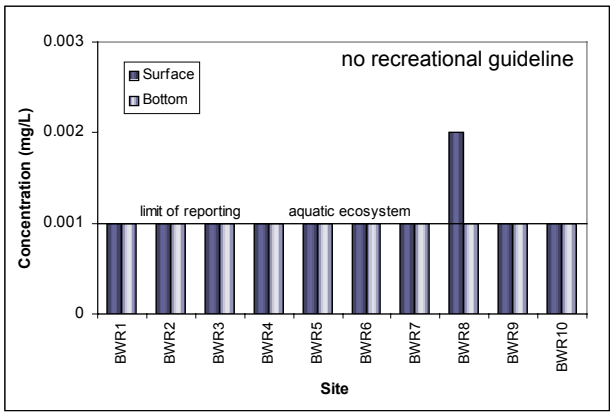
Uranium



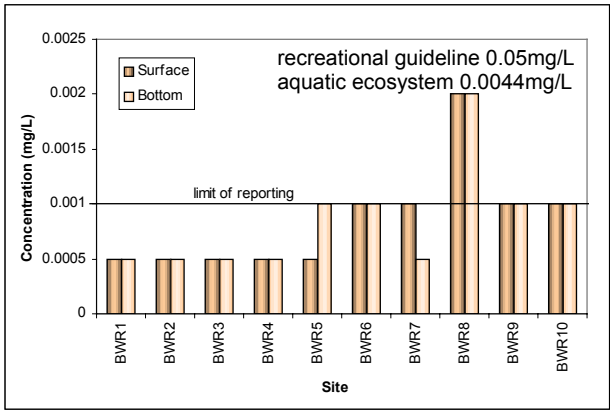
Limit of reporting
A concentration half the limit of reporting has been substituted for all concentrations reported as below the 'limit of reporting' to enable graphing of the results.

Dissolved heavy metal concentrations in the Swan River on 16 April 2003

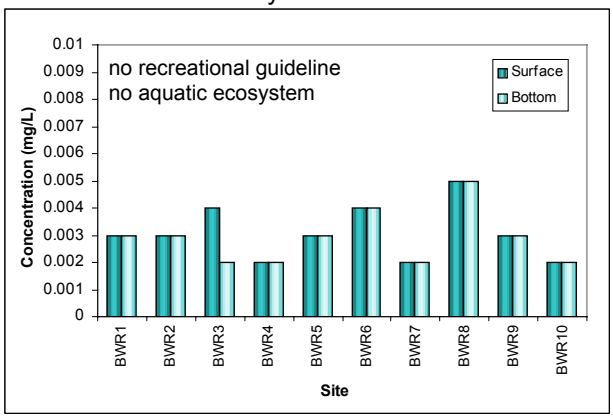
Cobalt



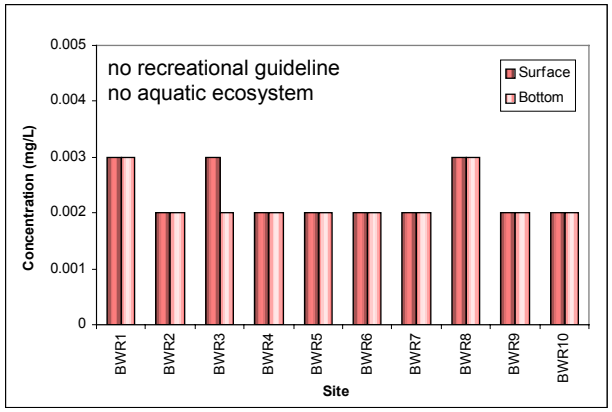
Chromium



Molybdenum



Uranium



Limit of reporting
A concentration half the limit of reporting has been substituted for all concentrations reported as below the 'limit of reporting' to enable graphing of the results.

Sulfate

Sulfate concentrations in the Bayswater drains were spatially variable with some localised elevated concentrations (page 34). The highest sulfate concentration in the Bayswater drains (880mg/L) occurred in the Beechboro Branch Drain upstream from the confluence with the Bayswater Main Drain (BWD4). Elevated sulfate concentrations extended downstream into the Bayswater Main Drain (BWD12). Sulfate concentrations were also elevated in the lower section of the Railway Parade Branch Drain (BWD8). The elevated sulfate concentrations in these drains were most likely due to the proximity of the sample sites to a plaster manufacturing/gypsum processing premises and the CSBP Cresco site.

Soils associated with old wetlands in the Bayswater Main Drain and Upper Swan catchments have the potential to generate acid sulfate soil conditions. Drains frequently intercept these soils and may have contributed to the sulfate concentration in the drain water.

The sulfate concentrations in the Swan River were consistently higher (median – 690mg/L) than in the drains (median – 140mg/L) however the river sulfate concentrations recorded are typical for a marine dominated estuary. The maximum sulfate concentrations in the river occurred near Ron Courtney Island (BWR8) and were approximately double all other river sulfate concentrations.

Aquatic ecosystem trigger values for fresh or marine sulfate concentrations do not currently exist (ANZECC & ARMCANZ, 2000). Only the sulfate concentration in the Beechboro Branch Drain, just upstream of the confluence with the Bayswater Main Drain (BWD4) exceeded the recreational guidelines (ANZECC & ARMCANZ, 2000). Sulfate concentrations at all river sites exceeded the recreational water quality guideline. The recreational guidelines are based on raw water values and sulphate is based on aesthetic considerations, particularly for taste.

Summary

The highest sulfate concentration in the Bayswater drains occurred in the Beechboro Branch Drain. The sulfate concentrations in the Swan River were consistently higher than in the drains however the sulfate concentrations recorded are typical for a marine dominated estuary. The maximum sulfate concentrations in the river occurred near Ron Courtney Island. Sulfate concentrations at all river sites and in the Beechboro Branch Drain exceeded the recreational water quality guideline. These results were reviewed by the Department of Health and because consumption of water is not expected to be significant the concentrations posed no health risk to users of the river.

Fluoride

Fluoride concentrations in the Bayswater drains showed some spatial variation with some localised elevated concentrations (page 35). The highest fluoride concentration (20mg/L) occurred in the Railway Parade Branch Drain (BWD8). The fluoride concentrations decreased rapidly up (BWD7) and downstream (BWD13) of this site. The elevated fluoride concentrations in the Railway Parade Branch Drain were most likely due to the proximity of the sample sites to the CSBP Cresco site.

Most fluoride concentrations in the drains were below 1mg/L and many were below the limit of reporting. Swan River estuary fluoride concentrations showed little spatial variation, ranging from 0.4mg/L to 0.6mg/L.

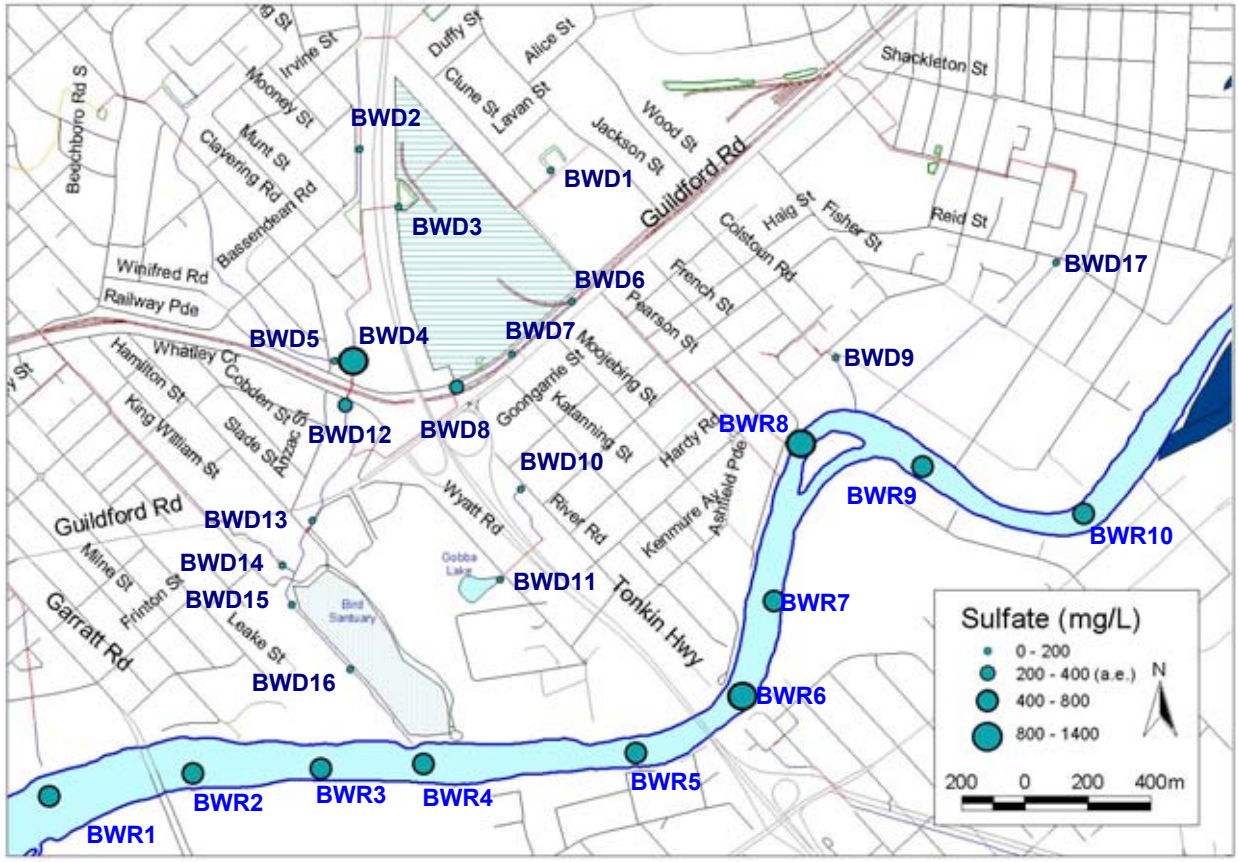
Neither aquatic ecosystem trigger values or recreational guidelines for fluoride concentrations currently exist (ANZECC & ARMCANZ, 2000). Current fluoride concentrations in the Bayswater Main Drain and the King William Street Branch Drain have not increased since 1990/91.

Summary

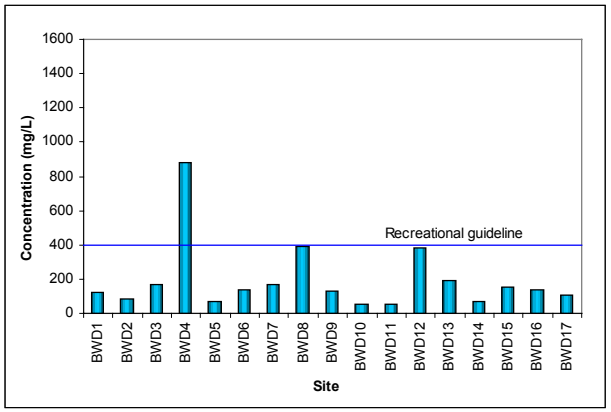
Fluoride concentrations were generally below detection in the drains except at the site nearest the western corner of Railway Parade. Fluoride concentrations in the Swan River were consistently around 0.5 mg/L.

Dissolved sulfate concentrations in Bayswater drains and the adjacent Swan River on 16 April 2003

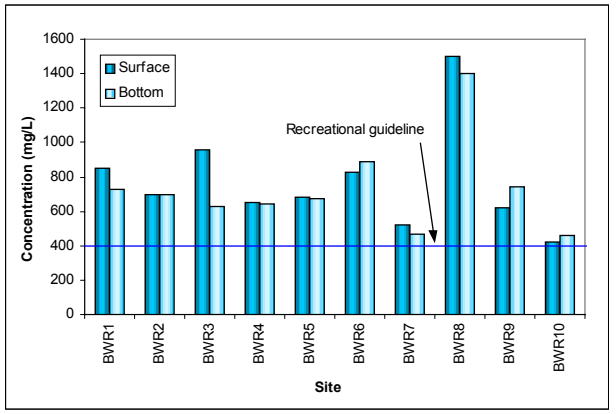
No aquatic ecosystem trigger value (freshwater)
No aquatic ecosystem trigger value (marine)
Recreational guideline 400mg/L



Bayswater drains

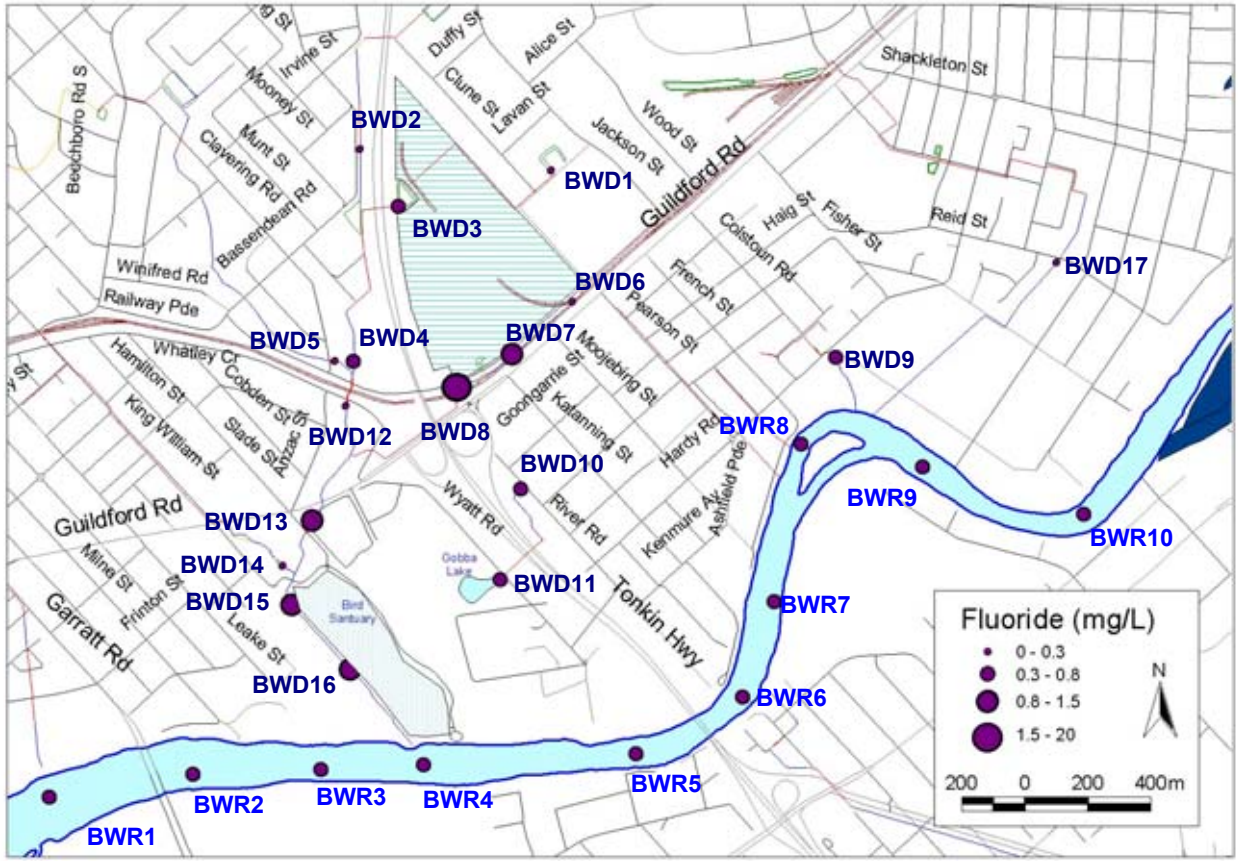


Swan River

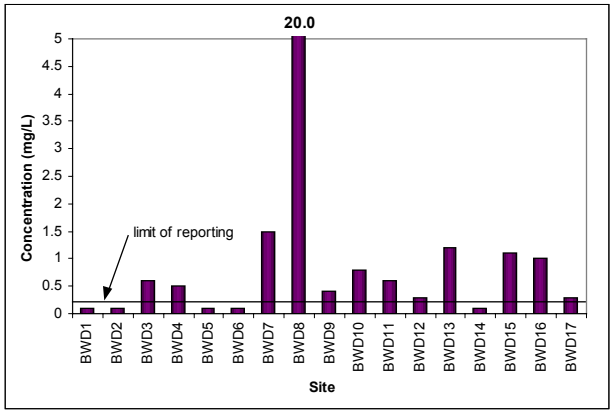


Dissolved fluoride concentrations in Bayswater drains and the adjacent Swan River on 16 April 2003

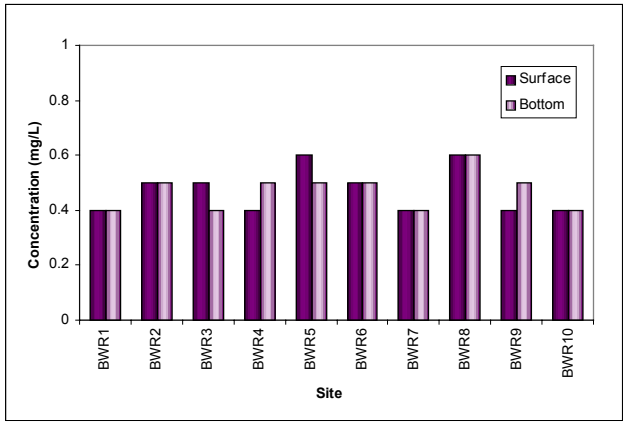
No aquatic ecosystem trigger value (freshwater)
No aquatic ecosystem trigger value (marine)
No Recreational guideline



Bayswater drains



Swan River



Limit of reporting
A concentration half the limit of reporting has been substituted for all concentrations reported as below the 'limit of reporting' to enable graphing of the results.

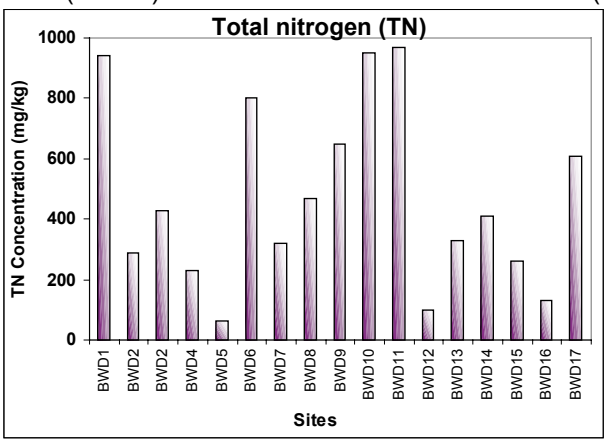
Sediments

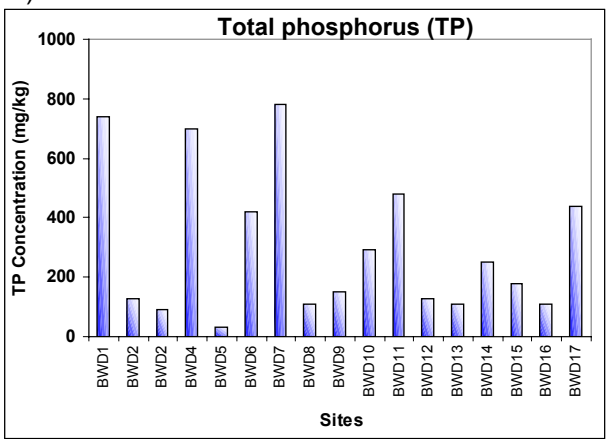
Nutrients

Sediment nutrient concentrations varied spatially throughout the Bayswater drains. Elevated concentrations of total nitrogen (TN) and total phosphorus (TP) in the drain sediments were localised. Sediment nutrient concentrations in the lower Bayswater Main Drain were comparatively low.

The TN concentrations in the Bayswater drains ranged from 61mg/kg to 970mg/kg. The highest TN concentrations occurred in the Stanmuir Road Main Drain (BWD10) and Gobba Lake near the drain inflow (BWD11). Elevated TN concentrations occurred in the Wicks Street Compensating Basin (BWD1) and in the Railway Parade Branch Drain (BWD6). Elevated TN concentrations also occurred in the drains sampled in the Kitchener Road Main Drain (BWD9) and in the Chapman Road Main Drain (BWD17). The Kitchener Road Main Drain and the Chapman Road Main Drain flow into the Swan River near Ron Courtney Island. The drains having high sediment nutrient concentrations all flow through or from industrial areas.

The TP concentrations in the Bayswater drains ranged from 30mg/kg to 780mg/kg. The highest TP concentrations occurred in the Wicks Street Compensating Basin (BWD1), the Railway Parade Branch Drain (BWD7) and in the Beechboro Branch Drain (BWD4).





Elevated total nitrogen and total phosphorus concentrations in the sediments of the Mills Street Main Drain catchment were localised similar to the Bayswater drains. The maximum concentrations of nutrients in the sediments of the Mills Street Main Drain catchment (TN – 5700mg/kg, TP – 1000mg/kg) were greater than in the Bayswater drains however sampling in the Mills Street Main Drain catchment occurred over 2 years.

Summary

Elevated total nitrogen and total phosphorus concentrations were recorded in the sediments of several drain segments including the Stanmuir Road Main Drain, the Railway Parade Branch Drain, the Kitchener Road Main Drain and the Beechboro Branch Drain.

Sediment sampling in the Bayswater Main Drain just upstream of the confluence with the Swan River

Heavy metals

Heavy metal concentrations throughout the Bayswater drains sediments were generally low compared to guidelines. Elevated heavy metal concentrations in the drain sediments were localised (page 38).

The Wicks Street Compensating Basin (BWD1) recorded the highest concentration of chromium (87mg/kg), copper (130mg/kg), manganese (56mg/kg), molybdenum (9.6mg/kg), nickel (76mg/kg), uranium (1.2mg/kg) and zinc (7430mg/kg). The sediment organic carbon content at site BWD1 (4.2%) was relatively high and consequently a reduced bioavailability of heavy metals at this site would be expected. The Wicks Street Compensating Basin is in an industrial area of the Bayswater Main Drain catchment.

The concentration of aluminium (8390mg/kg), iron (20600mg/kg), lead (150mg/kg) and selenium (0.61mg/kg) were greatest in the Chapman Road Main Drain (BWD17). The Chapman Road Main Drain originates in an industrial area and flows into the Swan River near the Ron Courtney Island.

Concentrations of heavy metals in the sediment of the Railway Parade Branch Drain were comparatively low despite the elevated heavy metal concentrations detected in the water (page 22). Low pH levels in the Railway Parade Branch Drain water have probably mobilised the heavy metals from the sediment into the water column.

Zinc concentrations in the sediment exceeded the high trigger values at five sites in the Bayswater drains (ANZECC & ARMCANZ, 2000). The arsenic, chromium and nickel concentrations in the drain sediments were generally low and mercury concentrations were below the limit of reporting at all sites.

Lead in the Chapman Road Main Drain (BWD17) and nickel in the Wicks Street Compensating Basin (BWD1) exceeded the high trigger value concentration for sediment. Lead, copper and cadmium concentrations in the sediment exceeded the low trigger value at several sites in the Bayswater drain system.

Trigger values were not yet available for aluminium, cobalt, iron, manganese, molybdenum, selenium and uranium concentrations in sediment (ANZECC & ARMCANZ, 2000).

The maximum concentrations of most heavy metals in sediment were lower in the Bayswater drains than in the Mills Street Main Drain catchment. The exceptions were cadmium (1.6mg/L), nickel (76mg/L) and zinc (7430mg/L) which were greater in the Wicks Street Compensating Basin (BWD1) than the concentrations recorded at any other site in the Bayswater drains or the Mills Street Main Drain catchment. The nickel and zinc concentrations at BWD1 were far greater than the maximum concentration recorded in the Mills Street Main Drain catchment.

Summary

Sediment contaminant concentrations varied spatially throughout the Bayswater drains. Elevated concentrations of contaminants in the drain sediments were localised.

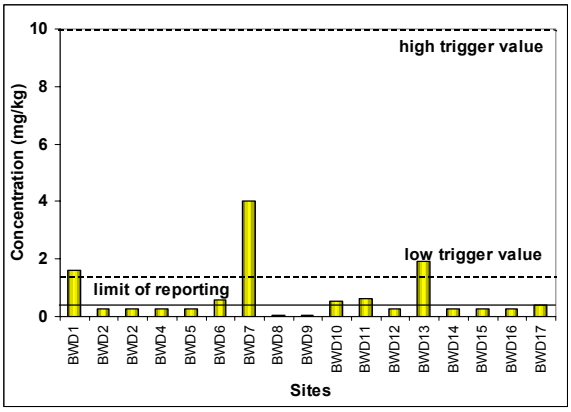
The highest concentration of most heavy metals and elevated total nitrogen and total phosphorus concentrations occurred in the Wicks Street Compensating Basin and the Chapman Road Main Drain.

Zinc concentrations in the sediment exceeded the high trigger values at five sites in the Bayswater drains. Lead in the Chapman Road Main Drain and nickel in the Wicks Street Compensating Basin exceeded the high trigger value concentration for sediment. Lead, copper and cadmium concentrations in the sediment exceeded the low trigger value at several sites in the Bayswater drain system.

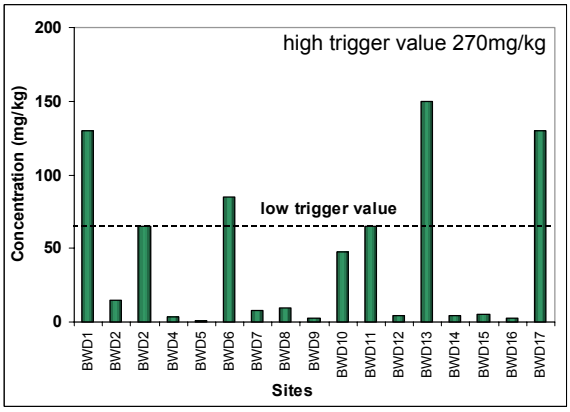
The maximum concentrations of most heavy metals, total nitrogen and total phosphorus in sediment were lower in the Bayswater drains than in the Mills Street Main Drain catchment. In contrast, the concentration of cadmium, nickel and zinc in the sediment of the Wicks Street Compensating Basin was greater than the concentration recorded at any other site in the Bayswater drains or the Mills Street Main Drain catchment.

Heavy metal concentrations in the Bayswater drain sediments between 2 and 15 May 2003

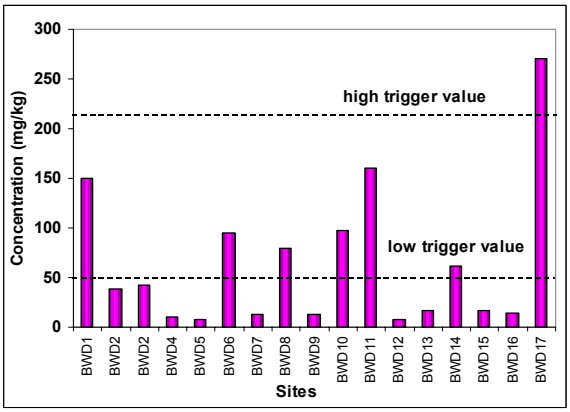
Cadmium



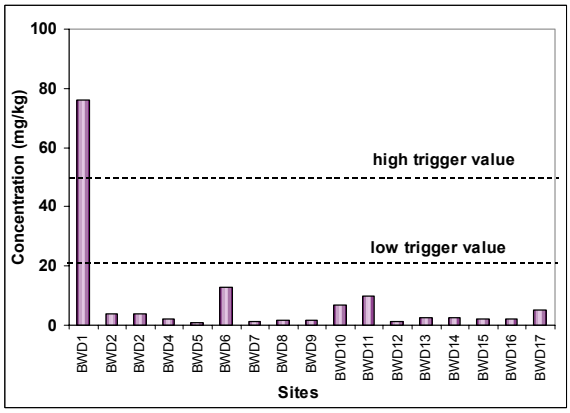
Copper



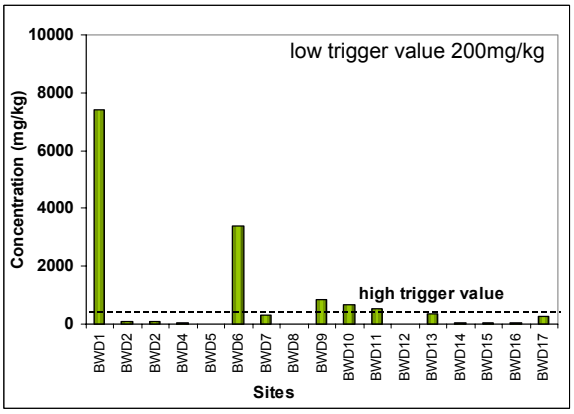
Lead



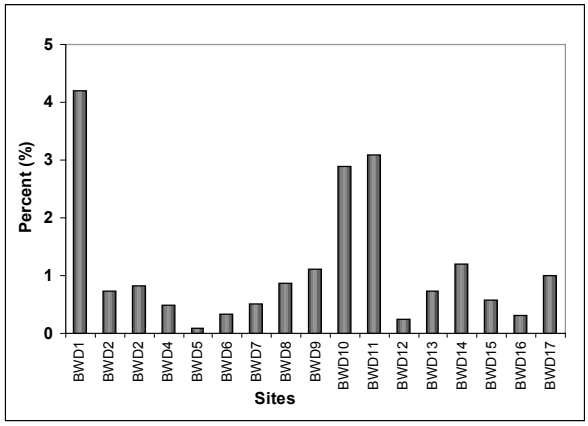
Nickel



Zinc



Organic carbon content



Limit of reporting
A concentration half the limit of reporting has been substituted for all concentrations reported as below the 'limit of reporting' to enable graphing of the results.

Fish

Heavy metals

There was generally a high degree of variability in heavy metal concentrations between the two fish species (Black bream and Yellowtail trumpeter) and between the locations. No consistent trends in heavy metal concentrations between fish species or between the locations sampled were identified, however further sampling would be required to support this observation (page 40). Total arsenic, mercury and manganese concentrations in both fish species were reasonably similar at all locations in the Swan River. An elevated arsenic concentration (1.2mg/kg) was recorded in the large Black bream sample collected near the confluence with the Bayswater Main Drain (BWR4). The arsenic concentration in this sample was well within arsenic concentrations in similarly sized Black bream from the Swan River analysed in 2000[7]. An elevated mercury concentration (0.11mg/kg) was recorded in the Yellowtail trumpeter sample collected near the confluence with the Bayswater Main Drain (BWR4). The mercury concentration in Yellow Trumpeter at BWR4 was almost twice the concentration at the Garratt Road bridge location (BWR2) despite that fact that the fish sampled were of equal size and age. The manganese concentration (0.26mg/kg) in small Black bream collected near the confluence with the Bayswater Main Drain (BWR4) was also more than double the concentration recorded at the other locations. The significance of these results was difficult to determine as the results are derived from one-off sampling and there is limited existing data with which to compare results.

There was little variation in total aluminium and iron concentrations between fish species or between sample locations however both were elevated in a sample collected near the Garratt Road Bridge (BWR2). The aluminium concentration in small Black bream near the Garratt Road Bridge (BWR2) was significantly elevated (0.73mg/kg) as was the iron concentration in Yellowtail trumpeter (19mg/kg) at the same location. The total nickel concentration in large (0.08mg/kg) and small (0.06mg/kg) Black bream collected at Sandy Beach Reserve (BWR10) were elevated compared with samples from the other locations (0.02–0.04mg/kg).

Total selenium concentrations were highly variable between fish species and between sample locations. However total chromium, copper and zinc concentrations showed little variation between fish species or between sample locations. The concentrations of cadmium, cobalt, molybdenum, lead and uranium in the fish samples at all locations were equal to or below the limit of reporting. Heavy metal concentrations in all fish flesh from all locations were below the Maximum Levels and Generally Expected Levels 90% for fish (ANZFA, 2000). Heavy metal concentrations in the fish flesh were also below the Generally Expected Levels 50% for fish. Selenium and zinc concentrations were the only exceptions.

Total selenium concentrations in Black bream and Yellowtail trumpeter at all sample locations exceeded the Generally Expected Level 50% (0.5mg/kg) for fish. Total zinc concentrations Black bream exceeded the Generally Expected Level 50% (5.0mg/kg) for fish near the confluence of the Bayswater Main Drain (BWR4) and upstream near the Sandy Beach Reserve (BWR10). Concentrations of zinc in most other fish samples tested were just below the Generally Expected Level 50% for fish. Concentrations of heavy metals in Yellowtail trumpeter from the Swan River adjacent to the Bayswater Main Drain have generally either remained similar or decreased since 1990/91. The concentration of cadmium, copper, selenium and zinc in Black bream recorded in this investigation are similar to the concentration recorded in 2000. Arsenic, mercury and lead concentrations in Black bream were lower than those recorded in 2000.

Summary

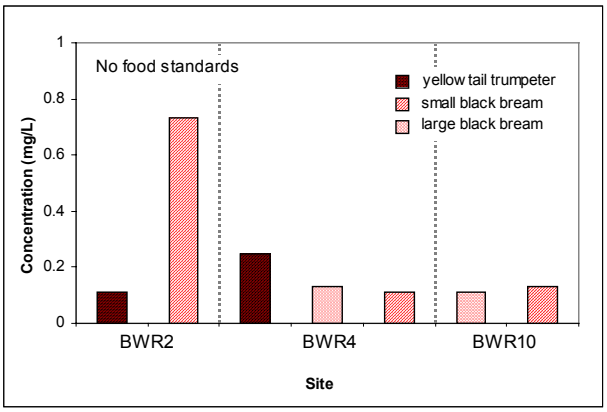
Several heavy metal concentrations were elevated in single fish samples collected near the confluence with the Bayswater Main Drain including arsenic in large Black bream, mercury in Yellowtail trumpeter and manganese in small Black bream. The total aluminium in small Black bream and the total iron concentration in Yellowtail trumpeter were elevated near the Garratt Road Bridge. The total nickel concentrations in Black bream at Sandy Beach Reserve were elevated compared with samples from the other locations.

[7] 2000 study sampled at least 3 year old Black bream.

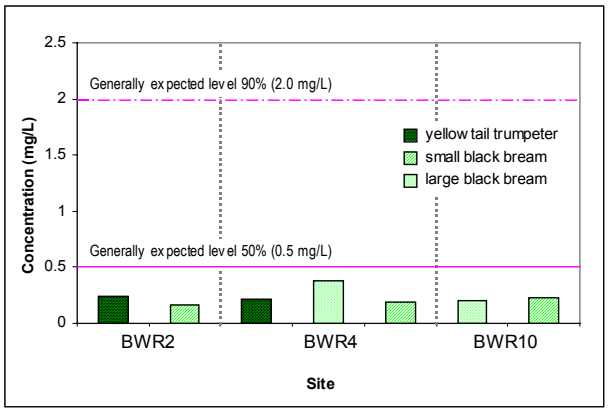
Heavy metal concentrations in all fish flesh from all locations were below the Maximum Levels and Generally Expected Levels 90% for fish. Heavy metal concentrations in the fish flesh were also below the Generally Expected Levels 50% for fish except selenium and zinc. Concentrations of heavy metals in Yellowtail trumpeter from the Swan River adjacent to the Bayswater Main Drain have generally either remained similar or decreased since 1990/91. The concentration of cadmium, copper, selenium and zinc in Black bream recorded in this investigation are similar to the concentration recorded in 2000. Arsenic, mercury and lead concentrations in Black bream were lower than those recorded in 2000.

Heavy metal concentrations in the Fish (fish flesh) in the Swan River on 30 April and 6 May 2003

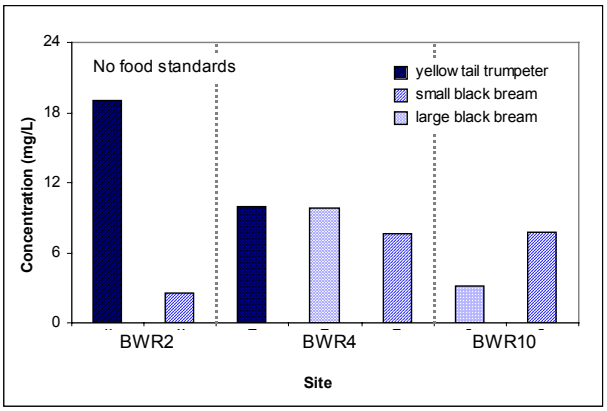
Aluminium



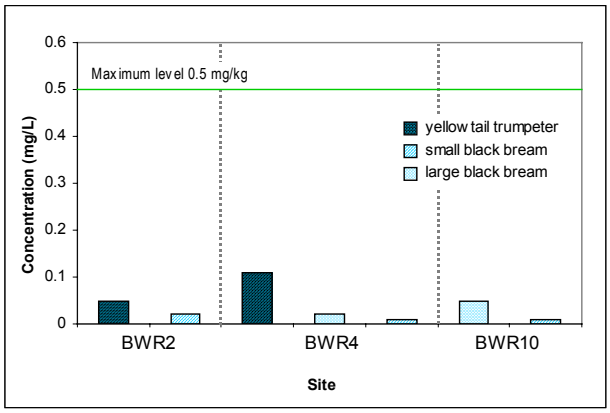
Copper



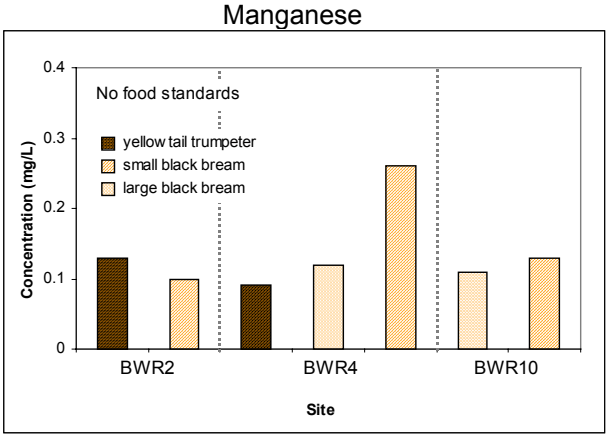
Iron



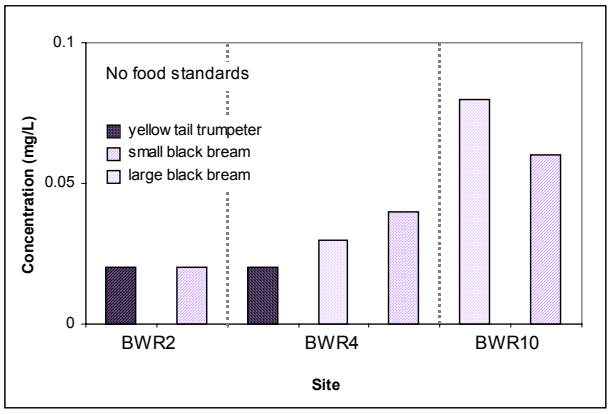
Mercury



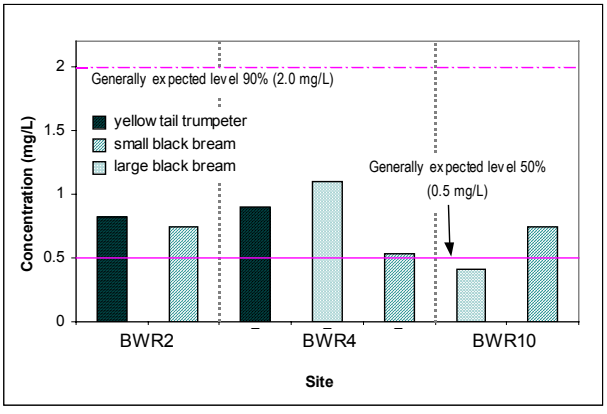
Manganese



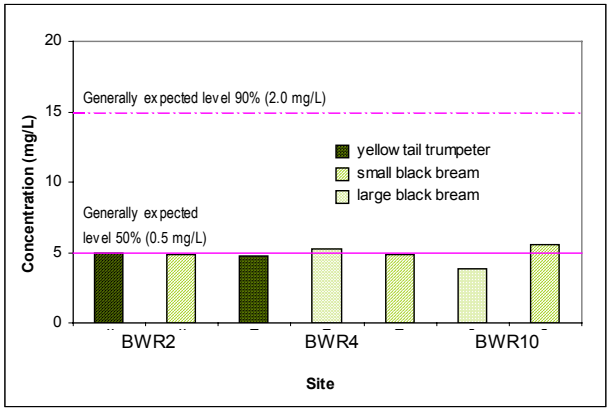
Nickel



Selenium



Zinc



References

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

ANZFA (2000). *Food Standards Code*. Australian and New Zealand Food Authority (ANZFA).

APHA (1998). *Standard Methods for the Examination of Water and Wastewater*, 20th Edition. American Public Health Association, American Water Works Association and Water Environment Federation.

AS/NZS (1998). *Water quality – Sampling. Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples.* AS/NZS 5667.1:1998. Standards Australia and Standards New Zealand.

Atkins R., Deeley D., Hosja W., Klemm V., Parker I. and Parsons G. (1990). *Pesticide and metal pollution of the Swan River adjacent to the Bayswater Main Drain*; Swan River Trust.

Chegwidden A. & Associates. (1980). *Heavy Metals in Sediments and Mussels of the Swan River System*, Report to the Waterways Commission.

DEP (2001). *Assessment Levels for Soil, Sediment and Water*: Version 2 Draft for Comment. Department of Environmental Protection.

Jakowyna B. (2002). *Swan-Canning Cleanup Program: Nutrients in Tributaries of the Swan-Canning Estuarine System (1987 – 2000): Seasonal and Flow Variation*. Swan-Canning Cleanup Report No. 26, Swan River Trust.

Klemm V., Deeley D. (1991). *Water Quality in the Bayswater Main Drain – A working paper for the Bayswater Integrated Catchment Management Steering Committee*, Report No. 4; Swan River Trust.

NHMRC and ARMCANZ (1996). *National Water Quality Management Strategy: Australian Drinking Water Guidelines - Summary.* National Health and Medical Research Council, Agriculture and Resource Management Council of Australia and New Zealand.

Parsons Brinkerhoff (2003). *A summary of Groundwater Conditions Associated with the CSBP Cresco Site, Bayswater*. Parsons Brinkerhoff.

Parsons Brinkerhoff (2003). *Interim Report: Off-site Groundwater Investigation – Former Cresco Site, Railway Parade, Bayswater*. Parsons Brinkerhoff.

Swan River Trust (1999). *Swan-Canning Cleanup Program Action Plan*. An Action plan to clean up the Swan-Canning Rivers and Estuary. Swan River Trust.

Swan River Trust (1999). *Swan Canning Program: Contaminants in the Swan-Canning Rivers and Estuary: A supporting document to the Swan –Canning Cleanup Program Action Plan*. SCCP Report No. 15

Swan River Trust (2003). *Nutrient and contaminant assessment for the Mills Street Main Drain catchment*. SCCP Report No. 31, Swan River Trust.

Von Altenstadt H.F. (1992). *Heavy Metals in the Swan River Estuary*. N422 Environmental Impact Assessment Project, Murdoch University

Webb D., Gagnon MM., Rose T., and Thomson C. (2000). *Monitoring the Health of the Swan River Estuary, Western Australia, using Fish Biomarkers*. SPIRT preliminary study, Curtin University and Water and Rivers Commission

Appendix A – Glossary

Aesthetic	Aspects of water that are perceivable by the senses.
ANZECC	Australian and New Zealand Environment and Conservation Council.
ANZFA	Australian and New Zealand Food Authority.
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand.
Bioavailable	Fraction of the total chemical (eg. nutrients and heavy metals) in the surrounding environment that can be taken up by organisms.
Fish	Animal and plant life.
Catchment	The area of land which intercepts rainfall and contributes the collected water to surface water (streams, drains, rivers, wetlands) or groundwater.
Compensating basin	Many stormwater drains discharge into compensating basins to allow temporary storage of run-off and reduce the need for large capacity stormwater drains.
Composite Sample	The bulking and thorough mixing of equal quantities of soil samples collected from more than one sample location to form a single soil sample for chemical analysis.
Contaminant	A substance which has the potential to present a risk of harm to human health or any environmental value.
FRP	Filterable reactive phosphorus; technical term for the form of dissolved inorganic phosphorus measured in standard water quality sampling
Generally Expected Levels 50%	50% of food samples tested should have a concentration less than this value.
Generally Expected Levels 90%	90% of food samples tested should have a concentrations less than this value
Hardness	Measure of calcium and magnesium concentrations in water.
Limit of reporting	Lowest level of detection achievable amongst laboratories; the level that another laboratory should reach given the same instrument, method and sample matrices.
pH	Measure of acidity or alkalinity of water.
Sediment	Loose particles of sand, clay, silt and other substances that settle at the bottom of a body of water. Sediment can derive from the erosion of soil or from the decomposition of plants and animals.
Specific conductivity	Measure of the total concentration of inorganic ions in water; relates closely to salinity.

Appendix B – Site locations

List and description of sampling sites in the Swan River

Site no.	Location	Easting	Northing
BWR1	Opposite Swan Lake Main Drain outlet	397205	6466444
BWR2	Upstream of Garret Road Bridge, opposite Hinds Park jetty	397712	6466554
BWR3	Opposite downstream end of Riverside Gardens beach	398165	6466596
BWR4	Upstream of Bayswater Main Drain outlet	398529	6466633
BWR5	Downstream of Redcliffe Bridge (Tonkin Highway), approximately 200 metres downstream of the jetty on the southern bank	399282	6466713
BWR6	Upstream of Redcliffe Bridge (Tonkin Highway), downstream of Perth Airport Southern Main Drain	399651	6466937
BWR7	Opposite Claughton Reserve, upstream of Perth Airport Southern Main Drain	399743	6467281
BWR8	West side of Ron Courtney Island (equivalent to WRC site RON)	399807	6467848
BWR9	Upstream of Ron Courtney Island	400244	6467790
BWR10	Opposite Sandy Beach Reserve	400826	6467654

List and description of sampling sites in the Bayswater drains

Site no.	Drain section/component	Location	Easting	Northing
BWD1	Wicks Street Branch Drain	Wicks Street CB outlet, Wicks Street	398865	6468776
BWD2	Beechboro Branch Drain	Northern end of open drain adjacent to Bassendean Road	398180	6468815
BWD3	Wicks Street Branch Drain	Cresco CB outlet	398329	6468616
BWD4	Beechboro Branch Drain	Open drain upstream of confluence with Bayswater MD	398200	6468055
BWD5	Bayswater Main Drain	Open drain upstream of confluence with Beechboro BD	398132	6468053
BWD6	Railway Parade Branch Drain	Most eastern point of open drain adjacent to Railway Parade	398966	6468311
BWD7	Railway Parade Branch Drain	Open drain south-west of railway crossing, adjacent to Railway Parade	398764	6468113
BWD8	Railway Parade Branch Drain	Most western point of open drain, adjacent to Railway Parade	398574	6467984
BWD9	Kitchener Road Main Drain	Downstream of Hardy Road	399913	6468163
BWD10	Stanmuir Road Main Drain	River Road culvert	398820	6467634
BWD11	Stanmuir Road Main Drain	Inlet to Gobba Lake, Wyatt Road	398764	6467307
BWD12	Bayswater Main Drain	Open drain downstream of Whatley Crescent culvert	398182	6467896
BWD13	Bayswater Main Drain	At gauging station (equivalent to WRC site SWS10),	398086	6467480
BWD14	King William Street Branch Drain	King William Street CB	397987	6467315
BWD15	Bayswater Main Drain	Open drain downstream of confluence with King William Street BD	398028	6467175
BWD16	Bayswater Main Drain	Open drain approximately 300 metres downstream of site BWD15 (equivalent to WRC site 6161874)	398250	6466957
BWD17	Chapman Road Main Drain	Downstream of Reid Street	400678	6468546

NOTE - Eastings and northings for all Swan River sites were obtained from global positioning system (GPS) reading at the site (except BWR8 and BWR9). Eastings and northing for all Bayswater drain sites, BWR8 and BWR9 were obtained using geographic information systems (GIS).

Appendix C - Freshwater trigger values and guidelines

Trigger values and guidelines for nutrient concentrations and physical properties in lowland rivers and freshwater

Guideline	DO % sat.	pH	Sp.Cond. mS/cm	Temp °C	TN mg/L	NH_4-N mg/L	NO_x-N mg/L	TP mg/L	FRP mg/L
ANZECC Water Quality Guidelines – Recreational (2000)	>80 (>6.5mg/L)	6.5-8.5	-	-	-	20-30	10	-	-
ANZECC Water Quality Trigger values – lowland river (2000)	80-120	6.5-8.0	0.12-0.30	-	1.2	0.08	0.150	0.065	0.04
NHMRC Drinking Water Guidelines (1996)	>85	6.5-8.5	-	-	-	0.5	50	-	-
ANZECC Water Quality Guidelines – Freshwater (1992)	>80-90 (>6mg/L)	6.5-9.0	1.5	<2 increase	0.1-0.75	20-30	-	0.01-0.1	-
AGAL LOR	-	-	-	-	0.025	0.01	0.01	0.005	0.005

Trigger values and guidelines for toxicants (heavy metals) in freshwater

Guideline	Al mg/L	As mg/L	Cd* mg/L	Co mg/L	Cr mg/L	Cu* mg/L	Fe mg/L	Hg mg/L	Mn mg/L	Mo mg/L	Ni* mg/L	Pb* mg/L	Se mg/L	U mg/L	Zn* mg/L	SO_4 mg/L	F mg/L
ANZECC Water Quality Guidelines – Recreational (2000)	0.2	0.05	0.005	-	0.05	1	0.3	0.001	0.1	-	0.1	0.05	0.01	-	5	400	-
ANZECC Water Quality Trigger values – Freshwater, 99%ile (2000)	0.027 (pH>6.5)	0.001	0.00006	-	0.00001	0.001	-	0.00006	1.2	-	0.008	0.001	0.005	-	0.0024	-	-
ANZECC Water Quality Trigger values – Freshwater, 95%ile (2000)	0.055 (pH>6.5)	0.024	0.0002	-	0.001	0.0014	-	0.0006	1.9	-	0.011	0.0034	0.011	-	0.008	-	-
ANZECC Water Quality Trigger values – Freshwater, 90%ile (2000)	0.080 (pH>6.5)	0.094	0.0004	-	0.006	0.0018	-	0.0019	2.5	-	0.013	0.0056	0.018	-	0.015	-	-
ANZECC Water Quality Trigger values – Freshwater, 80%ile (2000)	0.150 (pH>6.5)	0.360	0.0008	-	0.04	0.0025	-	0.0054	3.6	-	0.017	0.0094	0.034	-	0.031	-	-
NHMRC Drinking Water Guidelines (1996)	0.2	0.007	0.002	-	0.05	2	0.3	0.001	0.5	0.005	0.02	0.01	0.01	-	3	500	1.5
ANZECC Water Quality Guidelines – Freshwater (1992)	0.005 (pH<6.5) 0.1 (pH>6.5)	0.05	0.0002-0.002	-	0.01	0.002-0.005	1.0	0.0001	-	-	0.015-0.15	0.001-0.005	0.005	-	0.005-0.05	-	-
AGAL LOR	0.005	0.001	0.0001	0.001	0.001	0.001	0.05	0.0001	0.05	0.001	0.001	0.001	0.001	-	0.001	5	0.2

* = Trigger values not corrected for hardness

Appendix D - Bayswater drain water quality results

Nutrient concentrations and physical properties in drain water samples

Date	Site	DO mg/L	DO % sat[8]	pH	Sp.Cond. mS/cm	Temp ^{O}C	TN mg/L	NH_4-N mg/L	NO_x-N mg/L	TP mg/L	FRP mg/L
16/04/03	BWD1	1.66	17.37	5.98	0.64	18.62	1.6	1	0.11	0.058	0.011
16/04/03	BWD2	7.38	82.72	6.15	0.663	22.27	1.6	0.42	0.51	0.037	0.009
16/04/03	BWD3	0.72	7.64	5.43	0.709	19.35	2.1	1.6	<0.010	0.18	0.082
16/04/03	BWD4	7.21	81.31	5.88	3.733	22.08	1.6	0.94	0.27	0.064	0.01
16/04/03	BWD5	9.54	107.68	6.85	0.621	22.66	1.1	0.033	0.62	0.031	0.006
16/04/03	BWD6	4.89	57.00	6.58	0.782	24.46	2.6	1.2	0.76	0.054	0.012
16/04/03	BWD7	0.6	6.35	6.02	0.803	19.16	4	3.7	0.013	0.16	0.03
16/04/03	BWD8	6.99	75.22	2.99	1.187	19.99	3.7	3.3	0.29	0.1	0.013
16/04/03	BWD9	7.61	87.45	6.92	0.8745	23.63	1.3	0.34	0.41	0.048	0.008
16/04/03	BWD10	7.56	86.08	7.6	0.6911	23.14	2.1	0.2	1.4	0.05	0.026
16/04/03	BWD11	7.63	81.81	7.4	0.7382	19.87	1.6	0.074	0.7	0.078	0.029
16/04/03	BWD12	8.48	93.52	6.61	1.883	21.18	1.3	0.39	0.44	0.044	<0.005
16/04/03	BWD13	7.96	84.96	6.51	1.054	19.58	1.4	0.48	0.48	0.053	<0.005
16/04/03	BWD14	6.81	76.73	7.34	0.8159	22.53	1.2	0.17	0.42	0.086	0.04
16/04/03	BWD15	8.14	85.15	6.64	0.8574	18.57	1.3	0.43	0.48	0.049	<0.005
16/04/03	BWD16	7.72	80.73	6.93	1.066	18.52	2.3	0.53	0.44	0.15	<0.005
16/04/03	BWD17	7.26	80.87	7.22	0.9603	21.88	0.63	0.02	0.16	0.042	0.008

[8] Percent saturation of dissolved oxygen (DO % sat) was calculated from dissolved oxygen concentrations (DO mg/L)

Toxicant (heavy metal) concentrations in drain water samples

Date	Site	Al mg/L	As mg/L	Cd* mg/L	Co mg/L	Cr mg/L	Cu* mg/L	Fe mg/L	Hg mg/L	Mn mg/L	Mo mg/L	Ni* mg/L	Pb* mg/L	Se mg/L	U mg/L	Zn* mg/L	SO_4 mg/L	F mg/L
16/04/03	BWD1	0.19	<0.001	<0.0001	0.018	<0.001	0.077	4	<0.0001	0.13	0.001	0.013	<0.001	<0.001	<0.001	0.924	120	<0.2
16/04/03	BWD2	0.12	<0.001	<0.0001	<0.001	<0.001	0.027	0.33	<0.0001	<0.05	<0.001	0.003	0.003	<0.001	<0.001	0.046	84	<0.2
16/04/03	BWD3	0.5	0.001	<0.0001	0.015	<0.001	0.001	15	<0.0001	0.19	0.001	0.011	<0.001	<0.001	<0.001	0.194	170	0.6
16/04/03	BWD4	0.15	0.008	0.0002	0.014	<0.001	0.066	7.4	<0.0001	0.22	<0.001	0.015	<0.001	<0.001	0.004	0.244	880	0.5
16/04/03	BWD5	0.083	<0.001	<0.0001	<0.001	<0.001	0.002	0.45	<0.0001	<0.05	<0.001	0.001	0.002	<0.001	<0.001	0.027	72	<0.2
16/04/03	BWD6	0.081	<0.001	<0.0001	0.022	<0.001	<0.001	0.88	<0.0001	0.14	<0.001	0.006	<0.001	<0.001	<0.001	1.684	140	<0.2
16/04/03	BWD7	0.17	<0.001	<0.0001	0.011	<0.001	<0.001	5.1	<0.0001	0.22	0.002	0.013	<0.001	<0.001	<0.001	0.050	170	1.5
16/04/03	BWD8	14	0.001	0.0004	0.056	<0.001	0.026	24	<0.0001	0.44	<0.001	0.062	0.008	<0.001	<0.001	0.914	390	20
16/04/03	BWD9	0.19	<0.001	<0.0001	0.026	<0.001	0.004	0.67	<0.0001	0.095	<0.001	<0.001	<0.001	<0.001	<0.001	1.884	130	0.4
16/04/03	BWD10	0.063	<0.001	<0.0001	0.002	<0.001	0.018	0.61	<0.0001	<0.05	0.001	<0.001	<0.001	<0.001	<0.001	0.073	50	0.8
16/04/03	BWD11	0.012	<0.001	<0.0001	<0.001	<0.001	0.003	0.32	<0.0001	<0.05	0.002	0.002	<0.001	<0.001	<0.001	0.025	57	0.6
16/04/03	BWD12	0.038	0.003	<0.0001	0.006	<0.001	0.004	2.3	<0.0001	0.097	<0.001	0.009	<0.001	<0.001	0.002	0.124	380	0.3
16/04/03	BWD13	0.17	0.002	0.0002	0.009	<0.001	<0.001	2.3	<0.0001	0.13	<0.001	0.012	<0.001	<0.001	<0.001	0.154	190	1.2
16/04/03	BWD14	0.026	<0.001	<0.0001	<0.001	<0.001	<0.001	0.36	<0.0001	<0.05	<0.001	<0.001	0.001	<0.001	<0.001	0.012	69	<0.2
16/04/03	BWD15	0.1	0.002	<0.0001	0.008	<0.001	0.001	1.2	<0.0001	0.11	<0.001	0.011	<0.001	<0.001	<0.001	0.134	150	1.1
16/04/03	BWD16	0.047	0.001	<0.0001	0.007	<0.001	0.002	0.15	<0.0001	0.1	<0.001	0.009	<0.001	<0.001	<0.001	0.079	140	1
16/04/03	BWD17	0.014	<0.001	<0.0001	0.013	<0.001	0.002	0.35	<0.0001	0.15	<0.001	<0.001	<0.001	<0.001	<0.001	0.194	110	0.3

* = Toxicity depends on water hardness

Appendix E - Marine and estuarine water trigger values and guidelines

Trigger values and guidelines for nutrient concentrations and physical properties in estuaries and marine waters

Guideline	DO % sat.	pH	Sp.Cond. mS/cm	Temp °C	TN mg/L	NH_4-N mg/L	NO_x-N mg/L	TP mg/L	FRP mg/L
ANZECC Water Quality Guidelines – Recreational (2000)	>80 (>6.5mg/L)	6.5-8.5	-	-	-	20-30	10	-	-
ANZECC Water Quality Trigger values – estuaries (2000)	90-110	7.5-8.5	-	-	0.750	0.04	0.045	0.03	0.005
ANZECC Water Quality Guidelines – Marine (1992)	>80-90 (>6mg/L)	<0.2 pH unit change	-	<2 increase	-	0.005	0.01-0.1	-	0.005-0.015
AGAL LOR	-	-	-	-	0.025	0.01	0.01	0.005	0.005

Trigger values and guidelines for toxicants (heavy metals) in marine waters

Guideline	Al mg/L	As mg/L	Cd* mg/L	Co mg/L	Cr mg/L	Cu* mg/L	Fe mg/L	Hg mg/L	Mn mg/L	Mo mg/L	Ni* mg/L	Pb* mg/L	Se mg/L	U mg/L	Zn* mg/L	SO_4 mg/L	F mg/L
ANZECC Water Quality Guidelines – Recreational (2000)	0.2	0.05	0.005	-	0.05	1	0.3	0.001	0.1	-	0.1	0.05	0.01	-	5	400	-
ANZECC Water Quality Trigger values – Marine, 99%ile (2000)	-	-	0.0007	0.000005	0.00014	0.0003	-	0.0001	-	-	0.007	0.0022	-	-	0.007	-	-
ANZECC Water Quality Trigger values – Marine, 95%ile (2000)	-	-	0.0055	0.001	0.0044	0.0013	-	0.0004	-	-	0.070	0.0044	-	-	0.015	-	-
ANZECC Water Quality Trigger values – Marine, 90%ile (2000)	-	-	0.014	0.014	0.020	0.003	-	0.0007	-	-	0.200	0.0066	-	-	0.023	-	-
ANZECC Water Quality Trigger values – Marine, 80%ile (2000)	-	-	0.036	0.150	0.085	0.008	-	0.0014	-	-	0.560	0.012	-	-	0.043	-	-
ANZECC Water Quality Guidelines – Marine (1992)	-	0.05	0.002	-	0.05	0.005	-	0.0001	-	-	0.015	0.005	0.07	-	0.05	-	-
AGAL LOR	0.005	0.001	0.0001	0.001	0.001	0.001	0.05	0.0001	0.05	0.001	0.001	0.001	0.001	-	0.001	5	0.2

Appendix F - Swan River water quality results

Nutrient concentrations and physical properties in Swan River water samples

Date	Site	DO % sat		pH		Sp.Cond. mS/cm		Temp ^{O}C		TN mg/L		NH_4-N mg/L		NO_x-N mg/L		TP mg/L		FRP mg/L	
		S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B
16/04/03	BWR1	38.4	10.0	7.24	7.1	18.3	44.27	19.13	19.8	2.6	2.8	0.72	0.65	0.59	0.69	0.075	0.082	0.035	0.036
16/04/03	BWR2	47.3	10.1	7.3	7.12	13.57	42.91	18.73	19.83	3	2.9	0.65	0.64	0.78	0.75	0.087	0.083	0.039	0.036
16/04/03	BWR3	46.5	8.9	7.29	7.12	13.78	42.98	18.77	19.87	2.9	3	0.62	0.65	0.59	0.77	0.1	0.075	0.045	0.033
16/04/03	BWR4	49.2	6.9	7.1	7.11	12.94	42.81	19.18	19.9	2.9	3.2	0.64	0.64	0.84	0.85	0.084	0.087	0.038	0.036
16/04/03	BWR5	52.2	7.9	7.33	7.11	11.92	41.5	19.48	19.92	3.2	3	0.67	0.65	0.8	0.79	0.083	0.083	0.057	0.04
16/04/03	BWR6	49.8	6.0	7.33	7.11	11.83	41.52	19.55	19.95	3.3	2.7	0.64	0.63	0.64	0.53	0.093	0.09	0.043	0.044
16/04/03	BWR7	51.1	7.5	7.34	7.11	11.64	40.47	19.78	19.95	2.9	2.9	0.79	0.69	1.1	1.2	0.082	0.078	0.031	0.028
16/04/03	BWR8	47.4	5.0	7.28	7.17	12.22	40.66	19.49	19.99	2.3	2.1	0.56	0.56	0.49	0.47	0.14	0.12	0.057	0.054
16/04/03	BWR9	46.9	3.3	7.29	7.11	12.04	39.36	19.53	20.08	3	2.6	0.69	0.71	1	0.93	0.088	0.086	0.04	0.043
16/04/03	BWR10	52.8	3.6	7.31	7.11	3.96	39.05	20.19	20.11	3.1	2.9	0.71	0.69	1.2	1.1	0.083	0.084	0.053	0.046

Toxicant (heavy metal) concentrations in Swan River water samples

Date	Site	Al mg/L		As mg/L		Cd mg/L		Co mg/L		Cr mg/L		Cu mg/L		Fe mg/L		Hg mg/L	
		S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B
16/04/03	BWR1	<0.005	0.007	<0.001	<0.001	<0.0001	<0.0001	0.001	0.001	<0.001	<0.001	0.004	0.004	0.083	0.11	<0.0001	<0.0001
16/04/03	BWR2	<0.005	0.007	<0.001	<0.001	<0.0001	<0.0001	0.001	0.001	<0.001	<0.001	0.005	0.003	0.1	0.11	<0.0001	<0.0001
16/04/03	BWR3	<0.005	0.009	<0.001	<0.001	<0.0001	<0.0001	0.001	0.001	<0.001	<0.001	0.003	0.008	0.078	0.11	<0.0001	<0.0001
16/04/03	BWR4	0.006	<0.005	<0.001	<0.001	<0.0001	<0.0001	0.001	0.001	<0.001	<0.001	0.005	0.004	0.1	0.11	<0.0001	<0.0001
16/04/03	BWR5	<0.005	<0.005	<0.001	<0.001	<0.0001	<0.0001	0.001	0.001	<0.001	0.001	0.001	0.003	0.11	0.11	<0.0001	<0.0001
16/04/03	BWR6	<0.005	<0.005	<0.001	<0.001	<0.0001	<0.0001	0.001	0.001	0.001	0.001	0.003	0.003	0.097	0.088	<0.0001	<0.0001
16/04/03	BWR7	<0.005	<0.005	<0.001	<0.001	<0.0001	<0.0001	0.001	0.001	0.001	<0.001	0.003	0.003	0.11	0.13	<0.0001	<0.0001
16/04/03	BWR8	<0.005	<0.005	<0.001	<0.001	<0.0001	<0.0001	0.002	0.001	0.002	0.002	0.003	0.021	0.051	0.056	<0.0001	<0.0001
16/04/03	BWR9	<0.005	<0.005	<0.001	<0.001	<0.0001	<0.0001	0.001	0.001	0.001	0.001	0.002	0.002	0.093	0.087	<0.0001	<0.0001
16/04/03	BWR10	<0.005	<0.005	<0.001	<0.001	<0.0001	<0.0001	0.001	0.001	0.001	0.001	0.005	0.004	0.096	0.1	<0.0001	<0.0001

Site	Mn mg/L		Mo mg/L		Ni mg/L		Pb mg/L		Se mg/L		U mg/L		Zn mg/L		SO_4 mg/L		F mg/L	
	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B
BWR1	0.21	0.18	0.003	0.003	0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.003	0.012	0.035	850	730	0.4	0.4
BWR2	0.19	0.19	0.003	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.042	0.025	700	700	0.5	0.5
BWR3	0.23	0.18	0.004	0.002	0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.002	0.023	0.023	960	630	0.5	0.4
BWR4	0.18	0.17	0.002	0.002	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.020	0.033	650	640	0.4	0.5
BWR5	0.18	0.18	0.003	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.016	0.013	680	670	0.6	0.5
BWR6	0.20	0.20	0.004	0.004	0.002	0.002	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.016	0.011	830	890	0.5	0.5
BWR7	0.16	0.15	0.002	0.002	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.011	0.010	520	470	0.4	0.4
BWR8	0.26	0.25	0.005	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.003	0.018	0.017	1500	1400	0.6	0.6
BWR9	0.18	0.19	0.003	0.003	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.008	0.009	620	740	0.4	0.5
BWR10	0.16	0.16	0.002	0.002	0.001	0.004	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.001	0.010	420	460	0.4	0.4

Appendix G – Sediment trigger values and guidelines

Trigger values and guidelines for toxicants (heavy metals) in sediments

Guideline	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	U	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
ANZECC Interim Sediment Quality Guidelines – Low trigger value (2000)	-	20	1.5	-	80	65	-	0.15	-	-	21	50	-	-	200
ANZECC Interim Sediment Quality Guidelines – High trigger value (2000)	-	70	10	-	370	270	-	1	-	-	52	220	-	-	410
AGAL LOR	0.2	0.5	0.5	0.5	0.2	0.2	0.2	0.2	0.2	0.5	0.2	0.2	0.5	0.5	0.2

Appendix H – Bayswater drain sediment quality results

Total nitrogen, total phosphorus, total organic carbon and moisture results in drain sediment samples

Date	Site	TN mg/kg	TP mg/kg	TOC mg/kg	Moisture %
14/05/03	BWD1	940	740	42000	43.4
02/05/03	BWD2	290	130	7300	20.8
02/05/03	BWD2	430	91	8200	22.7
02/05/03	BWD4	230	700	4900	23
02/05/03	BWD5	61	30	970	16.1
15/05/03	BWD6	800	420	3400	38.5
15/05/03	BWD7	320	780	5200	18.2
15/05/03	BWD8	470	110	8700	22.9
14/05/03	BWD9	650	150	11000	26.2
14/05/03	BWD10	950	290	29000	33.7
14/05/03	BWD11	970	480	31000	47.5
02/05/03	BWD12	97	130	2500	17.9
02/05/03	BWD13	330	110	7300	20.5
02/05/03	BWD14	410	250	12000	19.3
02/05/03	BWD15	260	180	5700	20.9
02/05/03	BWD16	130	110	3100	16
14/05/03	BWD17	610	440	10000	29.8

Toxicant (heavy metal) concentrations in drain sediment samples

Date	Site	Al mg/kg	As mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Hg mg/kg	Mn mg/kg	Mo mg/kg	Ni mg/kg	Pb mg/kg	Se mg/kg	U mg/kg	Zn mg/kg
14/05/03	BWD1	8390	6.9	1.6	37	87	130	20600	<0.1	56	9.6	76	150	0.61	1.2	7430
02/05/03	BWD2	2030	1.2	<0.5	0.88	9.3	15	5080	<0.2	26	0.96	3.7	38	<0.5	0.68	75
02/05/03	BWD2[9]	2040	1.2	<0.5	0.96	9	65	4710	<0.2	29	1.5	3.7	42	0.5	0.66	94
02/05/03	BWD4	2330	13	<0.5	1.4	2.4	3.5	5980	<0.2	4.5	<0.5	2.2	10	<0.5	0.92	24
02/05/03	BWD5	610	<0.5	<0.5	<0.5	1.2	0.83	570	<0.2	2.1	<0.5	0.82	8.2	<0.5	<0.5	13
15/05/03	BWD6	5300	4.5	0.6	28	33	85	16500	<0.1	47	2.9	13	95	<0.5	0.93	3400
15/05/03	BWD7	1590	3.5	4	1.5	6.9	8	1900	<0.1	2.3	5.8	1.2	13	<0.5	<0.5	310
15/05/03	BWD8	890	37	<0.1	1.5	6.3	9.6	29400	<0.1	7.8	1.8	1.9	80	<0.5	<0.5	9.3
14/05/03	BWD9	1960	0.94	<0.1	6.5	1.6	2.2	5320	<0.1	9.3	<0.5	1.9	13	<0.5	<0.5	870
14/05/03	BWD10	3800	2.1	0.52	5.5	36	48	10100	<0.1	37	1.6	6.8	98	<0.5	0.75	670
14/05/03	BWD11	4880	2.4	0.63	5	26	65	11900	<0.1	43	2.2	9.7	160	0.56	1.2	520
02/05/03	BWD12	1950	2.8	<0.5	<0.5	3.9	4	3580	<0.2	4.4	<0.5	1.2	8	<0.5	<0.5	18
02/05/03	BWD13	3320	8.1	1.9	2.6	4.1	150	6630	<0.2	9.5	<0.5	2.5	17	<0.5	<0.5	360
02/05/03	BWD14	3510	0.88	<0.5	0.92	6.6	4.6	6020	<0.2	10	<0.5	2.5	61	<0.5	<0.5	50
02/05/03	BWD15	2910	6.8	<0.5	0.76	4	4.8	21500	<0.2	9.2	1.6	2	17	<0.5	0.75	43
02/05/03	BWD16	2030	6.9	<0.5	0.69	3	2.2	7210	<0.2	5.1	<0.5	2.2	14	<0.5	<0.5	54
14/05/03	BWD17	9220	9.2	0.39	4.9	22	130	32300	<0.1	34	3.8	5.1	270	0.94	1.2	270

[9] These results are from the analysis of a duplicate sample at site BWD2.

Appendix I – Food Standards

Levels for toxicants (heavy metals) in fish flesh

Guideline	Al mg/kg	As* mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Hg mg/kg	Mn mg/kg	Mo mg/kg	Ni mg/kg	Pb mg/kg	Se mg/kg	U mg/kg	Zn mg/kg
Australia New Zealand Food Standards Code - Maximum Levels (2003)	-	2.0	-	-	-	-	-	0.5	-	-	-	0.5	-	-	-
Australia New Zealand Food Standards Code - Generally Expected Levels 90% (2003)	-	-	-	-	-	2.0	-	-	-	-	-	-	2.0	-	15
Australia New Zealand Food Standards Code - Generally Expected Levels 50% (2003)	-	-	-	-	-	0.5	-	-	-	-	-	-	0.5	-	5.0
AGAL LOR	0.01	0.01	0.01	0.01	0.01	0.005	0.1	0.005	0.005	0.01	0.005	0.01	0.025	0.01	0.005

* = Contaminant levels for fish relate to inorganic arsenic (As) only.

Appendix J – Swan River fish flesh quality results

Toxicant (heavy metals) concentrations in Swan River fish flesh samples

Date	Site	Fish species	Fish age years	Number of fish	Average whole fish wet weight g	Average fish length mm	Fish flesh total weight g
30/04/03	BWR2	Yellowtail tumpeter		4	104	188	81.4
06/05/03	BWR2	Black bream (small)	2	4	126	171	96.6
30/04/03	BWR4	Black bream (large)	2	3	309	245	97.3
30/04/03	BWR4	Black bream (small)	2	6	75	158	92.5
30/04/03	BWR4	Yellowtail trumpeter		1	115.3	187	25
30/04/03	BWR10	Black bream (large)	2	3	208	225	87.6
30/04/03	BWR10	Black bream (small)	2	8	80	162	142.1

Site	Fish species	Al mg/kg	As mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Hg mg/kg	Mn mg/kg	Mo mg/kg	Ni mg/kg	Pb mg/kg	Se mg/kg	U mg/kg	Zn mg/kg
BWR2	Yellowtail tumpeter	0.11	0.21	<0.01	<0.01	0.01	0.24	19	0.05	0.13	<0.01	0.02	<0.01	0.82	<0.01	4.9
BWR2	Black bream (small)	0.73	0.47	<0.01	<0.01	0.01	0.17	2.5	0.02	0.1	<0.01	0.02	<0.01	0.75	<0.01	4.8
BWR4	Black bream (large)	0.13	1.2	<0.01	0.01	0.01	0.38	9.8	0.02	0.12	<0.01	0.03	<0.01	1.1	<0.01	5.3
BWR4	Black bream (small)	0.11	0.46	<0.01	<0.01	<0.01	0.19	7.6	0.01	0.26	<0.01	0.04	<0.01	0.53	<0.01	4.8
BWR4	Yellowtail trumpeter	0.25	0.25	<0.01	0.01	0.01	0.22	10	0.11	0.09	<0.01	0.02	<0.01	0.9	<0.01	4.7
BWR10	Black bream (large)	0.11	0.43	<0.01	<0.01	0.01	0.2	3.1	0.05	0.11	<0.01	0.08	<0.01	0.41	<0.01	3.8
BWR10	Black bream (small)	0.13	0.37	<0.01	<0.01	0.02	0.23	7.7	0.01	0.13	<0.01	0.06	<0.01	0.74	<0.01	5.6