

Brockman River Catchment

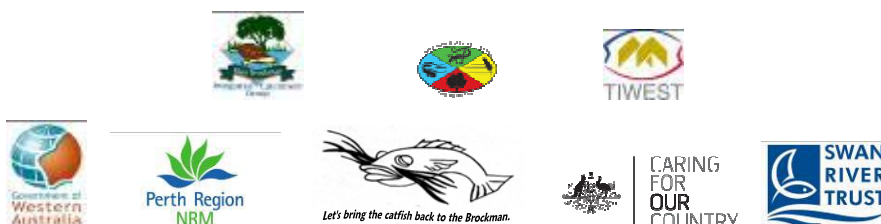
Water Quality Monitoring Snapshot

August and October 2009



Plate 1: Julimar Tributary, Brockman River catchment (2007).

Prepared by the Ellen Brockman Integrated Catchment Group: March 2010



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Ellen Brockman Integrated Catchment Group

1. Acknowledgements

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Water samples and monitoring data was collected by officers from the Ellen Brockman Integrated Catchment Group.

For further information contact the Ellen Brockman Integrated Catchment Group at the Chittering Landcare Centre.

Chittering Landcare Centre
PO Box 62
Muccea WA 6501
Phone: (08) 9571 0300
Fax: (08) 9571 4350
Email: chitteringlandcare@iinet.net.au

2. Executive Summary

The assessment of water quality within the Brockman River catchment was undertaken in August and October 2009 in compliance with the sampling and analysis plan (EBICG, 2009). The objective of the snapshot was to collect annual data on the water quality within the catchment, to identify trends and priority sub-catchments for nutrient transport and salinity.

Monitoring stream salinity throughout a catchment enables the isolation of areas where the discharge of saline groundwater to streams is greatest. This is important as increasing salinity is the dominant threat to the Brockman catchment. The findings of this report will be used to make recommendations for degraded sites, to identify the major nutrient and salinity contributing subcatchments, to mitigate, improve or maintain water quality, and to prevent detrimental environmental effects downstream.

The Brockman River catchment receives less than 1000mm of rain per annum and much of the salt is stored in the soil profile. Extensive clearing of vegetation for agriculture has reduced evapotranspiration; increased recharge has resulted in rising groundwater levels, which mobilizes the stored salt. The salt laden groundwater then surfaces as hillside springs and valley floor seeps. Groundwater discharge causes soil salinity and contaminates previously potable water resources (Angell, 2000). Nutrients are not an issue in the Brockman catchment. The Brockman River is a contributor to the level of saline water entering the Upper Reaches of the Swan-Canning system and this could potentially alter and degrade ecological environments. Sediment and nutrients bound to particles are carried downstream and add to sediments in the Swan River. Under anoxic conditions these nutrients bound in the sediments are released, causing algal blooms and fish deaths.

It must be noted that this assessment is based on once-off grab sampling of water quality on two separate occasions in August and October 2009 to capture winter and spring flow, from 26 selected sites within the Brockman River catchment (shown in Figure 5). Consequently, the results represent the condition of the water in the catchment at the

time of sampling only. All 26 sites were tested for physical parameters (pH, conductivity, temperature and total suspended solids) and nutrients including total nitrogen, filterable organic nitrogen, nitrogen as ammonia, total oxidised nitrogen, total phosphorous and filterable reactive phosphorous. Seven out of the twenty-six sampling sites were strategically identified for the testing of heavy metals and water hardness. Additionally, three sampling sites from the “Bindoon Defence Training Area (BDTA) water quality monitoring snapshot August and October 2009” (CLG, 2009) were also recorded in this report. This was a request by the Department of Defence to allow a comparison of the water quality of the BDTA with the rest of the Brockman River catchment.

In comparison to past water quality monitoring data collected by the Chittering Landcare Centre, pH values remain relatively stable at most sampling sites, and there is an overall trend of increasing salinity at most of the sampling sites since 1997. This is of great concern for the ecological health and function of the river and catchment. It is also of great concern to agriculture, industry and private landholders. If left unmanaged this could become a major issue for landholders in terms of agricultural production and water quality. Future monitoring will verify trends and patterns as more data is collected over a longer period of time. All data will be entered into the Department of Water’s (DOW) Water Information Network (WIN) database.

3. **Key Findings**

- Sampling sites within the Brockman River catchment recorded higher concentrations of all forms of nitrogen than in previous years. The following sites were identified through the 2009 snapshot as consistent contributors of nutrients to the Avon/Swan River and included Total Nitrogen, Total Oxidised Nitrogen and Filterable Organic Nitrogen which were recorded at these sites with concentrations above the ANZECC guidelines.

Sampling Site Name	Sampling Site Number
Kangaroo Creek Gully	BRN6
Romany Creek	BRN7
Wootra Brook	BRN9
Flat Rocks Road	BRN12
Aquila	BRN14
Lake Road	BRN15
Julimar/Chittering Bridge	BRN18
Keating Road	BRN21
Moondyne	BRN24
Yalliwirra	BRN25

- Total Phosphorous concentrations were not of concern although above the guideline at Jackson Road (BRN2), West Point Creek (BRN3), Wannamal South (BRN4), Kangaroo Gully (BRN6), and Wootra Brook (BRN9)
- Water Hardness was ‘extremely hard’ at all sites sampled for heavy metals except Spoonbill Lake (BRN13) which was ‘very hard’.
- Heavy metal concentrations in the surface waters of the Brockman River catchment were generally below the Hardness-modified Trigger Value (HMTV) and ANZECC guidelines on all sampling occasions. However, aluminium was above the ANZECC trigger value at all sites during the August sampling occasion. Iron concentrations were above the ANZECC indicative guideline at all sites, except Aquila (BRN14), during the August sampling occasion. Copper recorded concentrations above the HMTV during the August sampling occasion at

Spoonbill (BRN13) and Marbling Brook (BRN23). All other heavy metals remained below the guidelines and limits of reporting (LOR).

- The Brockman River catchment recorded pH levels predominately within the ANZECC guidelines.
- Water was more saline at the top of the catchment and became less saline as it flowed southwards towards the Avon River.
- Bindoon Defence Training Area (BDTA) sampling sites including BDTA Longbridge, BDTA Wootra North and BDTA Wootra South were identified as major contributors of aluminium and iron in comparison to other sites tested for metals. However, pH, conductivity, temperature and total suspended solid (TSS) levels were of no concern when compared to the rest of the catchment, except for BDTA Wootra North which recorded a significantly high TSS concentration during the August sampling occasion. Results represent the BDTA as a top of subcatchment, recharge zone and as such does not suffer from significantly high nutrient concentrations, acidity or salinity at the times of sampling.

Brockman River Catchment Water Quality Monitoring Snapshot August & October 2009

Table 1: Number of sites (out of a total of 26) equal to or exceeding the ANZECC water quality guidelines and trigger values. *Note: Heavy metals out of a total of eight sampling sites. Cadmium, chromium, copper, lead, nickel and zinc ANZECC water quality trigger values have been modified according to Water Hardness (Appendix D) and values must be equal to or exceed the Hardness-Modified Trigger Value to be over the Guideline.*

Parameter	Number of Sampling Sites	Water Quality Trigger Value - Lowland Rivers		TSS - DOW Interim Guideline	
		13 th August	1 st October	13 th August	1 st October
<i>Physical</i>					
pH	29	1	9		
Conductivity	29	28	29		
<i>Nutrients</i>					
Total Nitrogen	26	17	4		
Total Oxidised Nitrogen	26	20	17		
Filterable Organic Nitrogen	26	21	12		
Nitrogen as Ammonia	26	8	1		
Total Phosphorous	26	1	4		
Filterable Reactive Phosphorous	26	1	1		
Total Suspended Solids	26			6	7

<i>Metal</i>	Number of Sampling Sites	Hardness Modified Trigger Value (400)	Hardness Modified Trigger Value (210)	ANZECC Trigger Value (mg/L)	13 th August	1 st October
Aluminium	10			0.055	7	3
Arsenic	7			0.024	0	0
Cadmium	7	0.002mg/L	0.0011mg/L	0.0002	0	0
Chromium	7	0.0084mg/L	0.005mg/L	0.001	0	0
Copper	7	0.0126mg/L	0.0072mg/L	0.0014	2	1
Iron	10			0.3	9	4
Nickel	7	0.099mg/L	0.057mg/L	0.011	0	0
Mercury	7			0.0006	0	0
Lead	7	0.09mg/L	0.04mg/L	0.0034	0	0
Zinc	7	0.072mg/L	0.0416mg/L	0.008	0	0

Brockman River Catchment Water Quality Monitoring Snapshot August & October 2009

Key

12	Number of sites (out of a total of 26) equal to or exceeding guidelines or trigger value
0	All sites less than guideline or trigger value
-	No guideline or trigger value available
	Sample not analysed for parameter

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5. Background

The Brockman River catchment stretches across 1520 square kilometres and is the largest catchment of the lower Avon and upper Swan catchments. The Brockman River is approximately 90 kilometres in length and flows through the Chittering Valley along the Darling Scarp. The main issues within the catchment include a deteriorating natural resource base due to widespread clearing of native vegetation and an increased economic pressure on agricultural land to be more productive. This has resulted in increased salinity, waterlogging, erosion, pest plants and animals, and affected waterways due to increased sedimentation and reduced surface and ground water quality (WRC, 2003).

In 1996 discussions in Northam between the Water and Rivers Commission Regional Services, Western Australian state government and local governments in the catchment, documented their requirements for natural resource management. Together with the Shire of Chittering it was decided that the water quality of the Brockman River and its catchment was a priority and developed a successful funding application through the Natural Heritage Trust Fund to prepare an integrated natural resource management plan for the Brockman River catchment (WRC, 2003).

In 2009 the Ellen Brockman Integrated Catchment Group (EBICG) conducted an assessment of the Brockman River catchment surface water quality on 13th August and 1st October. The objective of the snapshot was to build upon the existing years of data and establish baseline data on the water quality within the catchment. By monitoring stream salinity throughout a catchment, areas where the discharge of saline groundwater to streams is identified can then be targeted for remediation efforts. This sampling program and associated water quality results will be registered and entered into the Department of Water's (DoW) Water Information Network (WIN) database.

5.1. Brockman River Catchment

The Brockman River catchment is located to the north-east of the Perth Metropolitan area in the south-west of Western Australia (Figure 1). The catchment covers an area inclusive of sixty-eight subcatchments, incorporating the townships of Bindoon and Wannamal (WRC, 2002). The greatest part of the catchment lies within the Shire of Chittering, with the remainder within the shires of Victoria Plains, Toodyay, Gingin and the City of Swan (Figure 2). Other localities within the catchment include Mooliabeenie, Lower Chittering, Maryville Downs and South Chittering.

While the Brockman River flows into the lower Avon River and is thus, part of the Avon River catchment, its greatest impact is on the Swan River and is therefore considered part of the Swan River catchment. The Brockman River itself follows the Darling Scarp, flowing through the deeply incised Chittering valley to enter the Swan-Avon River 40kms upstream from Perth (WRC, 2002).

The natural resource base of the catchment is deteriorating because of the widespread clearing of native vegetation and the increased economic pressure on agricultural land to be more productive. These impacts have resulted in increased salinity, waterlogging, soil erosion via wind and water, sedimentation, eutrophication, overgrazing, weed invasion and pest animals within the catchment. These cumulative impacts have an offsite effect on the Brockman River and local wetland systems, and ultimately the Avon-Swan River.



Figure 1: Catchments within the Swan-Canning Catchment (WRC, 2003).

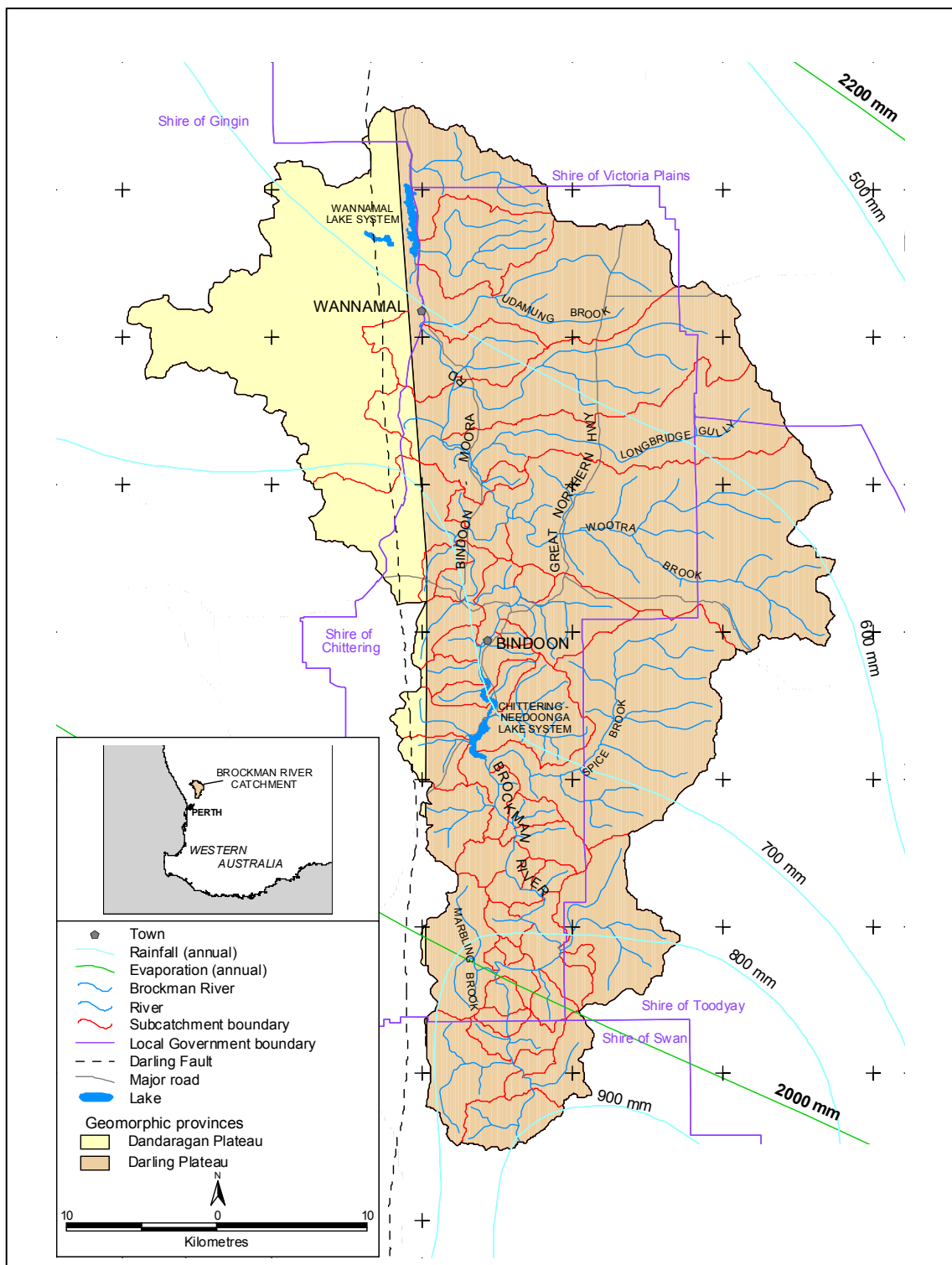


Figure 2: Brockman River Catchment (WRC, 2003).

5.1.1. Climate

The catchment experiences a typical Mediterranean climate of hot dry summers and cool wet winters. Average rainfall for the southern portion is 800mm/yr decreasing to less than 600mm/yr in the northern regions (Bureau of Meteorology, 1998). Rainfall in 2008 was significantly below the average annual rainfall for the region with a total of 466.6mm between January and November received at Wannamal (Station 009040) and 634.8mm received at Pearce RAAF Base (Station 009021). Total rainfall for 2009 was 548.5mm recorded at Bindoon (Figure 3). Although 2009 was viewed as a 'good' season due to the extended months of rainfall, the total annual rainfall was significantly below the average.

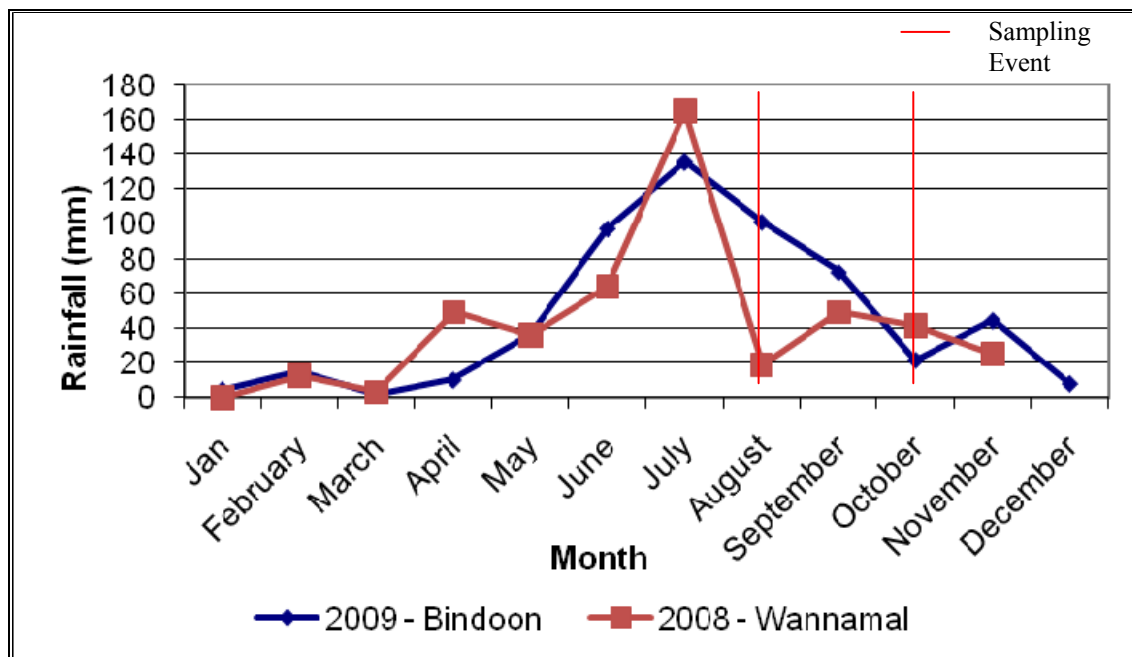


Figure 3: Total monthly rainfall within the Brockman River catchment recorded at 150 Bindoon-Moora Road Bindoon during 2009, and Wannamal Station 009040 in 2008 (Chittering Times, January 2010).

Most water courses in the catchment flow during the winter months and have reduced or no flow during the summer months. Weather patterns typically have strong easterly to north-easterly winds in the morning and south-westerly in the afternoon during summer with thunderstorms and lightning common. During winter the winds come from the northwest to southwest (WRC, 2003).

5.1.2. Geology and Geomorphology

The Darling Plateau, an ancient landmass worn down by erosion, underlies most of the eastern portion of the Brockman River catchment. To the west, the catchment extends over the Dandaragan Plateau. A major regional fault line, the Darling Fault, separates these two geomorphic regions (Figure 2).

The Darling Plateau

The Darling Plateau is made up of two major rock sequences. The first sequence is a 10km wide belt of crystalline rocks referred to as the Chittering Metamorphic belt. Intense erosion within the Chittering Metamorphic belt has produced a major north-south trending valley system in which the Brockman River flows south. The second sequence to the east is granitic rock covered with a lateritic cap referred to as the lateritic uplands (Wild and Low, 1978). Laterite is sometimes referred to as ironstone or coffee rock.

The deeply incised Chittering Valley is characterised by dissected, steep slopes and domed granite outcrops high in the landscape with variable and complex soils. Parent materials may be weathered or unweathered gneiss, granite or dolerite or may occur as colluvium. Colluvial lateritic material from the plateau surface may extend down slope. Yellow duplex and brown duplex and gradational earths are the most common soils. Generally, the yellower soils are associated with the granite, and the red and brown soils with dolerite dykes (King and Wells, 1990). Loamy soils, now extensively cleared for agriculture, are found on the lower valley slopes and floodplain.

The lateritic uplands are typified by undulating, dissected land surfaces with rubbly, pale orange lateritic soils and pea gravels. Red alluvial, clay soils characterise the valley floors while upland remnants of the plateau surface form higher land with sands and sandy gravels interspersed with laterite outcrops. Saline soils occur within the valley floors. Most of the area outside reserves is cleared for agriculture with small pockets of native vegetation along fence lines and watercourses. Gully erosion is the predominant erosion hazard but landslips have occurred on the steeper slopes of the Chittering Valley.

The Dandaragan Plateau

The Dandaragan Plateau to the west of the Darling Fault is a wedge shaped erosion remnant of the Perth Basin with sediments covered by recent deposits of sand and laterite (Wild and Low, 1978). Sand plain features dominate the landscape with broad U-shaped valleys, sand-filled drainage lines and some breakaways. The soil pattern is closely related to topography (Churchward, 1980). Brown deep sands, yellow deep sands, pale deep sands, sandy gravels and shallow gravels are dominant, with red deep sandy duplex soils on the valley floors (Moore, 1998).

Soil landscapes are outlined in the Shire of Chittering Land Capability and Management Study prepared by Land Assessment Pty. Ltd. Part 1 – Working Paper and LandSmart™.

5.1.3. Vegetation

Large areas of native vegetation remain in the eastern part of the catchment in the Avon Valley National Park, the proposed Julimar Conservation Park (currently State Forest) and in the Department of Defence Bindoon Training area. Other areas of native vegetation in the catchment are located within the ten CALM nature reserves and on some private property.

The greatest area of native vegetation occurs within the western forest/woodland and eastern heath regions while the central area consists of severely dissected remnants within an agricultural landscape. These areas have been heavily cleared and now the remaining remnants are generally small and dispersed.

Approximately 201 km² (13%) is reserved for conservation purposes with much of this conservation land being confined to the eastern Darling Scarp forests and north-western sand plain. The spatial extent of remnant vegetation in the Brockman River catchment is given in Table 2.

Table 2: Spatial extent of remnant vegetation in the Brockman River catchment (WRC, 2002).

Total area (km ²)	1,520
Number of remnants	2,000
Total Area Of Remnant Vegetation (km ²)	770
% Total Remnant Area	51
Remnant Vegetation Reserved (km ²)	201
% Original Area Reserved	13
% Remnant Area Reserved	26

Source: Connell and Ebert (2001).

5.1.4.Land Use

The economy of the Brockman River catchment and the livelihood of its residents are currently based on the natural resources of land and water. Animal products derived from pasture are the most extensive agricultural land use followed by broadscale crops and horticulture (Cook and Hatherly, 1997). The northern part of the catchment is mostly agricultural with cereal, beef, pigs, sheep and wool the major agricultural products with some horticultural products such as grapes and citrus. In the Chittering Valley, production is mostly beef, sheep, citrus and grapes (Figure 4).Expansion of horticulture and viticulture in the catchment is limited by the lack of suitable irrigation water.

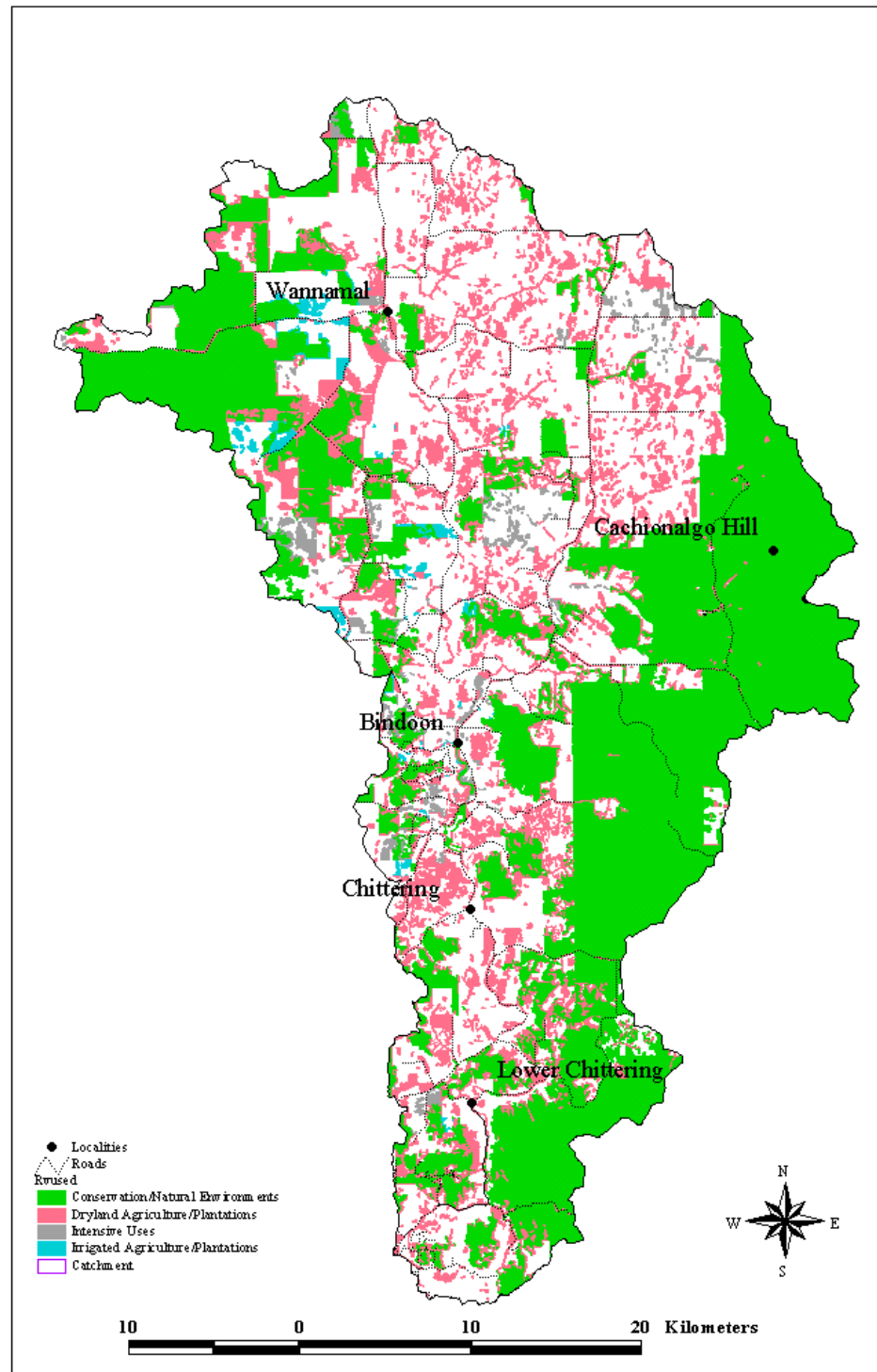


Figure 4: Land use in the Brockman River Catchment.

6. Methodology

Site Selection

Water samples were taken from twenty-six sites within the Brockman River catchment (Figure 5). Cresthill Road (BRN12) was removed from the sampling program in 2008 and replaced with Grey Road Bridge (BRN27), this was continued in 2009. These sites were selected to be representative of sub-catchments carrying large volumes of water to the Brockman River, to determine their salinity, relative nutrient and metal contribution, and whether they were situated upstream or downstream of potentially high impact land uses or of likely contaminant sources. Table 3 lists the twenty-six sample sites by site number, site name and relative waterway component. Site location is also provided using street names, northings and eastings.

Table 3: Location and description of selected sampling sites within the Brockman River catchment.

Site No.	Site name	Description of waterway (inc. old site number)	Easting	Northing
BRN1	Murphy Gully Creek	BR22 - Bindoon Moora Rd	409205	6561412
BRN2	Jackson Road (Wannamal Lake outlet)	BR21 - Jackson Road	409457	6555480
BRN3	West Point Creek	BR20 - West Point	409754	6555706
BRN4	Wannamal South	Wannamal South Road	407596	6552244
BRN5	Udumung Creek	BR18 - Hay Flat Road	410373	6551048
BRN6	Kangaroo Gully Creek	BR17A - Bindoon Moora Rd	412741	6547952
BRN7	Romany Creek	BR17 - Waldeck West Road - Romany Creek	413360	6546355
BRN8	Longbridge Creek	BR16A - Ashman Rd to gate (2km) over fence & nth on fire break	414649	6542478
BRN9	Wootra Brook	BR15 - Owen's Road	416762	6537439
BRN10	Bindoon River	BR15A - Great Northern Highway small bypass road bridge	417372	6531777
BRN12	Flat Rocks Creek	Densley Road (off Flat Rocks)	415077	6524296
BRN13	Spoonbill Lake	BR12 - spillway from Spoonbill Reserve	412361	6523223
BRN14	Aquila, Hart Drive	BR12A - Flows through Aquila Reserve	412306	6522632
BRN15	Lake Road Brockman River	BR9 - Bridge on Lake Road below Lake Weir	414090	6521308
BRN16	Spice Brook	BR11A - off Lake Road across paddock to bridge	414509	6521156
BRN17	Toodyay Creek Toodyay Creek	100m north of Blue Plains Road on Chittering Road	414561	6518111
BRN18	Julimar/Chittering Bridge Brockman River	BR5 - Julimar Rd/Chittering Rd intersection	415996	6515275
BRN19	Julimar/Chittering Tributary Julimar Rd Creek	BR8 - Julimar Rd (500m up from intersection Chittering Rd)	417103	6515877
BRN20	Chittering Valley	Cnr Chittering Valley and Chittering Road	416288	6510308
BRN21	Keating Road	BR4 - 500m east on Keating Road to gateway - Bitney Springs	419248	6508210
BRN22	South Chittering Creek	Chittering Road just north of Wilson Road	415559	6500608
BRN23	Marbling Brook	Bridge on Chittering Road	414704	6506641
BRN24	Moondyne Brockman River	BR2 - from crossing	416623	6499996
BRN25	Yalliwirra Brockman River	BR1 Gauging Station	416450	6495160
BRN26	Marda Brook	Smith Road bridge/gate	414266	6496860
BRN27	Grey Road Bridge	Brockman River	413885	6528696

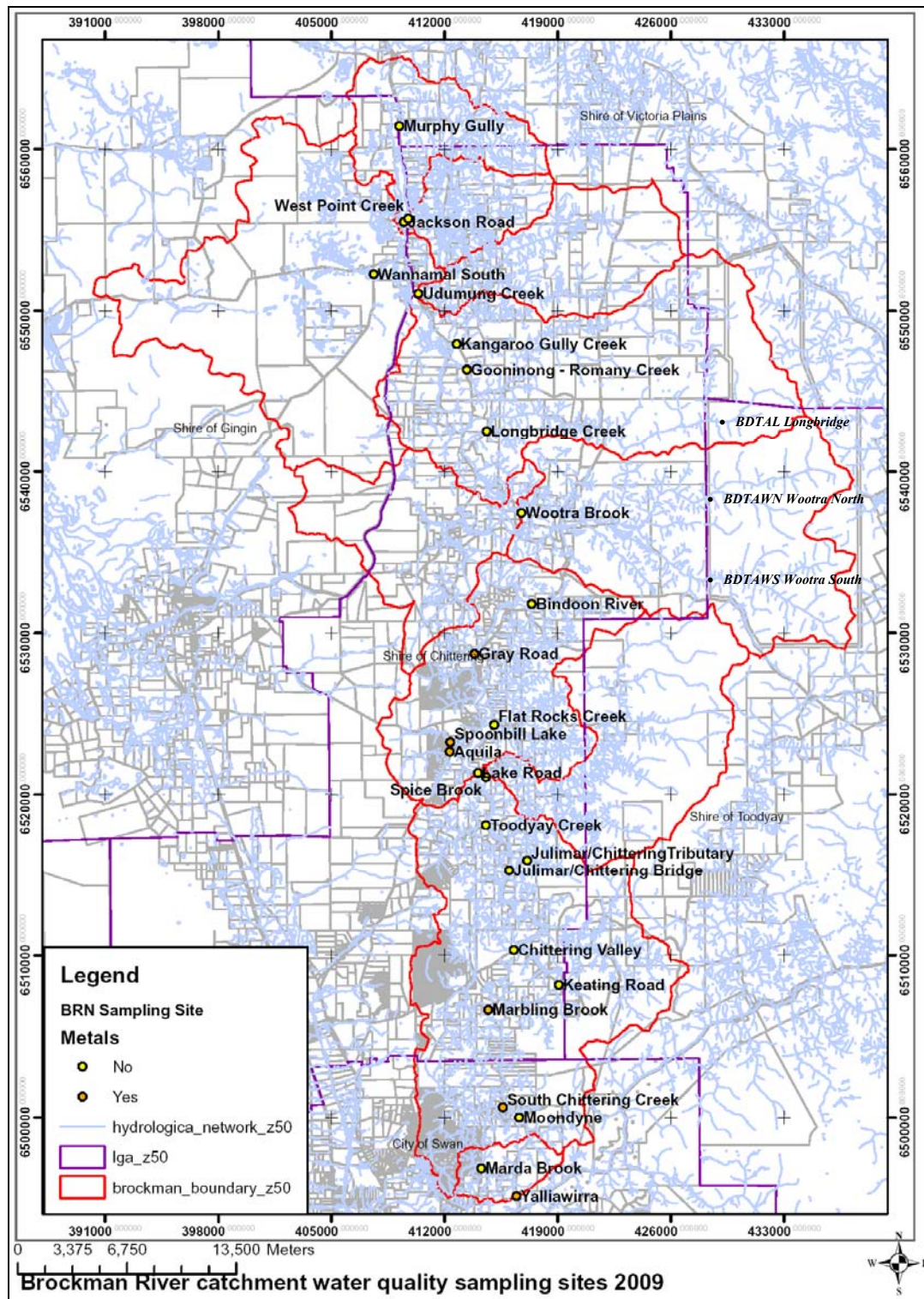


Figure 5: Sampling site locations within the Brockman River Catchment.

NB: Sampling Sites in *italic* are not part of the BROCKMANWQ program. These sites were part of the BDTA water quality monitoring program (CLG, 2009).

6.1. Water Sampling

Sampling of the Brockman River was undertaken in 2009 on the 13th August and 1st October. The collection of the samples followed strict protocols to prevent contamination and ensure consistency in results. An outline of the sampling collection technique is included in the sampling and analysis plan for the Brockman River catchment (EBICG, 2009).

Field observation forms were filled out for each water sample. All samples collected from the Brockman River catchment were transported to and analysed by the National Association of Testing Authorities (NATA) accredited MPL Laboratory.

6.2. Water Analysis

Water at each of the sites was measured *in situ* for physical properties (dissolved oxygen, pH, specific conductivity, salinity and temperature) using WTW pH and EC probes. Samples were collected and analysed for a range of contaminants likely to be present in semi-rural, agricultural catchments. They were then sent to MPL Laboratories to be analysed for nutrients including total nitrogen, total oxidised nitrogen, nitrogen as ammonia, total organic nitrogen, total phosphorous, filterable reactive phosphorous and total suspended solids.

Water samples from Spoonbill (BRN13), Aquila (BRN14), Lake Road (BRN15), South Chittering Creek (BRN22), Marbling Brook (BRN23), Yalliwirra (BRN25) and Grey Road (BRN27) were also tested for heavy metals. These included cadmium, mercury, arsenic, copper, lead, zinc, aluminium, chromium, iron and nickel.

Table 4 summarizes the MPL laboratories analysis techniques used for physical parameters, nutrients and heavy metals.

Table 4: Summary of chemical analysis techniques.

Parameters	Limit of Reporting (LOR)	Variable Unit	Analysis Technique	Lab Reference- WILAB (based on APHA)
Cond (Comp25)	1	uS/cm	direct read	5
pH	0.05		direct read	5
TSS	1	mg/L	grav	5
PO4-P	0.003	mg/L	DA	18
NOx-N	0.005	mg/L	DA	18
TP	0.01	mg/L	DA	18
TN	0.05	mg/L	DA	18
Na	1	mg/L	ICP OES	17
K	0.1	mg/L	ICP OES	17
Ca	0.1	mg/L	ICP OES	17
Mg	0.1	mg/L	ICP OES	17
Hard	1	mg/L	ICP OES	17
Al	0.005	mg/L	ICP OES	17
B	0.05	mg/L	ICP OES	17
Ba	0.001	mg/L	ICP OES	17
Be	0.0005	mg/L	ICP OES	17
Co	0.005	mg/L	ICP OES	17
Cr	0.001	mg/L	ICP OES	17
Cu	0.005	mg/L	ICP OES	17
Fe	0.01	mg/L	ICP OES	17
Mn	0.001	mg/L	ICP OES	17
Mo	0.005	mg/L	ICP OES	17
Ni	0.005	mg/L	ICP OES	17
Sn	0.05	mg/L	ICP OES	17
Sr	0.005	mg/L	ICP OES	17
Ti	0.01	mg/L	ICP OES	17
V	0.002	mg/L	ICP OES	17
Zn	0.005	mg/L	ICP OES	17
As	0.001	mg/L	GFAAS	6
Pb	0.001	mg/L	GFAAS	6

7. Results and Discussion

The National Water Quality Management Strategy provides guidance on both ecosystem and human health protection. Water quality guidelines are provided for a range of environmental values including aquatic ecosystems, primary industries, recreation and aesthetics, drinking water, industrial water, cultural issues, and monitoring and assessment (ANZECC & ARMCANZ, 2000). This report will compare sample concentration results with aquatic ecosystem trigger values for lowland river systems and, when necessary, livestock drinking water trigger values. This is in accordance with the trigger values suggested in the Brockman River Management Plan and the “Swan Canning Cleanup Program Action Plan”.

The Guidelines recognise three levels of protection for aquatic ecosystems; those with high conservation value, slightly to moderately disturbed ecosystems and highly disturbed ecosystems. To assess the level of toxicant contamination in aquatic ecosystems, trigger values were developed from data using toxicity testing on a range of test species. The trigger values (99%, 95%, 90% and 80%) approximately correspond to the levels of protection described above. This report will use the 95% protection level for aquatic ecosystems due to the high conservation value of the receiving environment of the Swan River.

It is important to note that an exceedence of the trigger value does not indicate that “standards” are not being met, but is rather an indication that further consideration should be given to the situation. An exceedence 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). No ecosystem is pristine, so when using guidelines the realistic and achievable water quality of the Brockman River should be considered.

7.1. Water Quality

7.1.1. Flow and Rainfall

The Brockman catchment makes up approximately 0.5% of the Avon catchment and discharges an average of 34 million cubic metres of water per year, which is roughly 5.5% of the Avon River annual flow (Land Assessment Pty. Ltd, 1999). In comparison to similar data from the Ellen Brook it can be noted that a significantly greater percentage of rainfall is retained and used within the Brockman River catchment.

The Brockman River flows south along the western edge of the Darling Plateau through a deeply incised valley to join the Avon River between the Walyunga and Avon Valley National Parks. The Wannamal Lake system to the north, and seasonal streams flowing from the east and west, drain directly into the Brockman River which meanders through three other wetland reserves including the Mogumber, Betts and Chittering Lakes Nature Reserves.

The Wannamal Lake system is listed as a culturally and ecologically significant wetland (Environment Australia, 2001). Analysis of water quality readings (J. Lane, CALM, pers. Comm.) since 1978 indicates that salinity in the lake is increasing. Observations made by long time residents of the area suggest that during the early 1950's the water was relatively fresh and that good clover pastures grew in nearby paddocks that are now bare salt scalds (Pers. Comm. D. Purser).

The township of Bindoon is situated on the Brockman River where it flows into Lake Needoonga, which is part of the Chittering Lake system and a wetland of National Significance (Environment Australia, 2001).

In the summer months water flow in the Brockman River is only from the southern end of the catchment. In 1975, CALM constructed a weir at the end of the Chittering Lakes Nature Reserve to control the levels of Chittering and Needoonga Lakes. The gates in the weir regulate the flow of water and the depth of the lakes. The weir was installed after a

drain was constructed that caused the lakebed to drain prematurely, impacting on the bird-breeding season.

The aim of the water management is to achieve a desirable water level in the lake throughout the year. The lake should be dry from mid-March to the opening rains and the more saline waters that accumulate during mid to late summer should not be released downstream in an uncontrolled manner (P. Dans, pers. Comm.). Thus, during the summer months, only the catchment south of the weir contributes to the water flow in the Brockman River.

The water levels in Lake Chittering are managed for:

- Wildlife management to sustain the lake vegetation survival and regeneration and the annual bird breeding season;
- The farming industry to avoid excessive flooding of adjoining agricultural land, and;
- The horticultural industry to avoid releasing excessively saline waters down the Brockman River that adversely impacts the opportunity for farmers to irrigate horticultural crops.

The Water and Rivers Commission has two monitoring stations along the Brockman River. The first monitoring station Tanamerah (S16006) is located a few kilometers upstream of the town of Bindoon at 413589E, 6531899N. This station records stage flow data for the Upper Catchment, which covers an area of approximately 96,000 hectares (Fulwood, 2001). The second monitoring station, Yalliawirra (S616019) is situated at the base of the Catchment at 416449E, 6495149N. It records stage flow data for the entire catchment, which covers an area of approximately 151,000 hectares.

Spoonbill Lake is one of two remaining fresh to marginal waterways monitored in the Brockman River catchment for salinity. This puts significant importance and pressure on this resource as it continues to feed into the lakes of Chittering and supports downstream irrigation. It must be noted that water extraction occurred within the Spoonbill subcatchment in 2008 and 2009. This has resulted in dramatic fluctuations in Spoonbill

Lake. Ongoing monitoring will be required to ensure that the existing ecosystem health and function of the reserve, subcatchment and Chittering Lakes is not negatively affected.

7.2. Physical Properties

7.2.1. Temperature

Samples taken were from sites with flowing water at a depth ranging from 10-20cm below the surface and not in contact with the sediment at any time. August temperatures ranged between 13.9°C at Marda Brook (BRN26) and 25°C at Wootra Brook (BRN9). Water temperatures were generally warmer during the October sampling run, and ranged between 11.4°C at Marda Brook (BRN26) and 26.1°C at Wannamal South (BRN4), (Figure 6). On both sampling occasions Marda Brook recorded the lowest temperature in the catchment at the time of sampling.

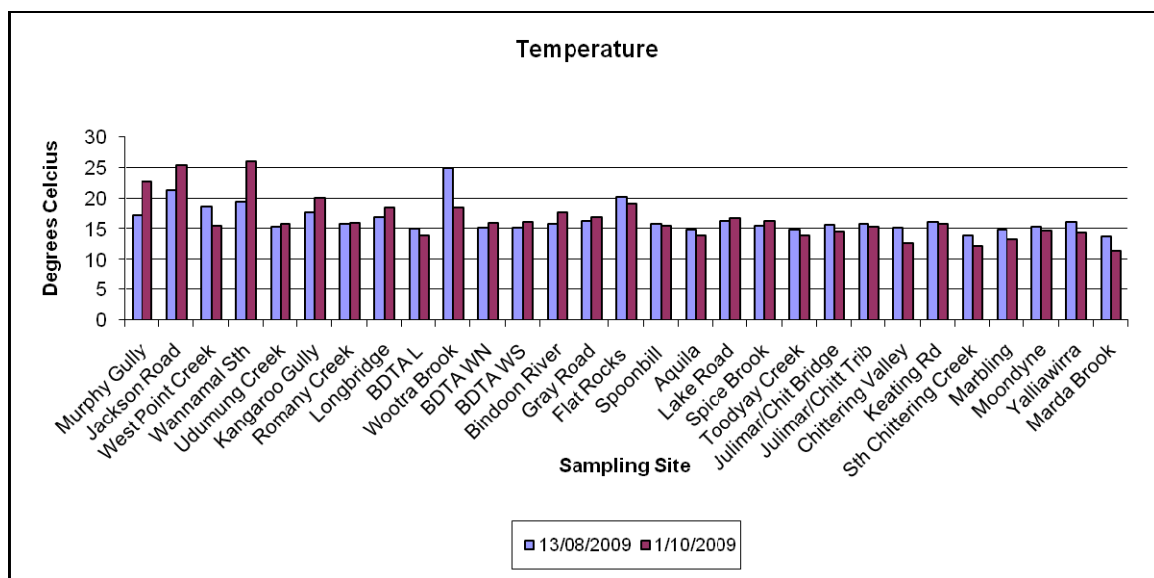


Figure 6: Water temperature of surface water within the Brockman River Catchment on the 13th August and 1st October 2009.

7.2.2. pH

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

The Brockman River had a slightly alkaline pH in the months of August and September 2007. In 2008 pH levels were generally within the ANZECC water quality guidelines of 6.5-8 for lowland rivers, and in 2009 pH values were slightly alkaline on the October sampling occasion but the majority of sites were within the guideline (Figure 7).

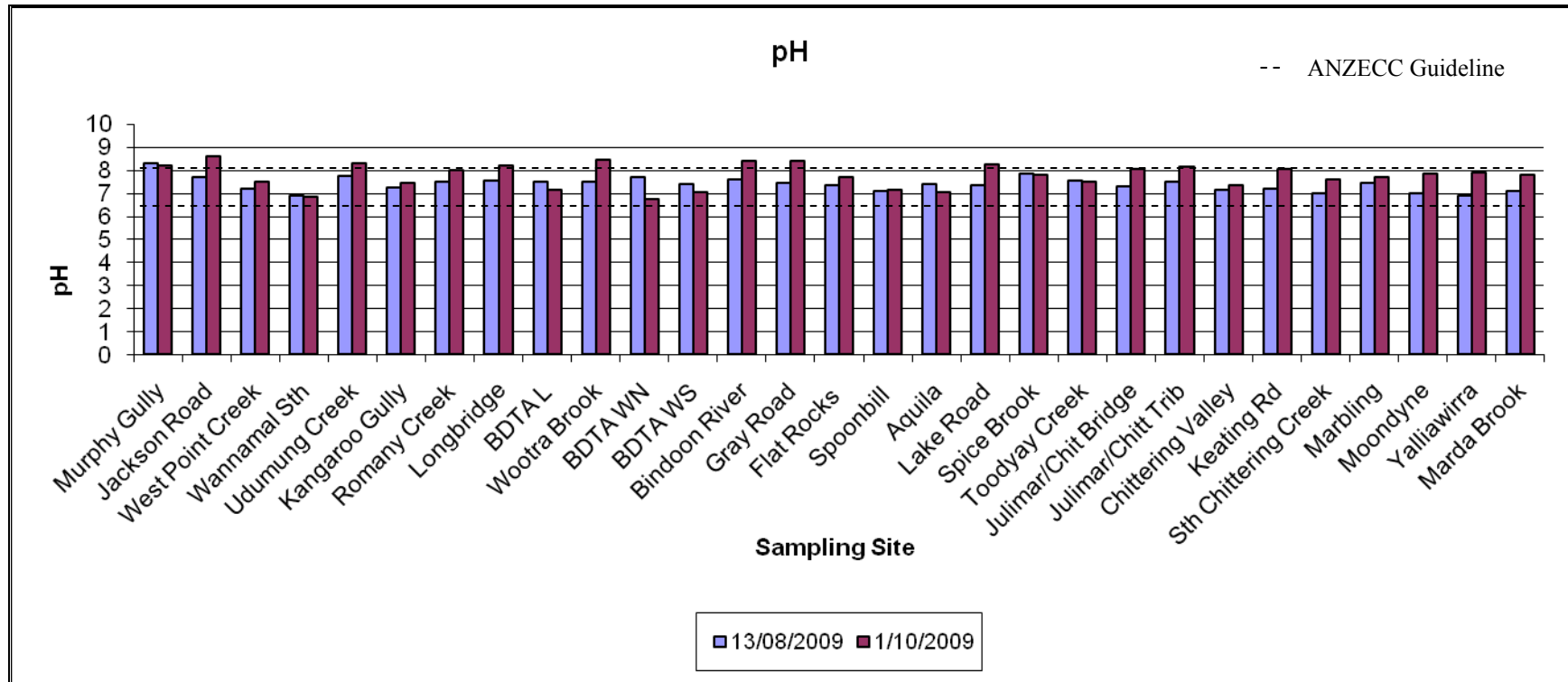


Figure 7: pH of surface water within the Brockman River catchment on 13th August and 1st October 2009.

7.2.3. Electrical Conductivity

Electrical conductivity (EC) is the total concentration of inorganic ions (particularly sodium, chlorides, carbonates, magnesium, calcium, potassium and sulfates). Conductivity is often used as a measure of salinity. The conductivity level can directly affect the use of the water. For example, flora and fauna have varying tolerance levels to salinity. Therefore, this can have adverse effects on crops and stock.

Electrical conductivity ranged from 0.079mS/cm at Bindoon Defence Training Area Wootra Brook North (BDTA WN) to 14.04mS/cm at Murphy Gully Creek (BRN1). All sites except BDTA WN during the August sampling occasion consistently exceeded the ANZECC guidelines for freshwater lowland rivers of 0.12mS/cm to 0.3mS/cm (Figure 9). It should be noted that of the sites that exceeded the guidelines for ecosystem value, the majority of them were also within the brackish to saline levels (brackish water is between 3mS/cm and 9.1mS/cm, saline water is between 9.5mS/cm and 23mS/cm), anything above 1.6 is becoming brackish and would be detrimental for irrigation of stone fruit and citrus orchards.

West Point Creek (BRN3) and Bindoon Defence Training Area Wootra North (BDTA WN) recorded freshwater levels of EC during 2009. Jackson Road, Bindoon Defence Training Area Longbridge (BDTA L), Spoonbill Lake (BDTA13), Chittering Valley (BDTA20), South Chittering Creek (BDTA22) and Marda Brook (BRN26) were identified as marginally saline sampling sites. The Marbling Brook which is the last 'freshwater' perennial stream in the Brockman River catchment recorded marginal conductivity readings in 2008 and 2009. The increasing conductivity levels in the Marbling Brook could be a direct result of the increased pressure on the aquatic ecosystem due to surrounding development and the number of bores drawing up water in Maryville. These results have caused landholders in the catchment to voice their concerns over the lack of good quality water required for new and expanding agricultural developments over the years (WRC, 2003). Ongoing monitoring is essential.

It is also of great concern for the environmental value that all sites consistently exceeded ANZECC water quality guidelines for lowland river systems, and were generally within the brackish to saline levels. The highest conductivity reading of 14.04mS/cm within the Brockman Catchment was recorded at Murphy Gully which is located at the northern most point of sampling along the Brockman River. Conductivity levels recorded at the sampling sites along the main body of the Brockman River were found to decrease from north to south (Figure 8). This pattern was also noted in the 2006, 2007 and 2008 *Water Quality Monitoring Snapshot of the Brockman River catchment* (EBICG, 2007, 2008&2009). Levels dropped to 3.39mS/cm at Yalliwirra (BRN25) during the October sampling occasion. This site is located just north of the confluence of the Brockman River and the Avon River and is the southernmost sampling site in the catchment. This concentration was above the guideline, brackish and as a result, unacceptable for the irrigation of stone fruit, citrus, peas, carrot, onion, grapes, lettuce and tomato. It is also unacceptable for human consumption or use in hot water systems (Appendix C).

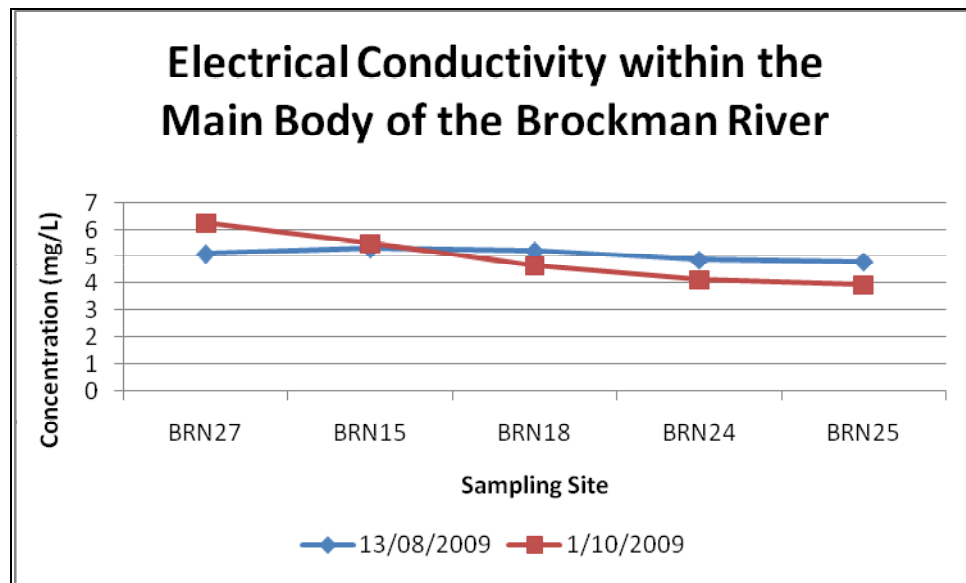


Figure 8: Electrical conductivity within the main body of the Brockman River, recorded at sampling sites Grey Road (BRN27), Lake Road (BRN15), Julimar/Chittering Bridge (BRN18), Moondyne (BRN24) and Yalliawirra (BRN25) in 2009.

The high level of vegetation clearing, primarily at the top of the catchment creates a weak correlation with increasing stream salinity, and a strong correlation with increasing groundwater salinity (Fulwood, 2001). This shows that the higher conductivity levels coming down the catchment and tributaries are diluted as they flow through the Brockman River catchment and into the Avon River. This trend was also described in the *Salinity Survey in the Shire of Chittering* (Angell, 2000). Additionally, Angell (2000) found that a considerable portion of stream flow is contributed to the Brockman from saline groundwater sources. Base flow maintains stream flow throughout the year however, if extremely saline, base flow can have devastating effects on the river particularly during low rainfall seasons (approximately 200mm below average). This results in lower surface water inputs and low dilution rates. With exception to rainfall, salinity within the catchment has increased over a period of time (Fulwood, 2001).

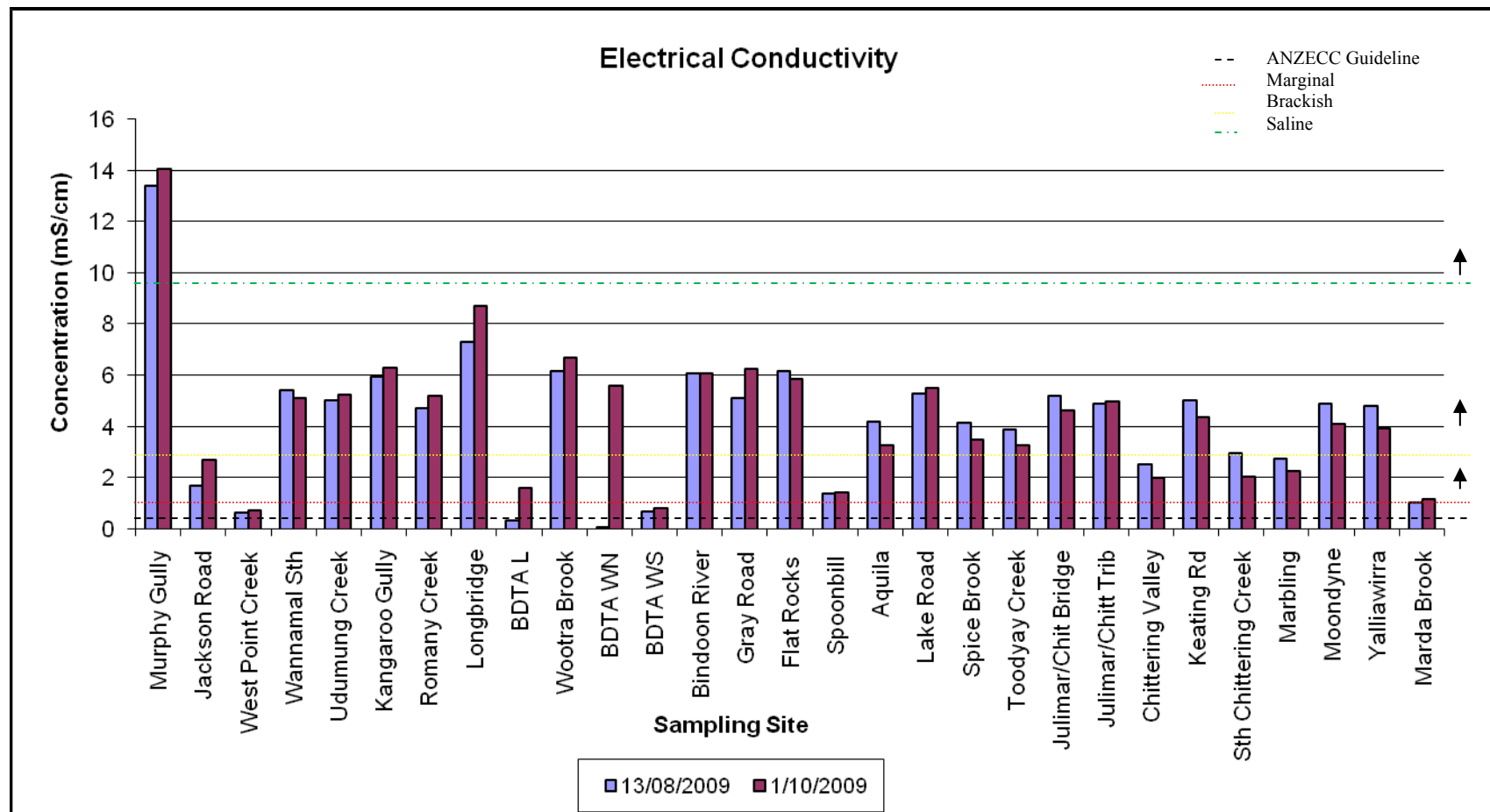


Figure 9: Conductivity in surface water within the Brockman River catchment on 13th August and 1st October 2009.

7.2.4. Total Suspended Solids

Total Suspended Solids (TSS) refers to naturally occurring suspended particles including; silt, phytoplankton and organic matter within a water body. Natural sources of TSS include water turbulence from storms, phytoplankton blooms and wind/wave action. However, TSS may also indicate detrimental environmental conditions such as erosion. This makes levels higher than normal in the water body and can result in increased deposition of material to the substrate that may smother faunal communities (McTaggart, 2002).

There are large variations in TSS throughout water bodies, therefore guidelines should be determined by including information on natural levels within the regional area of sampling. As no ANZECC guideline currently exists for TSS, this report will use the interim guideline of 6mg/L adopted by the Department of Water and originally developed by the Waters and Rivers commission for the Wilson Inlet report to community (October 2000). TSS in the Brockman catchment ranged between laboratory detection limits and 51mg/L recorded at West Point Creek in Wannamal.

West Point Creek (BRN3), Wootra Brook (BRN9), Julimar/Chittering Bridge (BRN18), Grey Road Bridge (BRN27), BDTA Longbridge (BDTAL), Keating Road (BRN21), Moondyne (BRN24) and Yalliwirra (BRN25) significantly exceeded the interim guideline of 6mg/L for TSS with concentrations between 9 and 95mg/L over the two sampling occasions (Figure 10). These concentrations are significantly lower than the 83-870mg/L experienced in 2008 at Murphy Gully (BRN1), Wootra Brook (BRN9), Grey Road (BRN27), Flat Rocks Creek (BRN12), Spice Brook (BRN16), and Toodyay Creek (BRN17). This is potentially a result of extreme rainfall events causing flooding in 2008, in comparison to reduced but consistent rainfall events experienced in 2009 without flooding.

Wootra Brook (BRN9) and Spice Brook (BRN16) have been identified as major contributors of TSS in previous years. High TSS levels from contributing catchments are located across the catchment in areas of intensive stocking rates and grazing, high levels of cleared vegetation and a lack of riparian vegetation. Stock have access to waterways in most of these areas causing increased erosion rates and sedimentation.

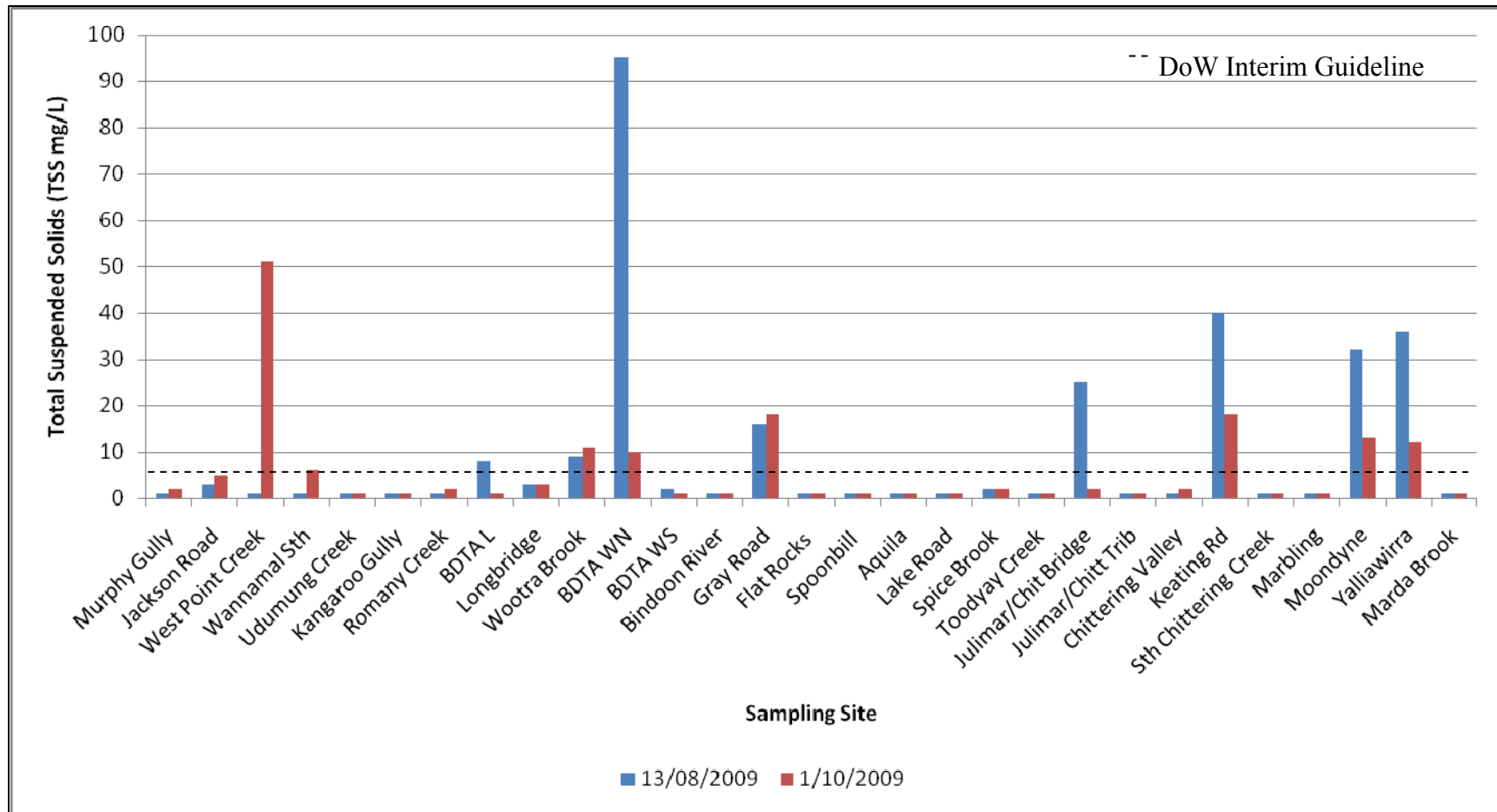


Figure 10: Total Suspended Solids in surface water within the Brockman River catchment sampled 13th August and 1st October 2009.

7.3. Nutrient concentrations in water

Most nutrients present in the catchment are stored in the soils and are transported to the Brockman River via surface water (tributaries, drains and general run-off). The original sources of nutrients include; weathering, leaching from soils particularly in eroded areas, fertiliser run-off, detergents, sewerage, fixation by some plants, and decomposition of plant matter, animal wastes and other organic wastes (IEA 2003). Nitrogen and phosphorus are the two major essential elements to plants. Excessive amounts of nutrients in waterways can result in eutrophication with plant and algae growth, increases in nuisance insect numbers and unbalanced aquatic ecosystems. Nutrients include nitrogen in the form of ammonia, nitrate and nitrite, and phosphorus in the form of phosphate either dissolved (soluble reactive phosphate) or particulate (suspended).

7.3.1. Total Nitrogen

When plants or animals die they release nitrogen in the form of ammonium (NH_4) that can then be oxidised by nitrifying bacteria to become nitrite and nitrate in a process known as nitrification. Total nitrogen (TN) refers to all forms of nitrogen present including organic (e.g. plant decay matter) and inorganic in the forms of ammonia, nitrate and nitrite (McTaggart 2002). Sources of nitrogen include fertilisers, industrial cleaning operations, feed lots, animal droppings, combustion of fossil fuels and plant debris.

All sites except Bindoon River (BRN10), Spoonbill Lake (BRN13), Aquilla (BRN14), Spice Brook (BRN16), Toodyay Creek (BRN17), Julimar/Chittering Tributary (BRN19), Chittering Valley (BRN20) and South Chittering Creek (BRN22), were above the ANZECC water quality guideline values of 1.2mg/L for lowland river system and ecosystem health during the August sampling occasion (Figure 11). All sites except Jackson Road (BRN2), West Point Creek (BRN3), Wannamal South (BRN4), Udumung Creek (BRN5), Romany Creek (BRN7), Longbridge Creek (BRN8) and Grey Road Bridge (BRN27) recorded TN concentrations below the guideline during the October sampling occasion.

TN concentrations at these sites ranged between 1.2mg/L (BRN5) and 4.3mg/L (BRN7). Duplex soils of sand over clay with high nutrient retention capabilities dominate on the Darling Plateau in the northern half of the Brockman River catchment. These soils have a high nutrient trapping capability and are able to retain nutrients in the soil. High TN concentrations in 2009 are probably due to the consistent rainfall season experienced, where run off carrying high nutrient concentrations from the over application of inorganic fertilisers by horticulture and agriculture, flowed into the waterways.

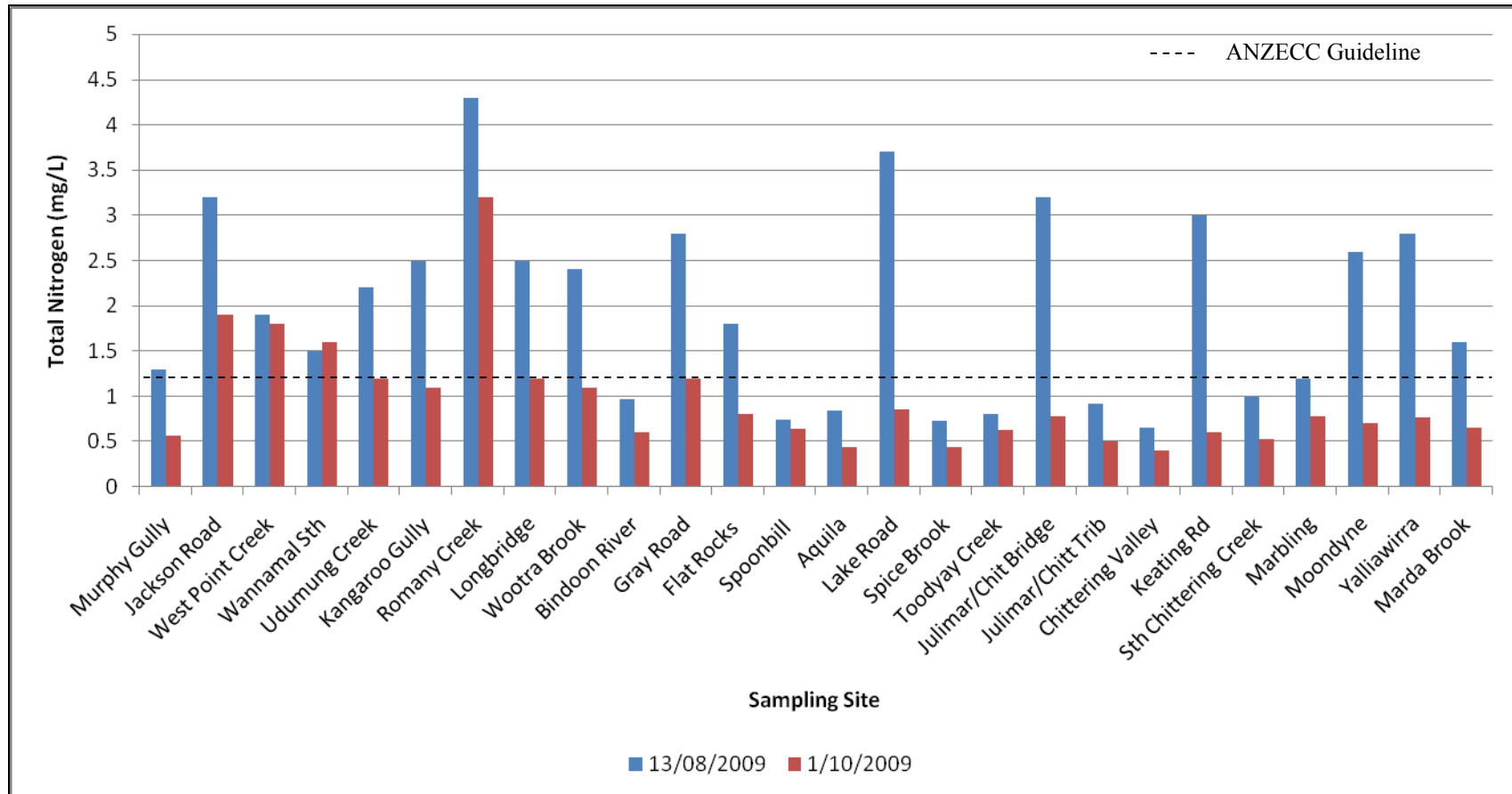


Figure 11: Total Nitrogen in surface water within the Brockman River catchment sampled 13th August and 1st October 2009.

7.3.2. Ammonia as Nitrogen

All sites were within the ANZECC guideline of 0.08mg/L except for Jackson Road (BRN2), West Point Creek (BRN3), Wannamal South (BRN4), Lake Road (BRN15), Julimar/Chittering Bridge (BRN18), Keating Road (BRN21), Moondyne (BRN24) and Yalliwirra (BRN25), (Figure 12). High concentrations mostly occurred during the August sampling occasion. This could be due to the high rainfall experienced around the time of sampling and increased runoff transporting nutrients directly into waterways, timing of fertiliser application and stock access to waterways.

Ammonia is used in fertilisers and cleaning agents. The majority of sampling sites are surrounded by agriculture including cattle grazing, pastures and cropping, stock yards, orchards and horticulture which are also sources of ammonia nitrogen.

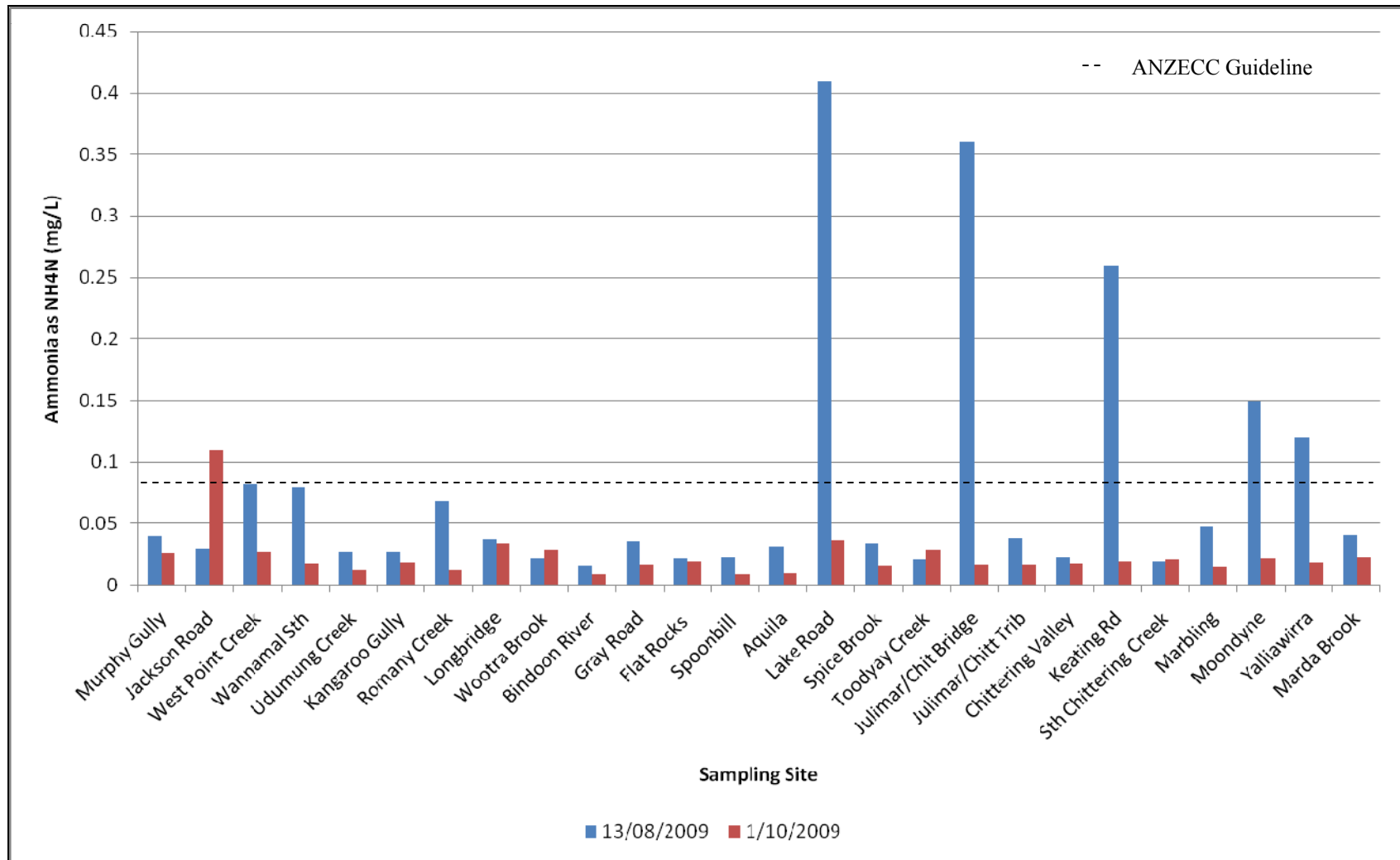


Figure 12: Ammonia as NH₄N concentrations in surface water within the Brockman River catchment on 13th August and 1st October 2009.

7.3.3. Filterable Organic Nitrogen

Filterable Organic Nitrogen (Dissolved Organic Nitrogen) is comprised of the organic forms of nitrogen including amino acids, proteins, urea and humic acid. All sampling sites exceeded the ANZECC guideline of 0.04mg/L on all sampling occasions. Additionally, FON concentrations compared with total nitrogen, ammonia and total oxidised nitrogen concentrations showed that nitrogen exists primarily in its soluble form in the Brockman River catchment.

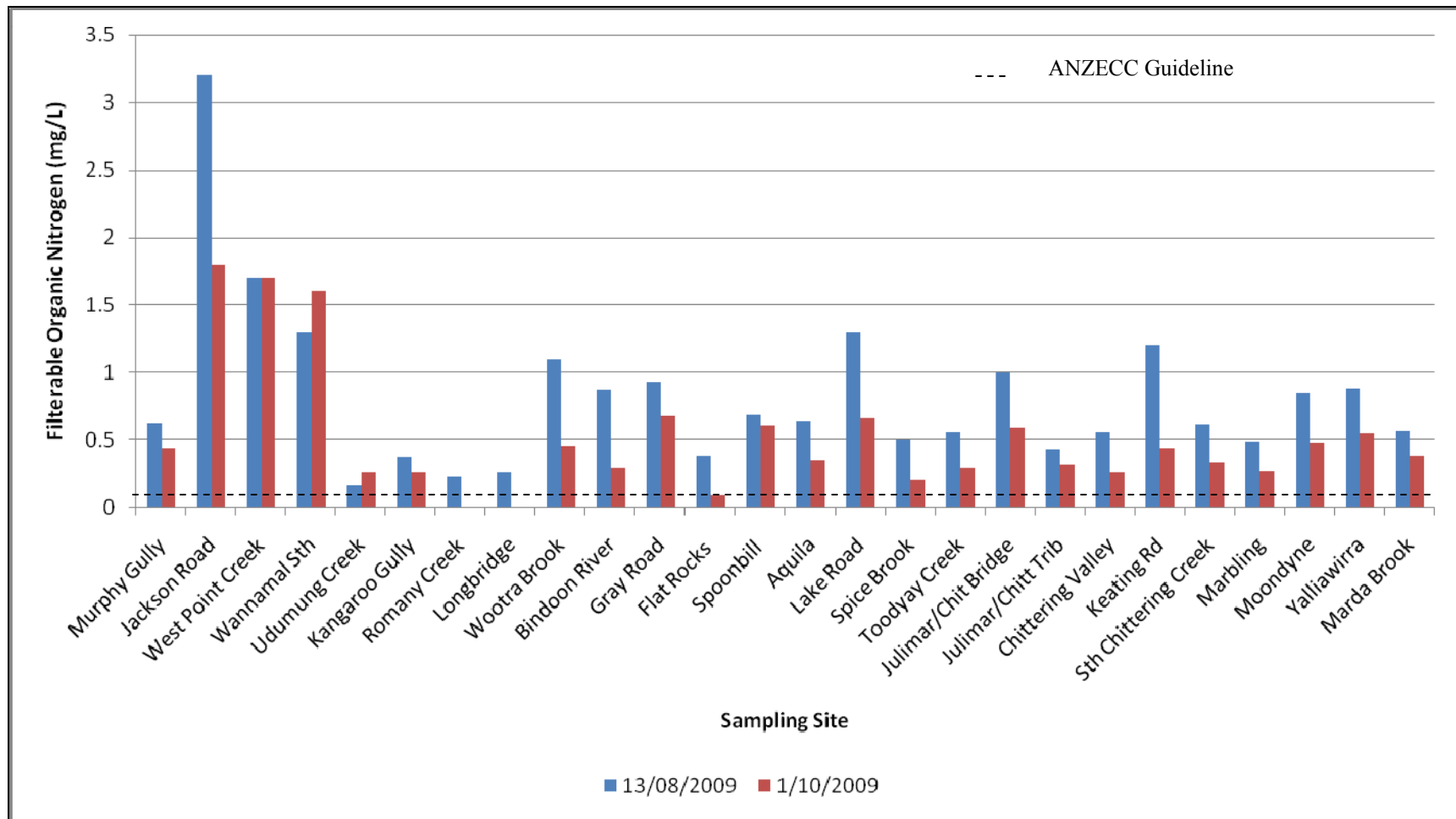


Figure 13: Filterable Organic Nitrogen concentrations in surface water within the Brockman River catchment on 13th August and 1st October 2009.

7.3.4. Total Oxidised Nitrogen

Total oxidised nitrogen is the sum of the oxidised forms of nitrogen, which includes nitrite and nitrate, and is often referred to as NO_x . Nitrite can be converted to nitrogen gas by denitrifying bacteria and ammonium (NH_4) and in the form of nitrate; hence plants can easily absorb this form of nitrogen in a continuous cycle as it is readily soluble in water and is rapidly transported through the catchment via surface run-off, sub-surface and groundwater flows (Horwood, 1997).

Jackson Road (BRN2), West Point Creek (BRN3), Wannamal South (BRN4), Spoonbill Lake (BRN13) and Chittering Valley (BRN20) were within the ANZECC water quality guidelines of 0.15mg/L for lowland river systems and ecosystem health (Figure 14). All other sites recorded concentrations above the guideline.

Romany Creek recorded a TON concentration of 4mg/L, over twenty-six times greater than the guideline. This is consistent with 2008 snapshot data where Romany Creek recorded the highest TON concentration out of the 26 sampling sites. This result is much higher in comparison to other sampling sites within the Brockman catchment and may be a result of site specific surface water runoff originating from the surrounding agricultural land uses.

TON concentrations are generally consistently higher in the northern half of the catchment, as shown in Figure 14. It is also interesting to note that TON concentrations dropped significantly at Spoonbill Lake (BRN13) and remained relatively low down to Yalliwirra (BRN25), except during the August sampling occasion. Cereal production, beef, pigs, and sheep may contribute to the higher concentrations of TON in the northern half of the catchment. In comparison, the primary production of the southern half of the catchment in the Chittering valley is vineyards and orchards. As a result the TON entering the river upstream from runoff carrying manure and organic matter is diluted as it flows through the catchment.

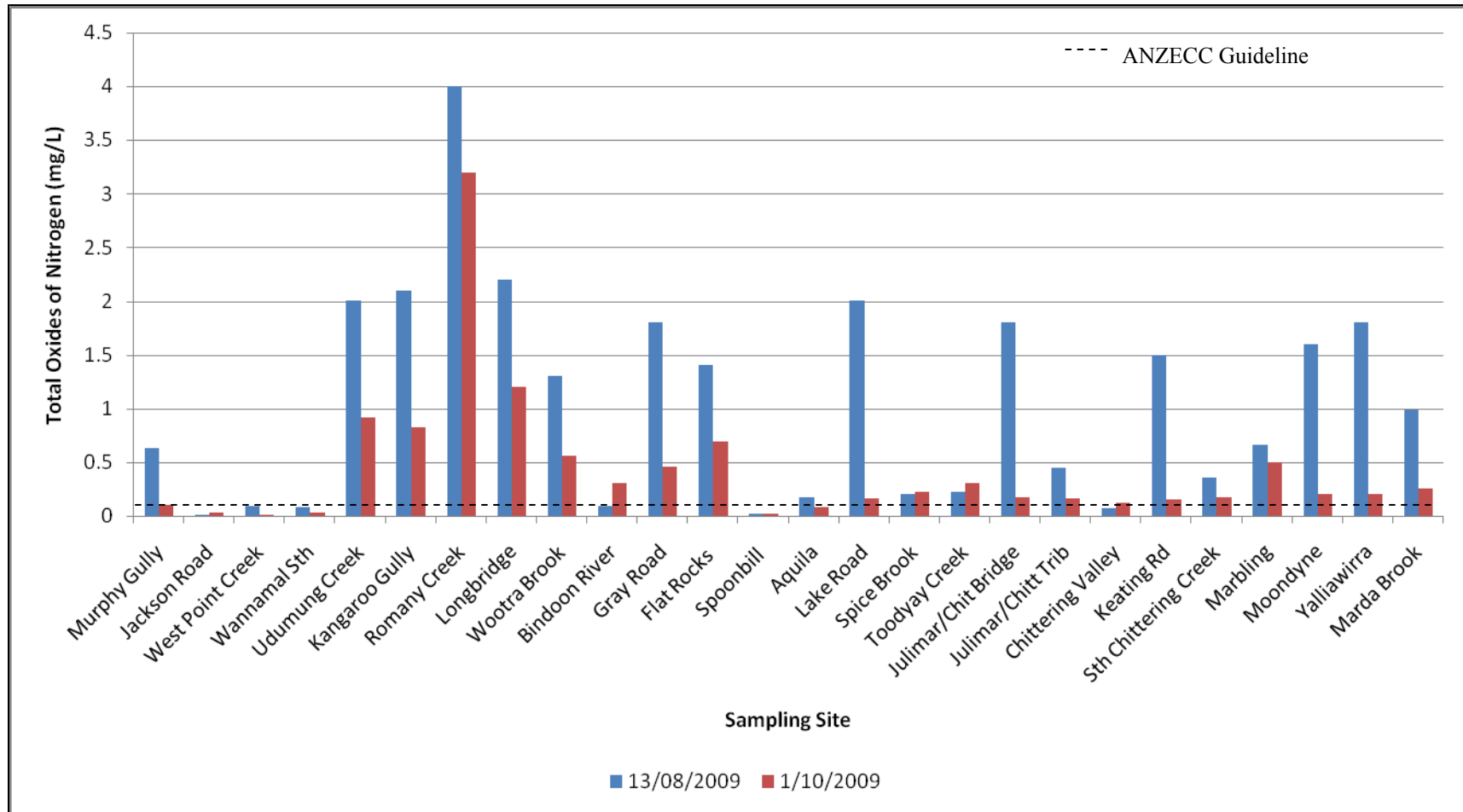


Figure 14: NOX_N (TON) concentrations in surface water within the Brockman River catchment in 13th August and 1st October 2009.

7.3.5. Total Phosphorous

Total phosphorus (TP) is a measure of all phosphorus in the water including the available and unavailable (or potentially available) forms of phosphorus including orthophosphates (fertilisers), organic phosphate (plants & animals) and condensed phosphates (inorganic cleaning agents). Sources of phosphorus include fertilisers, plant debris, detergents, industrial wastes and lubricants (McTaggart 2002). Phosphorus is naturally occurring in the environment and is usually the limiting factor for aquatic plant growth as it is generally lower than nitrogen in most waterways. However, an increase in the total P level in freshwater bodies stimulates the production of *Chlorophyll a* in phytoplankton and results in an algal bloom (Russell, 2001).

As plants and animals excrete waste or die then decay, the organic phosphate sinks to the bottom of the waterway where bacteria convert it back to inorganic phosphate. Inorganic phosphate returns to the water column when sediments are disturbed, making it available again to plants which uptake it and it continues in the cycle. Inorganic phosphate is not as mobile as soluble forms of nutrients and tends to be adsorbed by most soils and particulate material. This results in a steady accumulation of phosphorus slowly moving through the soil profile. Holding time of phosphorus in the catchment depends on the recharge rate to groundwater, rate of adsorption to soil particles and the extent of soil saturation (Gerritse, 1996).

Phosphorus concentrations within the Brockman catchment in 2006 and 2007 were below the ANZECC water quality guidelines of 0.065mg/L for lowland river systems and ecosystem health at all sampling sites (Figure 15). In 2008 concentrations were recorded above the guideline at Wannamal South (BRN4), Romany Creek (BRN7), Flat Rocks Road (BRN12), Aquila (BRN14), Lake Road (BRN15), Spice Brook (BRN16), Julimar/Chittering Tributary (BRN19) and Moondyne (BRN24). In 2009 concentrations were recorded above the guideline at Jackson Road (BRN2), West Point Creek (BRN3), Wannamal South (BRN4), Kangaroo Gully (BRN6) and Wootra Brook (BRN9) on one of the sampling occasions.

Duplex soils of sand over clay and loamy clays with high nutrient retention capabilities dominate on the Darling and Dandaragan Plateaus of the Brockman River catchment. These soils have a high nutrient retention capacity which reduces the level of nutrients entering the waterways other than through erosion and sedimentation (DEBCMP, 2001).

According to Russell (2001) it is storm events that trigger the hydrological pathways important for phosphorous loss. Export of phosphorus during peak flow times can get up to 20 times higher than pre-storm levels in stream flow from an agricultural catchment. Most of the phosphorus exported from an area during these periods of heavy rainfall and storm activity are in particulate form as it is carried primarily in sediment and soil as a result of rill, gully and sheet erosion. It is interesting to note that total phosphorous concentrations were generally higher on the October sampling occasion. This could be due to lower rainfall causing reduced dilution, or surrounding land use practices such as fertiliser application and stock. Therefore, continued long term monitoring is recommended to gain an understanding of phosphorous export from this catchment.

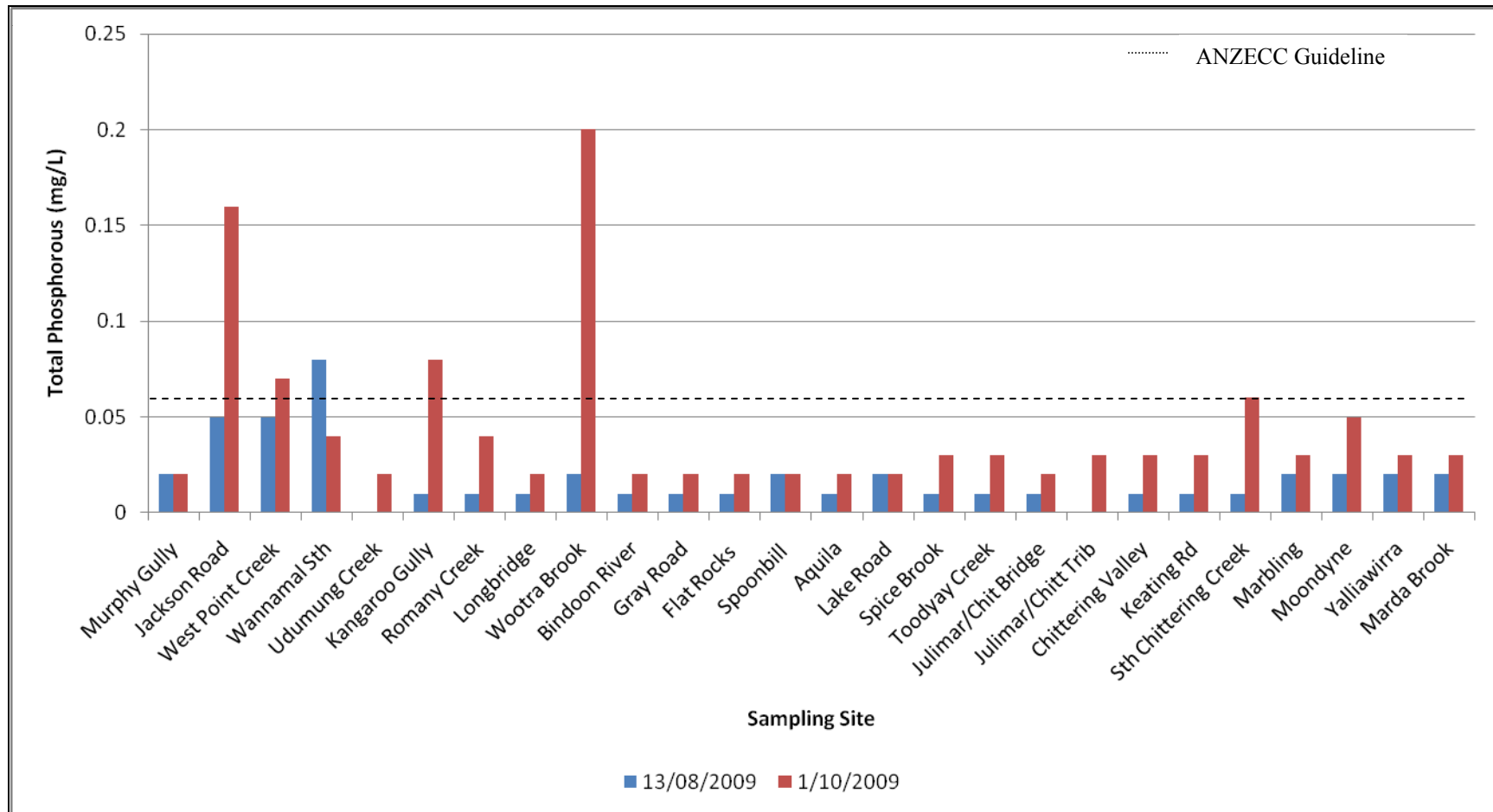


Figure 15: Total Phosphorous concentrations in surface water within the Brockman River catchment sampled on 13th August and 1st October 2009.

7.3.6. Filterable Reactive Phosphorous

Filterable reactive phosphorus (FRP) measures only the dissolved phosphorus in water and provides a measure of the immediately available phosphate in the system at the time of sampling; it is also referred to as PO_4 . As this form of phosphorus is readily available it is more likely to stimulate algal blooms and this can lead to more decaying vegetation which alters river characteristics including elevated temperature, reduced oxygen and fish kills. This nutrient enrichment process is known as eutrophication (McTaggart, 2002).

FRP concentrations in surface water within the Brockman catchment were well below the ANZECC water quality guideline for lowland river systems value of 0.04mg/L, and the Limit of Reporting (LOR) at all sampling sites on both sampling occasions, except for Jackson Road (BRN2) and Kangaroo Gully (BRN6), (Figure 16).

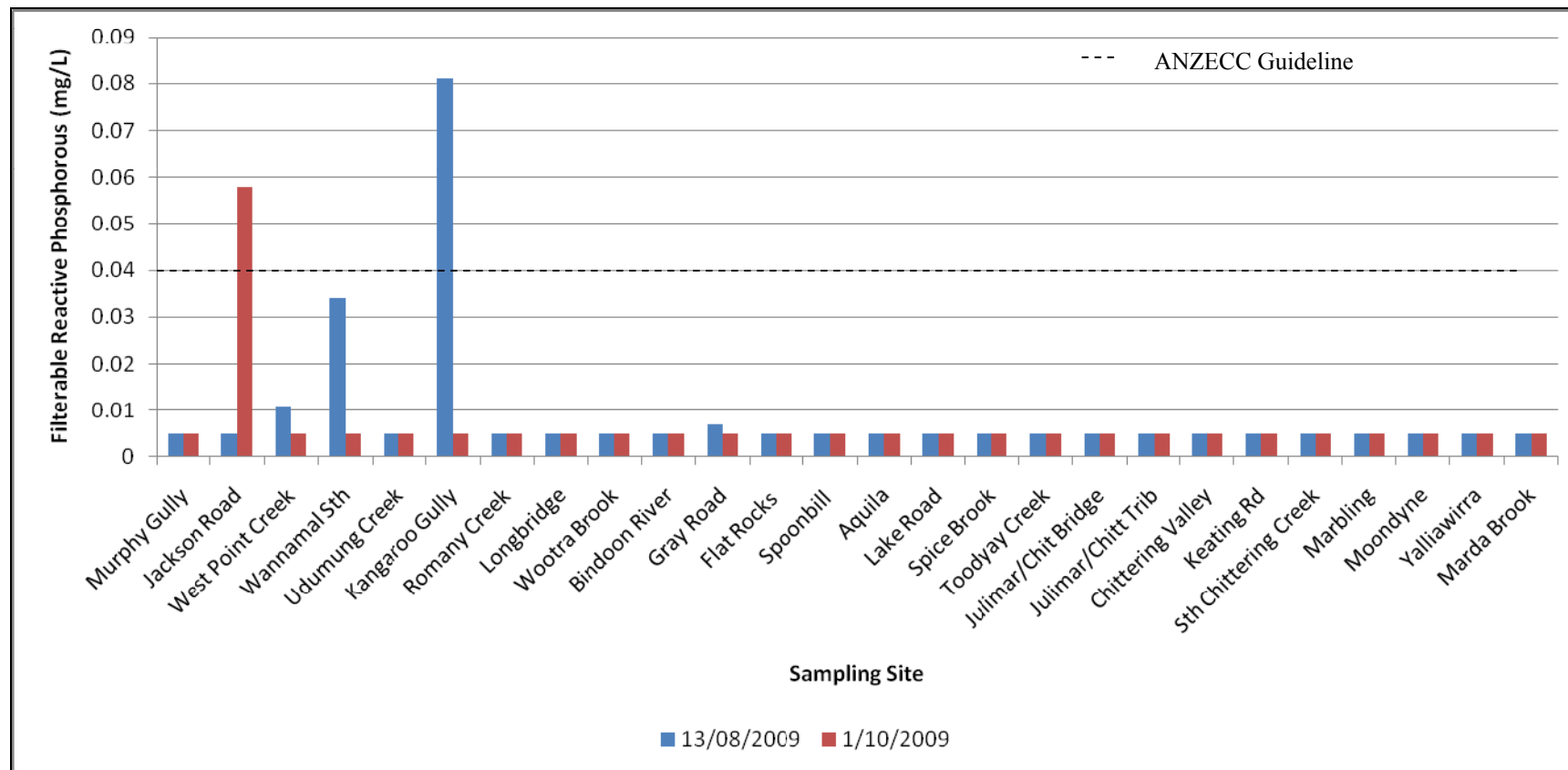


Figure 16: Filterable Reactive Phosphorous concentrations in surface water within the Brockman River catchment sampled on 13th August and 1st October 2009.

7.4. Heavy Metals in surface water

Heavy metals are usually found naturally in aquatic ecosystems; however, in excessive amounts they are associated with toxicity and pollution. They are derived from a variety of sources such as industrial waste, refuse leachate, corrosion of pipes and roofs (McTaggart, 2002). The most common sources of heavy metal contaminants in the Brockman are pesticides and fertiliser application. Copper, zinc and cadmium in particular are often found in fertilisers. In the Brockman catchment most heavy metals would enter the river via surface water run-off and groundwater contamination.

Aquatic organisms have varying tolerance levels to different metals. Metals that are essential for growth can become toxic to aquatic organisms at levels beyond their tolerance. This may only be slightly higher than normal concentrations. Heavy metals may also accumulate in fatty tissues of animals and in the human body, so repeated exposure to heavy metals can cause levels to build up to a toxic level (IEA 2003). This is known as “bioaccumulation”.

Biomagnification can result in animals at the top end of the food chain accumulating a high concentration of heavy metals even if the organisms consumed at lower levels of the food chain have acceptable levels of heavy metals. Tolerance levels of aquatic organisms to heavy metals and ability to absorb those metals can be influenced by many factors including; interaction with other metals and formation of organic complexes (e.g. with organic carbon compounds), the chemical form of the metal, dissolved oxygen levels, salinity levels, temperature and the hardness of the water.

Metals were sampled for at seven strategically identified sites including Spoonbill (BRN13), Aquila (BRN14), Lake Road (BRN15), South Chittering Creek (BRN22), Marbling Brook (BRN23), Yalliawirra (BRN25) and Gray Road (BRN27) in August and October 2009.

In 2006, heavy metal concentrations in the waters of the Brockman River catchment were below the limit of reporting except at Yalliwirra (BRN25), the most southern sampling site in the catchment. These heavy metals included aluminium, arsenic, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, selenium and zinc. Iron was the only metal which recorded a value which was above the limit of reporting.

In 2007, heavy metal concentrations in the waters of the Brockman River catchment were above the limit of reporting and on occasion above the Hardness-modified Trigger Value on one of the sampling occasions at various sampling sites. These metals included Aluminium, Copper, Iron, Zinc and Cadmium. The elevated concentrations of these metals could be a result of surrounding land use and practices including fertiliser application, soil erosion carrying heavy metals to the waterways, groundwater contamination and sub-surface flow, and the natural occurrence of these trace elements in the soil. Water hardness affects the toxicity of the heavy metals in the environment. Arsenic and Mercury were both below the limit of reporting on all sampling occasions at all sites (Appendix A).

In 2008, aluminium was above the ANZECC trigger value in the Marbling Brook (BRN23), which could be due to land use practices or the influence of groundwater as the concentration was high during the spring sampling occasion at low flow. Zinc was above the relative hardness modified trigger value at some sites sampled. Iron was below the ANZECC guideline at all sites sampled for metals, and all other metals were recorded as below the limits of reporting.

In 2009, aluminium was above the ANZECC trigger value at all sites during the August sampling occasion. Iron concentrations were above the ANZECC indicative guideline at all sites, except Aquilla (BRN14), during the August sampling occasion.

7.4.1. Hardness

Total hardness, expressed as calcium carbonate (CaCO_3), is the combined concentration of alkali-earth metals, predominantly magnesium (Mg^{2+}) and calcium (Ca^{2+}), and some strontium (Sr^{2+}). The source of this hardness is possibly through the weathering of granite. Hardness levels range from $<60\text{mg/L}$ (soft) to $>400\text{mg/L}$ (extremely hard).

Water hardness can have an ameliorating effect on the toxicity of some heavy metals including cadmium, copper, zinc, lead, nickel and chromium, as the calcium and carbonate ions compete directly for the same uptake pathways as these metals. Water samples with higher concentrations of water hardness need to have the trigger values for these metals adjusted by a hardness-dependent algorithm or the approximate factors applied to soft water trigger values of varying water hardness provided in ANZECC and ARMCANZ (2000), (Appendix D). Refer to Table 5 for the calculated Hardness-Modified Trigger Values (HMTV) for cadmium, copper, chromium, lead, nickel and zinc. Hardness ranged between 140mg/L at Spoonbill Lake (BRN13) – very hard, and 860mg/L at Gray Road Bridge (BRN27) – extremely hard (Figure 17).

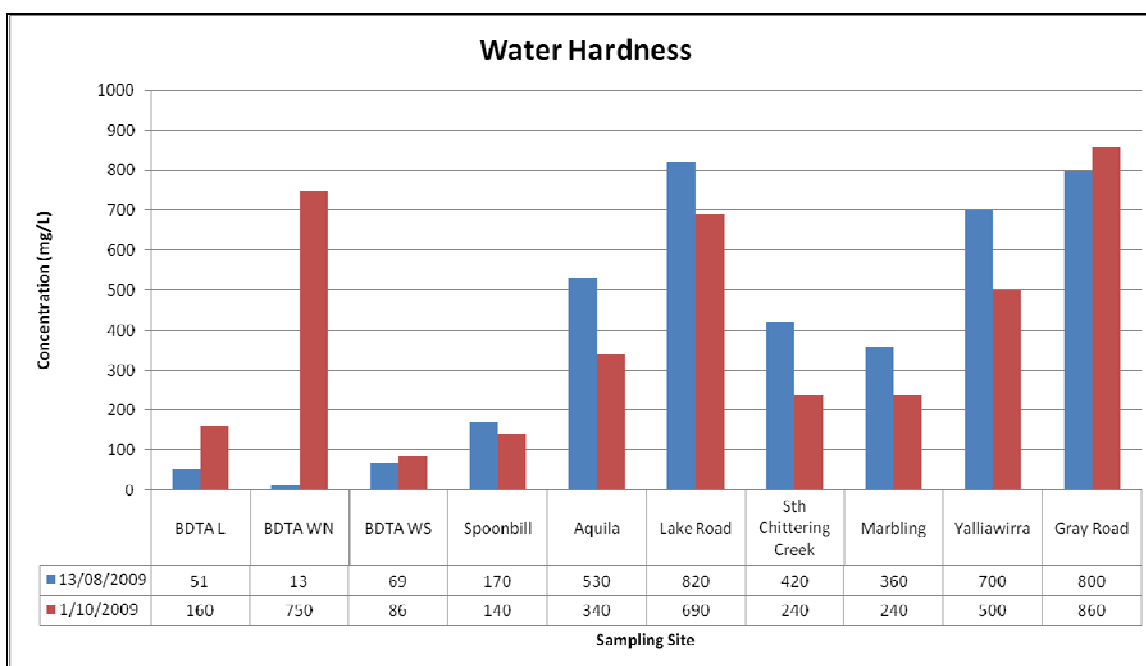


Figure 17: Water Hardness sampled from surface waters within the Brockman River catchment on 13th August and 1st October 2009.

Table 5: Hardness-Modified Trigger Values (HMTV) for Cadmium, Copper, Chromium, Lead, Nickel and Zinc based on Figure 17 and Appendix D calculations.

Metal	ANZECC Trigger Value	HMTV for very hard water (180 – 240).	HMTV for extremely hard water (250 - >400mg/L)
Cadmium	0.0002	0.0011	0.002
Copper	0.0014	0.0072	0.0126
Chromium	0.001	0.005	0.0084
Nickel	0.011	0.057	0.099
Lead	0.0034	0.04	0.09
Zinc	0.008	0.04	0.07

7.4.2. Aluminium

All sites except Spoonbill Lake (BRN13) and Aquilla Reserve (BRN14) exceeded the ANZECC trigger value of 0.055mg/L for aluminium, on the August sampling occasion, (Figure 18). Those sites sampled on the Bindoon Defence Training Area including Londgbridge (BDTA L), Wootra North (BDTA WN) and Wootra South (BDTA WS) were above the trigger value on both sampling occasions. All other sites remained below the trigger value.

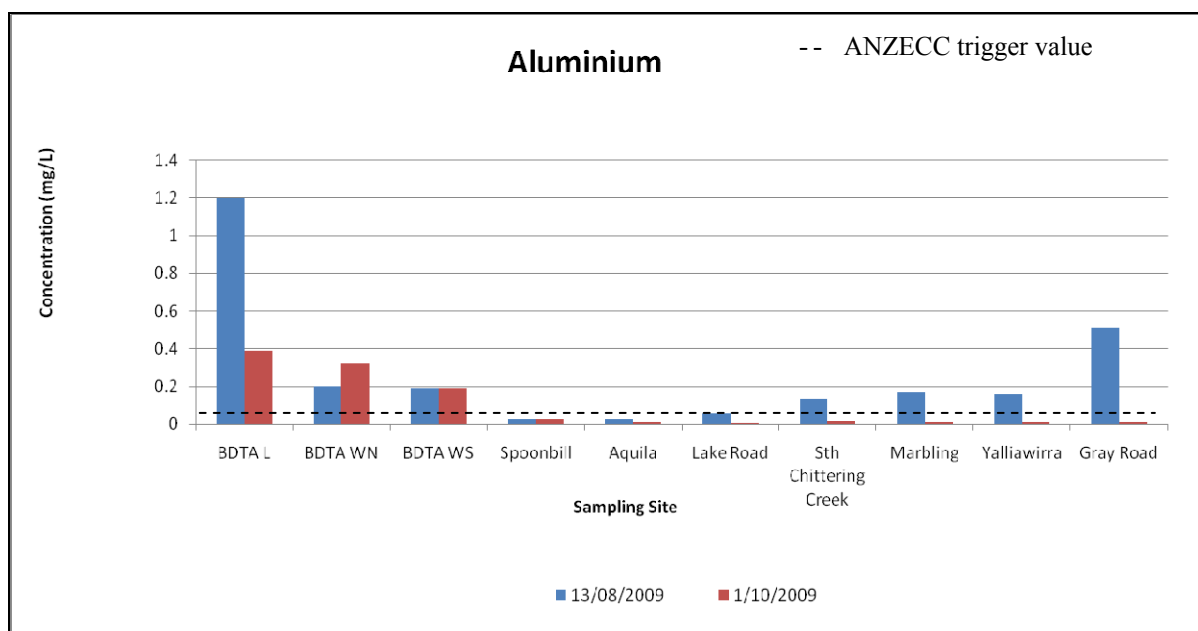


Figure 18: Aluminium concentrations in surface water within the Brockman River catchment on the 13th August and 1st October 2009.

7.4.3. Iron

There is no ANZECC guideline trigger value or environmental concern level (ECLs) available for iron in fresh water as a result of insufficient data (ANZECC and ARMCANZ, 2000). All sites, except Aquilla (BRN14), recorded iron concentrations above the current Canadian guideline of 0.3mg/L during the August sampling occasion, (Figure 19). This guideline is advised by the ANZECC water quality guidelines to be used as an interim indicative working level for aquatic ecosystems and requires further monitoring. Sites sampled on the Bindoon Defence Training Area including Longbridge (BDTA L), Wootra North (BDTA WN) and Wootra South (BDTA WS) were above the trigger value on both sampling occasions. Spoonbill (BRN13) also recorded iron concentrations above the trigger value on both sampling occasions. Spoonbill (BRN13) also recorded iron concentrations above the trigger value on both sampling occasions.

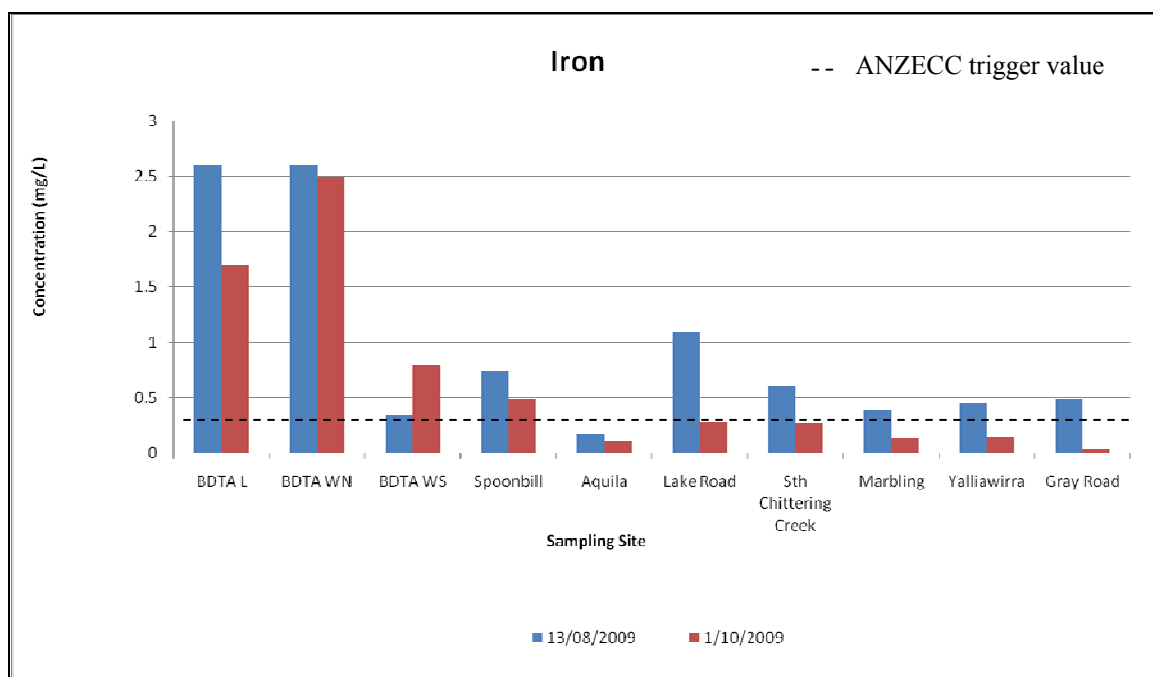


Figure 19: Iron concentrations in surface water within the Brockman River catchment on the 13th August and 1st October 2009.

7.4.4. Zinc

All sites were below the Hardness Modified Trigger Values (HMTV) of 0.07mg/L for sites Lake Road (BRN15), South Chittering Creek (BRN22), Marbling Brook (BRN23), Yalliwirra (BRN25) and Grey Road Bridge (BRN27), 0.0416mg/L for South Chittering Creek (BRN22), and 0.04mg/L for Aquilla Reserve (BRN14), during both sampling occasion, (Figure 20). Concentrations were generally higher on the October sampling occasion.

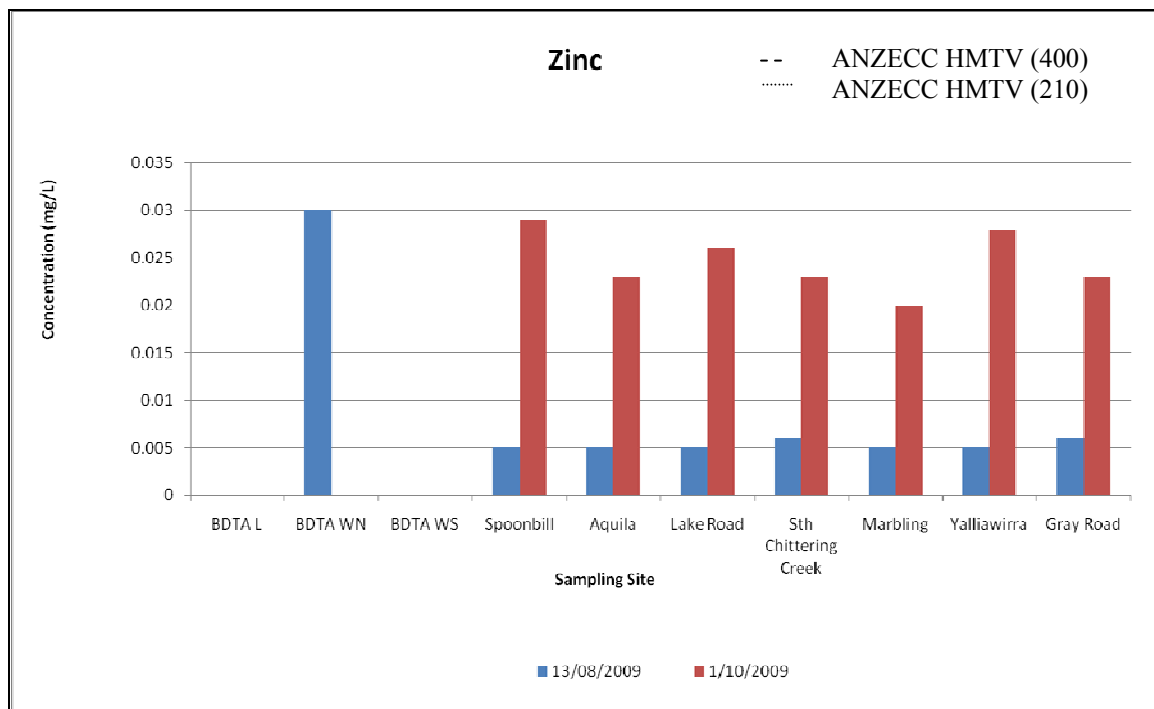


Figure 20: Zinc concentrations in surface water within the Brockman River catchment on the 13th August and 1st October 2009.

7.4.5. Copper

All sites were well below the hardness-modified trigger value (HMTV) of 0.0126mg/L except Marbling Brook (BRN23) on the August sampling occasion. Spoonbill Lake was above the HMTV of 0.007mg/L on the August sampling occasion, (Figure 21).

All sites are below the recommended ANZECC trigger value of 0.4mg/L for sheep, 1mg/L for cattle, and 5mg/L for pigs and poultry (low risk) in livestock drinking water on all sampling occasions.

Copper is used in building material, electrical and heat conductors, and in household products. It is also an essential trace element; however in sufficient amounts it can be toxic.

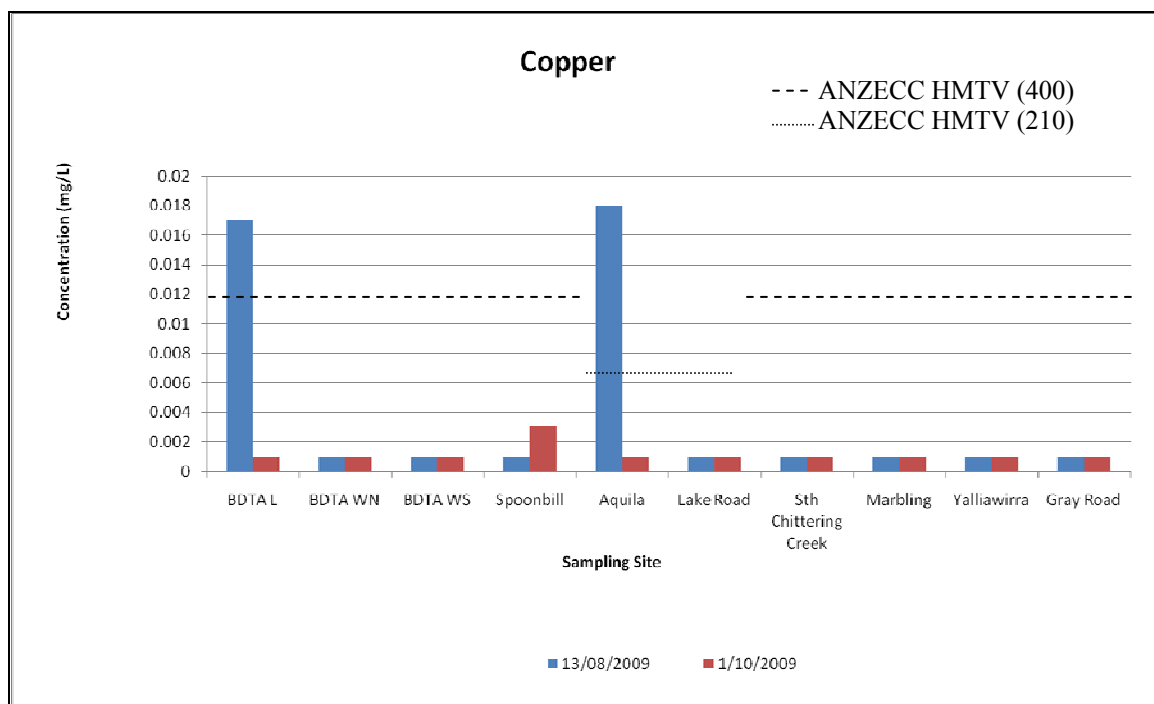


Figure 21: Copper concentrations in surface water within the Brockman River catchment on the 13th August and 1st October 2009.

7.4.6. Additional Heavy Metals

Chromium (Cr), Arsenic (As), Nickel (Ni), Lead (Pb) and Mercury (Hg) all recorded concentration levels below the relative limits of reporting (LOR) and ANZECC Trigger Values on both sampling occasions. However, cadmium (Cd) recorded a concentration of 0.0012mg/L at Lake Road during the October sampling occasion. This is significantly above the HMTV of 0.002mg/L.

8. Comparison with previous results

The Brockman River Catchment Water Quality Monitoring Snapshot September 2006 was the first snapshot developed by EBICG for this catchment. Conductivity data of the sampling sites listed in table 6 have been collected on a regular basis since 2006 by officers at the Chittering Landcare Centre. This data was collected using WTW EC meters and represents the water quality at the time of sampling only. This provides some certainty in comparing the data over the years of sampling. Table 6 provides the salinity (conductivity) of the subcatchments within the Brockman River catchment between 2006 and 2009.

Table 6: Sub catchment salinity measurement based on two-three years of data between 2006 and 2009.

Site Name	Salinity Measurement
BRN1 Murphy Gully Road	Saline
BRN2 Jackson Road	Brackish-Saline
BRN3 West Point Creek	Brackish
BRN4 Wannamal South	Brackish
BRN5 Udumung Creek	Brackish
BRN6 Kangaroo Gully Creek	Saline
BRN7 Romany Creek	Brackish
BRN8 Longbridge Creek	Brackish
BRN9 Wootra Brook	Brackish
BRN10 Bindoon River	Brackish
BRN11 Cresthill Road	Brackish
BRN12 Flat Rocks Creek	Brackish
BRN13 Spoonbill Lake	Marginal
BRN14 Aquila	Brackish
BRN15 Lake Road	Brackish
BRN16 Spice Brook	Brackish
BRN17 Toodyay Creek	Brackish
BRN18 Julimar/Chittering Bridge	Brackish
BRN19 Julimar/Chittering Tributary	Brackish
BRN20 Chittering Valley	Marginal-Brackish
BRN21 Keating Road	Brackish
BRN22 South Chittering Creek	Marginal
BRN23 Marbling Brook	Marginal-Brackish
BRN24 Moondyne	Brackish
BRN25 Yalliwirra	Brackish
BRN26 Marda Brook	Marginal
BRN27 Grey Road Bridge	Brackish

NB: The ANZECC guideline for conductivity in Lowland Rivers is 0.12mS/cm to 0.3mS/cm.

As stated in previous ‘Water Quality Snapshots’, there has been a steady increase in the salinisation of waterways within the Brockman River catchment over the past four years. Table 6 shows a direct relationship between salinity and location in the catchment where the sample has been taken. Northern sampling sites have been affected the most by salinity over the years and as the river flows southwards and receives more inflow from fresh tributaries, salinity appears to reduce (Table 6). However, without flow estimates load cannot be calculated so it is difficult to pinpoint areas of high salt input within the catchment and subsequent sites for remediation works (Angell, 2000). Salinity in the Brockman River catchment ranges from marginal-brackish at Spoonbill Lake (BRN13),

Chittering Valley (BRN20), South Chittering Creek (BRN22), Marbling Brook (BRN23) and Marda Brook (BRN26), to saline at Murphy Gully (BRN1), Jackson Road (BRN2) and Kangaroo Gully (BRN6).

pH levels in the Brockman River catchment appear to remain relatively stable, although slightly alkaline, over the years of sampling.

Nutrient concentrations in the Brockman River catchment are generally not of concern; however concentrations of Total Nitrogen (TN), Total Oxidised Nitrogen ($\text{NO}_x\text{-N/TON}$), Filterable Organic Nitrogen, Ammonia (NH_3N), and Total Phosphorous (TP) have been recorded at various sites above the ANZECC guidelines on a number of sampling occasions. This should continue to be monitored to determine whether or not the Brockman River catchment is contributing significant levels of nutrients to the Avon/Swan River.

9. Recommendations

- Continue the sampling and analysis monitoring program within the Brockman River catchment and add new sampling sites where nutrient transport or salinity is expected to be significant, or to increase the number of sampling events as funding permits.
- Identify areas of future rehabilitation, revegetation and waterway protection based on the results of the sampling program.
- Identify subcatchments which contribute significant amounts of saline water, nutrients or metals to the Brockman River, determine possible causes and conduct remediation works.
- Subcatchments have been prioritised according to water quality, surrounding land use, and influence on their immediate environment. See table below. Sub catchment scale monitoring/progress reports will be conducted on one priority sub catchment per year, commencing with priority 1 (Spoonbill) and working towards priority 14 (Keating). It is the aim of these reports to compliment existing water quality monitoring snapshots; utilise monitoring data to determine existing trends over the years of sampling; to determine the impacts of on-ground works and monitor their success; and to provide detailed information on the priority subcatchments of the Brockman River catchment.

Priority	Sub-catchment
1	Spoonbill
2	Marbling
3	Udumung
4	West Point
5	Flat Rocks
6	Blue Plains
7	Chittering Creek
8	Marda Brook
9	Murphy Gully
10	Romany Creek
11	Kangaroo Gully
12	Longbridge
13	Wootra
14	Keating

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Appendix A: Water Quality Results (raw)

Physical Parameters

SITE NAME	SITE	DATE	TEMP	pH	CONDUCTIVITY
Measurement			°C		mS/cm
WQG (Aquatic Ecosystems; upland and <i>lowland rivers</i>)				6.5-8	0.12-0.3
Murphy Gully Creek	BRN1	13/08/2009	17.3	8.3	13.38
		1/10/2009	22.8	8.192	14.04
Jackson Road	BRN2	13/08/2009	21.3	7.69	1.702
		1/10/2009	25.4	8.579	2.7
West Point Creek	BRN3	13/08/2009	18.7	7.18	0.665
		1/10/2009	15.6	7.481	0.727
Wannamal South	BRN4	13/08/2009	19.4	6.88	5.42
		1/10/2009	26.1	6.859	5.11
Udumung Creek	BRN5	13/08/2009	15.4	7.76	5.01
		1/10/2009	15.9	8.307	5.26
Kangaroo Gully Creek	BRN6	13/08/2009	17.8	7.24	5.96
		1/10/2009	20.1	7.415	6.31
Romany Creek	BRN7	13/08/2009	15.9	7.51	4.71
		1/10/2009	16	7.976	5.19
Longbridge Creek	BRN8	13/08/2009	16.9	7.53	7.3
		1/10/2009	18.6	8.167	8.71
Wootra Brook	BRN9	13/08/2009	25	7.5	6.17
		1/10/2009	18.6	8.446	6.7
Bindoon River	BRN10	13/08/2009	15.9	7.6	6.07
		1/10/2009	17.8	8.411	6.09
Cresthill Road	BRN11	13/08/2009	NS	NS	NS
		1/10/2009	NS	NS	NS
Flat Rocks Creek	BRN12	13/08/2009	20.3	7.32	6.16
		1/10/2009	19.1	7.698	5.85
Spoonbill Lake	BRN13	13/08/2009	15.8	7.11	1.387
		1/10/2009	15.6	7.126	1.435
Aquila	BRN14	13/08/2009	14.9	7.4	4.2
		1/10/2009	14	7.042	3.27
Lake Road	BRN15	13/08/2009	16.4	7.33	5.31
		1/10/2009	16.8	8.229	5.51
Spice Brook	BRN16	13/08/2009	15.6	7.82	4.17
		1/10/2009	16.4	7.792	3.5
Toodyay Creek	BRN17	13/08/2009	14.9	7.52	3.9

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		1/10/2009	14	7.492	3.28
Julimar Bridge	BRN18	13/08/2009	15.7	7.27	5.22
		1/10/2009	14.6	8.064	4.65
Julimar Tributary	BRN19	13/08/2009	15.8	7.5	4.88
		1/10/2009	15.4	8.121	4.98
Chittering Valley	BRN20	13/08/2009	15.3	7.13	2.55
		1/10/2009	12.8	7.348	2.02
Keating Road	BRN21	13/08/2009	16.1	7.2	5.01
		1/10/2009	15.8	8.045	4.39
South Chittering Creek	BRN22	13/08/2009	14	7	2.96
		1/10/2009	12.2	7.576	2.04
Marbling Brook	BRN23	13/08/2009	14.9	7.45	2.76
		1/10/2009	13.4	7.673	2.28
Moondyne	BRN24	13/08/2009	15.4	7	4.89
		1/10/2009	14.8	7.86	4.12
Yalliwirra	BRN25	13/08/2009	16.1	6.9	4.82
		1/10/2009	14.4	7.87	3.93
Marda Brook	BRN26	13/08/2009	13.9	7.07	1.036
		1/10/2009	11.4	7.803	1.16
Grey Road	BRN27	13/08/2009	16.4	7.42	5.12
		1/10/2009	17	8.4	6.27

Nutrients

SITE NAME	SITE	DATE	TSS	NOx_N	Tot N	Tot P	NH4_N	PO4_P	Org_N
Measurement			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LOR			1	0.005	0.05	0.01	0.005	0.005	0.01
WQG (Aquatic Ecosystems; upland and lowland rivers)			6		1.2	0.065			
Murphy Gully Creek	BRN1	13/08/2009	<1	0.63	1.3	0.02	0.04	<0.005	0.63
		1/10/2009	2	0.1	0.57	0.02	0.026	<0.005	0.44
Jackson Road	BRN2	13/08/2009	3	0.009	3.2	0.05	0.03	<0.005	3.2
		1/10/2009	5	0.034	1.9	0.16	0.11	0.058	1.8
West Point Creek	BRN3	13/08/2009	<1	0.087	1.9	0.05	0.082	0.011	1.7
		1/10/2009	51	0.009	1.8	0.07	0.027	<0.005	1.7
Wannamal South	BRN4	13/08/2009	1	0.076	1.5	0.08	0.08	0.034	1.3
		1/10/2009	6	0.026	1.6	0.04	0.018	<0.005	1.6
Udumung Creek	BRN5	13/08/2009	<1	2	2.2	<0.01	0.027	<0.005	0.17
		1/10/2009	<1	0.92	1.2	0.02	0.012	<0.005	0.26
Kangaroo Gully Creek	BRN6	13/08/2009	1	2.1	2.5	0.01	0.027	0.081	0.37
		1/10/2009	<1	0.82	1.1	0.08	0.019	<0.005	0.26
Romany Creek	BRN7	13/08/2009	<1	4	4.3	0.01	0.068	<0.005	0.23
		1/10/2009	2	3.2	3.2	0.04	0.012	<0.005	<0.01
Longbridge Creek	BRN8	13/08/2009	3	2.2	2.5	0.01	0.038	<0.005	0.26
		1/10/2009	3	1.2	1.2	0.02	0.034	<0.005	<0.01
Wootra Brook	BRN9	13/08/2009	9	1.3	2.4	0.02	0.022	<0.005	1.1
		1/10/2009	11	0.56	1.1	0.2	0.029	<0.005	0.46
Bindoon River	BRN10	13/08/2009	<1	0.086	0.97	0.01	0.016	<0.005	0.87
		1/10/2009	<1	0.3	0.61	0.02	0.009	<0.005	0.3
Cresthill Road	BRN11	13/08/2009	NS	NS	NS	NS	NS	NS	NS
		1/10/2009	NS	NS	NS	NS	NS	NS	NS
Flat Rocks Creek	BRN12	13/08/2009	<1	1.4	1.8	0.01	0.022	<0.005	0.38
		1/10/2009	<1	0.69	0.8	0.02	0.02	<0.005	0.09
Spoonbill Lake	BRN13	13/08/2009	<1	0.024	0.74	0.02	0.023	<0.005	0.69
		1/10/2009	<1	0.018	0.64	0.02	0.009	<0.005	0.61
Aquila	BRN14	13/08/2009	<1	0.17	0.84	0.01	0.031	<0.005	0.64
		1/10/2009	<1	0.08	0.44	0.02	0.01	<0.005	0.35
Lake Road	BRN15	13/08/2009	<1	2	3.7	0.02	0.41	<0.005	1.3
		1/10/2009	<1	0.16	0.86	0.02	0.037	<0.005	0.66
Spice Brook	BRN16	13/08/2009	2	0.2	0.73	0.01	0.034	<0.005	0.5
		1/10/2009	2	0.22	0.44	0.03	0.016	<0.005	0.2
Toodyay Creek	BRN17	13/08/2009	<1	0.22	0.8	0.01	0.021	<0.005	0.56
		1/10/2009	<1	0.3	0.63	0.03	0.029	<0.005	0.3
Julimar Bridge	BRN18	13/08/2009	25	1.8	3.2	0.01	0.36	<0.005	1

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		1/10/2009	2	0.17	0.78	0.02	0.017	<0.005	0.59
Julimar Tributary	BRN19	13/08/2009	<1	0.45	0.92	<0.01	0.039	<0.005	0.43
		1/10/2009	<1	0.16	0.5	0.03	0.017	<0.005	0.32
Chittering Valley	BRN20	13/08/2009	1	0.071	0.65	0.01	0.023	<0.005	0.56
		1/10/2009	2	0.12	0.4	0.03	0.018	<0.005	0.26
Keating Road	BRN21	13/08/2009	40	1.5	3	0.01	0.26	<0.005	1.2
		1/10/2009	18	0.15	0.61	0.03	0.02	<0.005	0.44
South Chittering Creek	BRN22	13/08/2009	<1	0.36	1	0.01	0.02	<0.005	0.62
		1/10/2009	<1	0.17	0.53	0.06	0.021	<0.005	0.34
Marbling Brook	BRN23	13/08/2009	<1	0.66	1.2	0.02	0.048	<0.005	0.49
		1/10/2009	<1	0.5	0.78	0.03	0.015	<0.005	0.27
Moondyne	BRN24	13/08/2009	32	1.6	2.6	0.02	0.15	<0.005	0.85
		1/10/2009	13	0.2	0.7	0.05	0.022	<0.005	0.48
Yalliwirra	BRN25	13/08/2009	36	1.8	2.8	0.02	0.12	<0.005	0.88
		1/10/2009	12	0.2	0.77	0.03	0.019	<0.005	0.55
Marda Brook	BRN26	13/08/2009	<1	0.99	1.6	0.02	0.041	<0.005	0.57
		1/10/2009	<1	0.25	0.65	0.03	0.023	<0.005	0.38
Grey Road	BRN27	13/08/2009	16	1.8	2.8	0.01	0.035	0.007	0.93
		1/10/2009	18	0.46	1.2	0.02	0.017	<0.005	0.68

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Heavy Metals

SITE NAME	SITE	DATE	Hardness	Al	Cr	Fe	Ni	Zn	As	Cd	Cu	Pb	Hg
Measurement			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Limit of Reporting				0.005	0.001	0.01	0.005	0.005	0.001	0.0001	0.001	0.001	0.0001
ANZECC				0.055mg/L	0.001mg/L	0.3mg/L	0.011mg/L	0.008mg/L	0.024mg/L	0.0002mg/L	0.0014mg/L	0.0034mg/L	0.0006mg/L
Spoonbill Lake	BRN13	13/08/2009	170	0.026	<0.001	0.74	<0.005	<0.005	0.001	<0.0001	0.017	<0.001	<0.0001
		1/10/2009	140	0.026	<0.001	0.49	<0.005	0.029	<0.001	<0.0001	<0.001	<0.001	<0.0001
Aquila	BRN14	13/08/2009	530	0.023	<0.001	0.17	<0.005	<0.005	0.001	<0.0001	<0.001	<0.001	<0.0001
		1/10/2009	340	0.01	<0.001	0.12	<0.005	0.023	<0.001	<0.0001	<0.001	<0.001	<0.0001
Lake Road	BRN15	13/08/2009	820	0.053	0.001	1.1	<0.005	<0.005	<0.001	<0.0001	0.001	<0.001	<0.0001
		1/10/2009	690	0.006	<0.001	0.28	<0.005	0.026	<0.001	0.0012	<0.001	<0.001	<0.0001
South Chittering Creek	BRN22	13/08/2009	420	0.13	<0.001	0.61	<0.005	0.006	<0.001	<0.0001	<0.001	<0.001	<0.0001
		1/10/2009	240	0.013	<0.001	0.27	<0.005	0.023	<0.001	0.0001	0.003	<0.001	<0.0001
Marbling Brook	BRN23	13/08/2009	360	0.17	<0.001	0.39	<0.005	<0.005	<0.001	<0.0001	0.018	<0.001	<0.0001
		1/10/2009	240	0.008	<0.001	0.13	<0.005	0.02	<0.001	0.0001	<0.001	<0.001	<0.0001
Yalliwirra	BRN25	13/08/2009	700	0.16	<0.001	0.45	<0.005	<0.005	<0.001	<0.0001	<0.001	<0.001	<0.0001
		1/10/2009	500	0.01	<0.001	0.15	<0.005	0.028	<0.001	0.0001	<0.001	<0.001	<0.0001
Grey Road	BRN27	13/08/2009	800	0.51	<0.001	0.49	<0.005	0.006	0.001	<0.0001	<0.001	<0.001	<0.0001
		1/10/2009	860	0.011	<0.001	0.04	<0.005	0.023	<0.001	0.0001	<0.001	<0.001	<0.0001

* Note: '<' represents a value below the limit of reporting.

Appendix B – Freshwater Trigger Values and Guidelines

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

Guideline	EC mScm	D0 % Sat	pH	Temp °C	TN mg/L	NO _x N mg/L	TP mg/L	FRP mg/L
ANZECC Water Quality Guideline – Recreational (2000)	-	>80 (>6.5 mg/L)	6.5-8.5	-	-	10	-	-
ANZECC Water Quality Trigger Values - lowland river (2000)	0.12-0.3	80-120	6.5-8.0	-	1.2	0.150	0.065	0.04
ANZECC Water Quality Guidelines – Freshwater (1992)	-	>80-90 (>6mg/L)	6.5-9.0		<2 increase	20-30	0.01-0.1	-

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

* Trigger values not corrected for hardness, ID = insufficient data to have ANZECC water quality guideline

Guideline	As mg/L	Cr mg/L	Cu* mg/L	Fe mg/L	Mo mg/L	Mn mg/L	Ni* mg/L
ANZECC Water Quality Guidelines – Recreational (2000)	0.05	0.05	1	0.3	ID	0.1	0.1
ANZECC Water Quality Trigger Values Freshwater 99% (2000)	0.001	0.00001	0.001	ID	ID	1.2	0.008
ANZECC Water Quality Trigger Values Freshwater 95% (2000)	0.024	0.001	0.0014	ID	ID	1.9	0.011
ANZECC Water Quality Trigger Values Freshwater 90% (2000)	0.094	0.006	0.0018	ID	ID	2.5	0.013
ANZECC Water Quality Trigger Values Freshwater 80% (2000)	0.360	0.04	0.0025	ID	ID	3.6	0.017
ANZECC Water Quality Guidelines – Freshwater (1992)	0.05	0.01	0.002-0.005	ID	ID	ID	0.015-0.15
Limit of reporting	0.001	0.001	0.001	0.01	0.005	0.001	0.001

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

* Trigger values not corrected for hardness, ID = insufficient data to have ANZECC water quality guideline

Guideline	Pb* mg/L	Sn	Sr mg/L	Ti mg/L	V mg/L	Zn* mg/L
ANZECC Water Quality Guidelines – Recreational (2000)	0.05	ID	ID	ID	ID	5
ANZECC Water Quality Trigger Values Freshwater 99% (2000)	0.001	ID	ID	ID	ID	0.0024
ANZECC Water Quality Trigger Values Freshwater 95% (2000)	0.0034	ID	ID	ID	ID	0.008
ANZECC Water Quality Trigger Values Freshwater 90% (2000)	0.0056	ID	ID	ID	ID	0.015
ANZECC Water Quality Trigger Values Freshwater 80% (2000)	0.0094	ID	ID	ID	ID	0.031
ANZECC Water Quality Guidelines – Freshwater (1992)	0.001-0.005	ID	ID	ID	ID	0.005-0.05
Limit of reporting	0.001	0.05	0.001	0.01	0.002	0.001

Appendix C – Salinity measurements and tolerance limits

Salt Measurement Conversions					
mS/cm	mS/m	ppm,mg/L	ppt	gr/gal	
0	0	0	0	0	distilled water
0.1	10	55	0.06	4	
0.2	20	110	0.11	8	
0.3	30	165	0.17	12	
0.4	40	220	0.22	15	
0.5	50	275	0.28	19	FRESH
0.6	60	330	0.33	23	
0.7	70	385	0.39	27	
0.8	80	440	0.44	31	
0.9	90	495	0.50	35	
1.0	100	550	0.55	39	maximum stonefruit, citrus, peas, onion, carrot
1.5	150	825	0.83	58	
2.0	200	1100	1.10	77	
2.5	250	1375	1.38	96	
2.7	273	1500	1.50	105	
3.0	300	1650	1.65	116	MARGINAL
3.5	350	1925	1.93	135	
4.0	400	2200	2.20	154	
4.5	450	2475	2.48	173	
5.0	500	2750	2.75	193	
5.5	550	3025	3.03	212	maximum for people, grapes, tomato, lettuce
6.0	600	3300	3.30	231	
6.5	650	3575	3.58	250	
7.0	700	3850	3.85	270	
7.5	750	4125	4.13	289	
8.0	800	4400	4.40	308	BRACKISH
8.5	850	4675	4.68	327	
9.0	900	4950	4.95	347	
9.1	910	5005	5.01	350	
9.5	950	5225	5.23	366	
10.0	1000	5500	5.50	385	maximum for milk cows and poultry, olives, figs
10.5	1050	5775	5.78	404	
11.0	1100	6050	6.05	424	
11.5	1150	6325	6.33	443	
12.0	1200	6600	6.60	462	
12.5	1250	6875	6.88	481	maximum for horses
13.0	1300	7150	7.15	501	
13.5	1350	7425	7.43	520	
14.0	1400	7700	7.70	539	
14.5	1450	7975	7.98	558	
15.0	1500	8250	8.25	578	SALINE
15.5	1550	8525	8.53	597	
16.0	1600	8800	8.80	616	
16.5	1650	9075	9.08	635	
17.0	1700	9350	9.35	655	
17.5	1750	9625	9.63	674	maximum septic Tanks
18.0	1800	9900	9.90	693	
18.5	1850	10175	10.18	712	
19.0	1900	10450	10.45	732	
19.5	1950	10725	10.73	751	
20.0	2000	11000	11.00	770	maximum beef cattle
20.5	2050	11275	11.28	789	
21	2100	11550	11.55	809	
21.5	2150	11825	11.83	828	
22	2200	12100	12.10	847	
22.5	2250	12375	12.38	866	maximum sheep
23	2300	12650	12.65	886	
23.5	2350	12925	12.93	905	
24	2400	13200	13.20	924	
24.5	2450	13475	13.48	943	
25	2500	13750	13.75	963	sea water
30	3000	16500	16.50	1155	
53	5300	29150	29.15	2041	
64	6400	35200	35.20	2464	
11.97	1197	6584	6.58	461	

Measurement Units

mS/cm = millisiemens per cm
mS/m = millisiemens per metre
ppm = parts per million
mg/L = milligrams per litre
gr/gal = grains per gallon

Conversion Factors

mS/m x 100 = mS/cm
mS/m x 5.5 = mg/L
mS/m x 0.385 = gr/gallon
mS/m x 10 = EC uS/cm
gr/gall x 14.25 = mg/L

Appendix D - Hardness-Modified Trigger Value calculations based on varying water hardness (Table 3.4.4. ANZECC & ARMCANZ, 2000).

Hardness category (mg/L as CaCO₃)	Water Hardness (mg/L as CaCO₃)	Cd (mg/L)	Cr(III) (mg/L)	Cu (mg/L)	Pb (mg/L)	Ni (mg/L)	Zn (mg/L)
Soft (0-59)	30	TV	TV	TV	TV	TV	TV
Moderate (60-119)	90	*2.7	*2.5	*2.5	*4	*2.5	*2.5
Hard (120-179)	150	*4.2	*3.7	*3.9	*7.6	*3.9	*3.9
Very Hard (180-240)	210	*5.7	*4.9	*5.2	*11.8	*5.2	*5.2
Extremely Hard (400)	400	*10	*8.4	*9	*26.7	*9	*9

Appendix E - Sampling and Analysis Plan

Brockman River Catchment Water Quality Monitoring Snapshot July and September 2009



Plate 1: Julimar Tributary, Brockman River catchment (2007).

Prepared by Ellen Brockman Integrated Catchment group: March 2009



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1. Background

The Brockman River catchment is located to the north-east of the Perth Metropolitan area in the south-west of Western Australia (Figure 22). The catchment covers an area inclusive of sixty-eight subcatchments, incorporating the townships of Bindoon and Wannamal (WRC, 2002). The greatest part of the catchment lies within the Shire of Chittering, with the remainder falling within the shires of Victoria Plains, Toodyay, Swan and Gingin (Figure 23). Other localities within the catchment include Mooliabeenie, Lower Chittering, Maryville Downs and South Chittering.

The catchment stretches across 1520 square kilometres and is the largest catchment of the lower Avon and upper Swan catchments. The Brockman River is approximately 90 kilometres in length and flows through the Chittering Valley along the Darling Scarp. The main issues within the catchment include a deteriorating natural resource base due to widespread clearing of native vegetation and an increased economic pressure on agricultural land to be more productive. This has resulted in increased salinity, waterlogging, soil erosion, sedimentation, eutrophication, overgrazing, weed invasion and pest animals. These cumulative impacts have an offsite effect on the Brockman River and local wetland systems, and ultimately the Avon-Swan River.

Monitoring involves observations and measurements that are analysed and reported for the purpose of providing information and knowledge about catchments and waterways (DoW, 2006). With support from Tiwest Joint Venture and the Department of Water (DoW), the Ellen Brockman Integrated Catchment Group commenced an annual sampling program focusing on nutrients, physical parameters and total suspended solids at 25 sites within the Brockman River catchment in 2006 and 2007. Water samples collected from seven of the twenty-five strategically selected sampling sites were also analysed for heavy metals. Sampling was conducted once during spring flow (September). However, due to funding provided by Tiwest, sampling in 2007 involved the addition of the 'Marda Brook' sampling site and a second sampling occasion commencing with the first consistent flow (Figure 25). The 2009 sampling program will reflect that of 2007 and 2008 with the sampling of twenty-six sites over two days on two occasions to capture the first consistent flow and the spring flow. Heavy metals will be sampled at seven sites on both sampling occasions. Additionally,

the sampling of Grey Road (BRN27) will replace Cresthill Road (BRN11) for the 2009 sampling program to monitor the adjacent subdivision.

The aim of this sampling and analysis plan is to provide a report on the development of the Brockman River water quality monitoring program, to ensure that sampling is conducted according to the relevant guidelines, ensuring that data standards are met and data quality continuity maintained (DoW, 2006). The aim of sampling from twenty-six strategically identified sites along the Brockman River is to determine the priority sub-catchments, which are those that are contributing levels of nutrients and heavy metals in concentrations above the ANZECC Water Quality Guidelines. The SAP and the sampling program will also help to establish baseline data for surface water quality within the catchment, and enable the identification of trends and emergent trends.



Figure 22: Sub-catchments within the Swan-Canning Catchment (WRC, 2003).

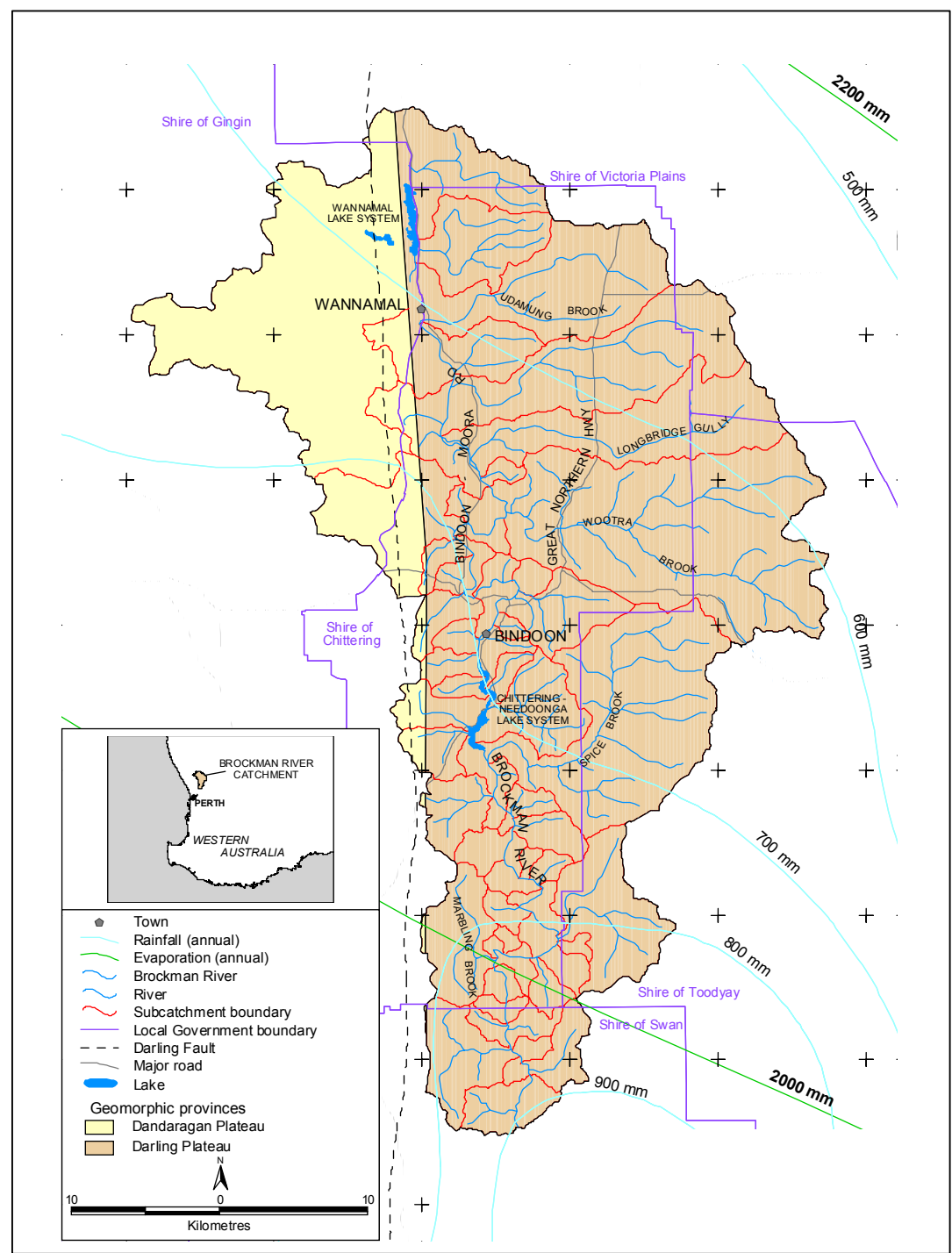


Figure 23: Brockman River Catchment (WRC, 2003).

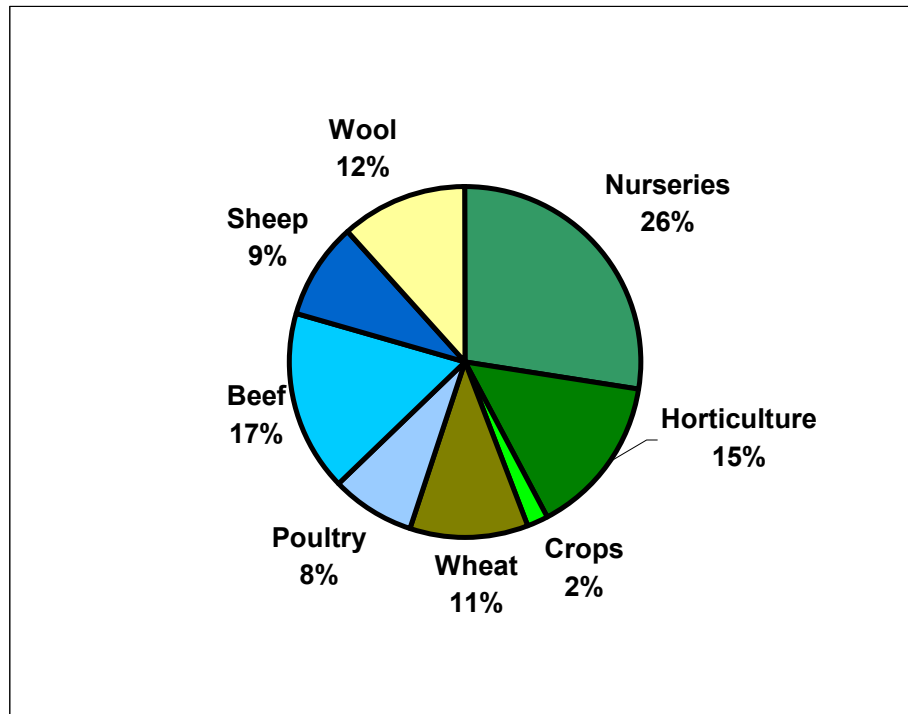


Figure 24: Proportion of Gross Value of Agricultural Production (GVAP) (Total \$23 million) by commodity: 1996/97. (Cook and Hatherly, 1997).

2. Changes to the project

This project commenced in 2006, please refer to the sampling and analysis plan (latest version/highest number) for details of the sampling for that year.

In 2007 the following changes were made to the project:

- Sampling frequency was increased from a one off event in 2006 to two events in 2007, one being conducted with the onset of winter rains and the second being undertaken during spring flows.
- Due to reduced budget DOW could not fund the analysis of samples at NMI laboratories; as a result EBICG sent the samples to MPL for analysis, through their funding arrangement with Tiwest.
- Site BRN 26 (Marda Brook) was added to the project, as it was considered a possible source of heavy metals and nutrients to the Brockman River. Analysis on water collected from that site was carried out for the following total heavy metals Ag, Al, B, Ba, Be, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Si, Sn, Sr, Ti, Tl, V, Zn, Hg, As, Pb, Sb, Se & Cr(VI) as well as total water hardness, total suspended solids, total phosphorous , total nitrogen, total oxidised nitrogen, soluble reactive phosphorous, dissolved organic nitrogen, and nitrogen as ammonia/ammonium.
- Samples were collected from a total of eight sites and analysed for total water hardness and for heavy metals (listed above) in 2007. Those sites were BRN 5, 19-23, 25 & 26 and 28.
- Water samples were also collected from the bottom of catchment site (BRN 25) for analysis for total and dissolved organic carbon.

In 2008 the following changes were made to the project:

- Site BRN 27 (Grey Road) was added to the project.
- Site BRN 11 (Bridge on Cresthill Road over the Brockman River) was removed from the project.

In 2009 the following changes were made to the project:

- Heavy metal concentrations were found to be insignificant at the sampling sites identified in 2007 and 2008, therefore, the following sampling sites have replaced previous years sampling sites;

2008 Sampling Sites for Heavy Metals	2009 Sampling Sites for Heavy Metals
BRN 5 Udumung	BRN13 Spoonbill Lake
BRN19 Julimar Tributary	BRN14 Aquila, Hart Drive
BRN20 Chittering Valley	BRN15 Lake Road
BRN21 Keating Road	BRN22 South Chittering Creek
BRN23 Marbling Brook	BRN23 Marbling Brook
BRN25 Yalliwirra	BRN25 Yalliwirra
BRN27 Grey Road Bridge	BRN27 Grey Road Bridge
BRN26 Marda Brook	Removed

3. Sampling Site Location

Water samples will be taken from twenty-six sites within the Brockman River catchment (Figure 25). These sites have been selected to be representative of a particular part of the catchment; to determine their relative nutrient and metal contribution to the Brockman River; and whether they are situated upstream or downstream of potentially high impact land uses or of likely contaminant sources. Table 1 lists the sampling sites by site number, site name and relative waterway component. Site location is also provided using street names, northings and eastings.

4. Sampling frequency

Initial sampling will take place in early winter (August). Timing will be dependent on consistent rainfall and flow. The second and final sampling occasion will be conducted during spring flow (September/October). Water will be analysed for heavy metals on both occasions from Spoonbill Lake (BRN13), Aquila (BRN14), Lake Road (BRN15), South Chittering Creek (BRN22), Marbling Brook (BRN23), Yalliwirra (BRN25) and Grey Road Bridge (BRN27).

Table 7: Location and description of selected sampling sites within the Brockman River catchment.

Site No.	Site name	Description of waterway (inc. old site number)	Easting	Northing
BRN1	Murphy Gully Creek	BR22 - Bindoon Moora Rd	409205	6561412
BRN2	Jackson Road (Wannamal Lake outlet)	BR21 - Jackson Road	409457	6555480
BRN3	West Point Creek	BR20 - West Point	409754	6555706
BRN4	Wannamal South	Wannamal South Road	407596	6552244
BRN5	Udumung Creek	BR18 - Hay Flat Road	410373	6551048
BRN6	Kangaroo Gully Creek	BR17A - Bindoon Moora Rd	412741	6547952
BRN7	Gooninong Romany Creek	BR17 - Waldeck West Road - Romany Creek	413360	6546355
BRN8	Longbridge Creek	BR16A - Ashman Rd to gate (2km) over fence & nth on fire break	414649	6542478
BRN9	Wootra Brook	BR15 - Owen's Road	416762	6537439
BRN10	Bindoon River	BR15A - Great Northern Highway small bypass road bridge	417372	6531777
BRN12	Flat Rocks Creek	Densley Road (off Flat Rocks)	415077	6524296
BRN13	Spoonbill Lake	BR12 - spillway from Spoonbill Reserve	412361	6523223
BRN14	Aquila, Hart Drive	BR12A - Flows through Aquila Reserve	412306	6522632
BRN15	Lake Road Brockman River	BR9 - Bridge on Lake Road below Lake Weir	414090	6521308
BRN16	Spice Brook	BR11A - off Lake Road across paddock to bridge	414509	6521156
BRN17	Toodyay Creek Toodyay Creek	100m north of Blue Plains Road on Chittering Road	414561	6518111
BRN18	Julimar/Chittering Bridge Brockman River	BR5 - Julimar Rd/Chittering Rd intersection	415996	6515275
BRN19	Julimar/Chittering Tributary Julimar Rd Creek	BR8 - Julimar Rd (500m up from intersection Chittering Rd)	417103	6515877
BRN20	Chittering Valley	Cnr Chittering Valley and Chittering Road	416288	6510308
BRN21	Keating Road	BR4 - 500m east on Keating Road to gateway - Bitney Springs	419248	6508210
BRN22	South Chittering Creek	Chittering Road just north of Wilson Road	415559	6500608
BRN23	Marbling Brook	Bridge on Chittering Road	414704	6506641
BRN24	Moondyne Brockman River	BR2 - from crossing	416623	6499996
BRN25	Yalliawirra Brockman River	BR1 Gauging Station	416450	6495160
BRN26	Marda Brook	Smith Road bridge/gate	414266	6496860
BRN27	Grey Road Bridge	Brockman River	413885	6528696

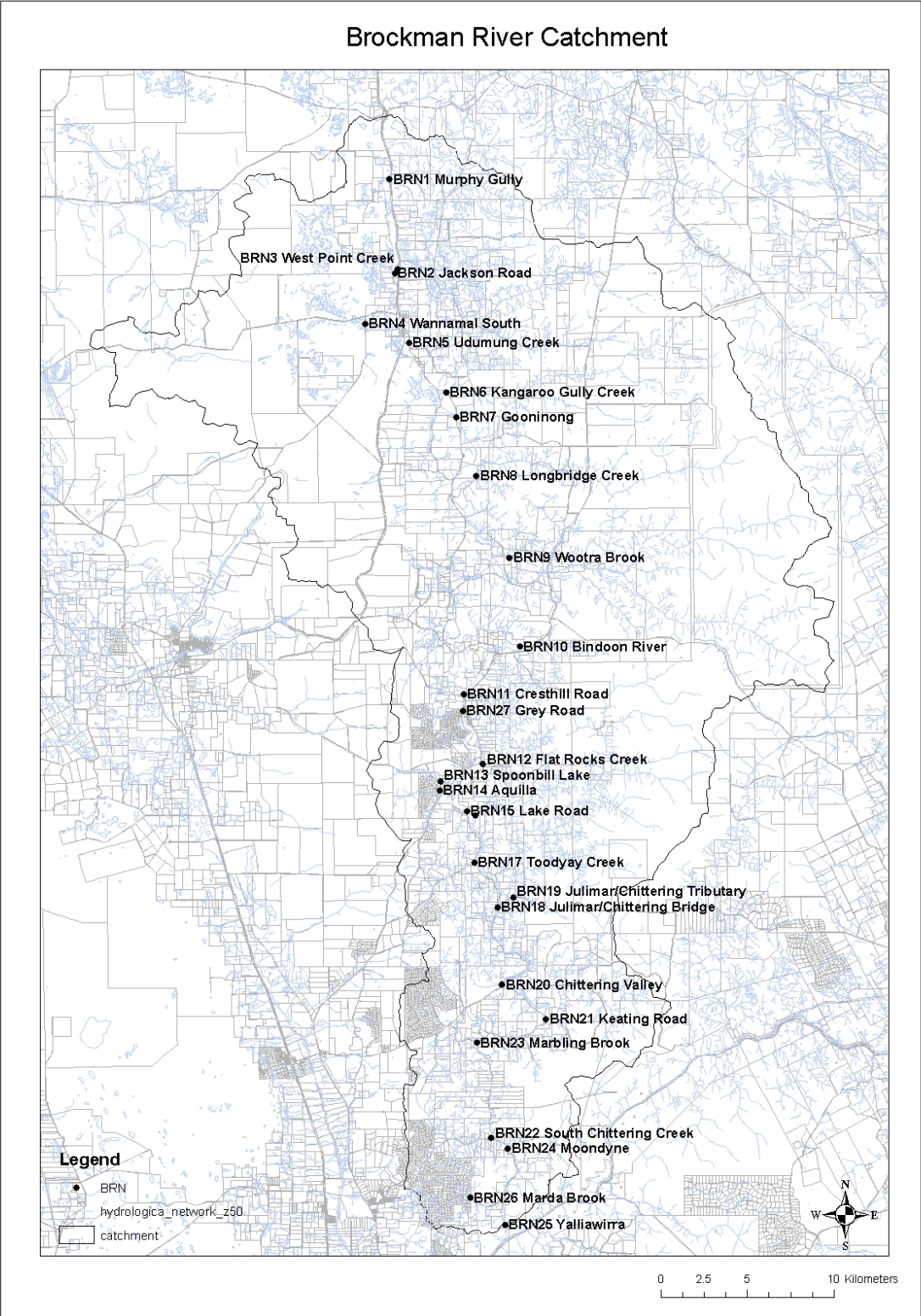


Figure 25: Sampling site locations within the Brockman River Catchment 2008.

5. Measured parameters

The twenty-six selected sampling sites will be analysed in the field using pH and salinity meters. Dissolved oxygen in milligrams per Litre (mg/L) and percentage saturation (%) will not be sampled in 2009 due to a lack of equipment.

These sites will also be sampled for the analysis of nutrients including Total phosphorous (TP), Total nitrogen (TN), Total oxidised nitrogen (TON), Soluble reactive phosphorous (SRP), Dissolved organic nitrogen (DOrgN), and Nitrogen as ammonia (NH₄-N), Dissolved organic carbon, Total organic carbon, Total suspended solids, Total water hardness and total heavy metals including iron, aluminium, copper, arsenic, lead, nickel, zinc, chromium, mercury and cadmium. Refer to Appendix A for a tabular format of the selected parameters to be measured in surface waters within the Brockman River catchment.

6. Quality Assurance and Quality Control

It is important to collect quality control samples as firm conclusions cannot be drawn from sampling data unless the quality of the data is known. The number and the types of quality control samples depend on the final use of the data, as well as the amount of time and money available for the monitoring program (DOW). This monitoring program will include one field blank and one replicate taken on one sampling occasion to ensure quality assurance and quality control of water quality data.

6.1. Blank Samples

Blanks are clean samples of deionised or distilled water, introduced at various stages of sampling. They are collected to detect and measure contamination in the sampling process as a result of ineffective field procedures, containers, equipment and transport. Often it is not possible to achieve absolutely no contamination, but rather only stable, minimal contamination levels. You need to set acceptable limits for these contamination levels, and when blanks are collected that fall outside this, you have a contamination issue that will require further investigation (DOW).

6.2. *Field Blanks (FB)*

Extra containers are taken to the site. Take a stock container of deionised/distilled water. On site, containers are opened and closed and the contents handled just as if these were normal samples being collected during transfer and storage, except they are filled with deionised/distilled water (leave or add appropriate preservative in the bottle if required—depending on which parameters the field blank is checking). These detect mainly contamination of sample during the collection procedure. Ideally at least one of these is collected per sampling team, per sampling trip, for all measured analytes (DOW).

6.3. *Replicates Samples (RS)*

Replicate samples are two or more samples collected from the same site and time, using exactly the same method. They can indicate the natural variations in the environment and variations caused by the field sampling method. It provides the experimental error and thus a measure of sampling accuracy. Two replicates will only indicate that variation exists (if there is any) but three replicates will enable some assessment of precision and bias (DOW).

7. Standard Operating Procedures

To reduce contamination of samples with disturbed sediment, sampling is to begin at the most downstream site within the catchment and to be continued upstream. Physical parameters will be measured using WTW pH and EC probes while the water samples are collected. Calibration of the logger will need to occur prior to and at the end of the sampling with all calibration records kept in a logbook.

Grab surface water samples for chemical analysis of nutrients and heavy metals is collected just below the surface, avoiding any surface scums or debris (DoW, 2006a). Measuring of physical parameters, direct sampling and taking filtered samples are to be conducted using the ‘Guideline for Field Sampling for Surface Water Quality Monitoring Programs’, by the Water Science Branch, Department of Water (2006a).

7.1. *Physical Parameter Sampling (DoW, 2006a).*

- Lower the clean, maintained and calibrated data logger into the water body near or at the same site where the water samples were taken. Minimise disturbance to the sediment.
- Ensure that all probes are fully submerged. Ideally the probes should be approximately 10cm under the water surface and 10cm above the sediment.
- The probes should be kept in a gentle motion while taking care not to stir up the sediments.
- If the probe has a built in circulator ensure this is turned on.
- Allow sufficient time for the probe to stabilise, and then take the readings.
- Store the physical results electronically on the instrument's console, and on the Field Observation Form.

7.2. *Grab Pole Sampling (DoW, 2006a)*

- Ensure that labelling on the bottle to be filled is correct and that the sample number matches the number on the paperwork (Field Observation Form and Chain of Custody form).
- Check that the grab pole sampler is clean.
- Extend the pole sampler so that it will reach the point that you wish to sample.
- Lower the grab sampler into the water with the mouth of the bottle facing upstream into the flow of water to a depth of 15cm. Keep the bottle moving forwards, into the flow of water whilst it is filling (Standards Australia AS/NZS 566.6:1998 5.3.1).
- Allow to partially fill, take the bottle out of the water, swirl around and tip out the rinsate downstream of sampling site.
- Repeat two more times so that the grab pole sampler has been rinsed three times.
- Then, fill the grab sampler at a depth of 15cm, with the mouth of the bottle facing upstream, slowly moving the bottle forward, into the flow of water.
- Use this sample to rinse the labelled sample container three times. Cap, shake well, and pour the rinsate downstream of yourself.

- Remove the cap from the sample container only at the time of sampling and replace the cap immediately after collection of the sample.
- Fill the bottle to the shoulder.
- Metal samples do not require nitric acid in the sample bottles as the laboratory nitrifies the water sample in the lab.
- Do not touch the opening of the sample container with any part of the grab pole bottle or your hands as this can introduce contaminants.
- Cap and store the sample container in an ice-esky overnight. The samples will be delivered (chilled) to TiWest where a courier will pick them up and deliver them to MPL laboratory the following day.

7.3. Filtering a Nutrient Sample

Refer to DoW (2006a) for details on setting up a Filter Tower.

- Shake the sample gently before filtering.
- Pour a small amount of the sample into the top of the cleaned and assembled filter tower.
- Use the vacuum pump and the rubber bung.
- Swirl the filtered sample by carefully pouring it through both vacuum ports.
- Put the rubber bung back on and reattach the pump.
- Pour the required amount of sample plus a bit extra (for rinsing the sample container) into the top of the filter tower.
- Use the vacuum pump to filter the sample.
- Once the sample is filtered remove the vacuum from the collection chamber.
- Pour a small amount of the filtered sample into the pre-labelled sample container.
- Remove the cap from the sample container only at the time of sampling and replace the cap immediately after collection of the sample.
- Cap, swirl around the filtrate and discard.
- Repeat twice to ensure that the sample container is well rinsed.
- Fill the labelled sample container with the filtrate to the required level.
- Cap and store the sample container in an esky on ice-bricks.

7.4. *DOC/TOC Sampling*

- Rinse both DOC and TOC sample bottles three times prior to filling.
- When filling the bottles fill all the way to the top (i.e. leave no air bubble).
- As a standard use a filter tower to filter your sample.

8. Sampling operation requirements

Table 8: Measurement parameters analysed at a given number of sites on two sampling runs.

Sample Run	Field personnel	Number of sites	Measurement parameters
1	Bonny Dunlop	26/26 (BRN 1 -26)	<u>Water</u> Nutrients, physical properties total suspended solids
	Amy Salmon	1/26 (BRN 25)	TOC/DOC
		7/26 (BRN 13,14,15,22,23,25 & 27).	Heavy Metals and total water hardness (from TSS)
2	Bonny Dunlop	26/26 (BRN 1 -26)	<u>Water</u> Nutrients, DOC, TOC, physical properties and total suspended solids
	Amy Salmon	1/26 (BRN 25)	TOC/DOC
		7/26 (BRN 13,14,15,22,23,25 & 27).	Heavy Metals and total water hardness (from TSS) Field Blank and Replicate

9. Sample bottle requirements

Table 9: Number of bottles required to sample for all identified measurement parameters, field blanks and replicates.

Matrix	Parameters	Bottle type	Sites	Sampling events	Samples/site	Duplicates	Field blanks	Total bottles
Water	Total Nutrients and TSS	500ml HDPE	26	2	1	1	1	54
Water	Dissolved Nutrients	500ml HDPE	26	2	1	1	1	54
Water	Heavy metals	500ml HDPE	7	2	1	1	1	16
Water	Total Water Hardness	500ml HDPE	7	2	1	1	1	16
Water	Total Organic Carbon	500ml HDPE	1	2	1			2
Water	Dissolved Organic Carbon	500ml HDPE	1	2	1			2
Water	Physical parameters	N/A – insitu						

10. Labelling

The sample containers should be labelled with sequential sample registration number, the date of collection, the type of preservation (if any) and the client identification. Water samples are to be accompanied by field notes, field observation forms and chain of custody forms.

The sample bottle will be labelled prior to the time of sampling and collection in the field to ensure efficiency and organisation.

Sample number	200638340
Date	22/08/2009
Parameters	Nutrients & TSS
Agency	EBICG/Tiwist

Figure 26: Example of bottle label

11. Personal Safety

A separate safety plan will be prepared and approved by representatives of the Department of Water and the Ellen Brockman Integrated Catchment Group prior to field sampling. Field sampling should not commence until the safety plan has been signed off by all parties involved in the sampling. The safety plan will indicate all areas of potential risk to personnel before, during and after the sampling, and develop specific strategies to minimise the risk.

12. MPL Laboratory

MPL Laboratory is an accredited analytical laboratory which has been identified to analyse the water samples for the Brockman River catchment water quality monitoring program.

Table 10 provides information on the analytical methods and limits of reporting, which are used by the laboratory. Following analysis MPL must produce a laboratory report which must provide details on the following in both electronic and final laboratory reports:

- Date and time of sample analysis
- Method code and description
- All laboratory Quality Control results including analyte recovery, accepted recovery range, lab blanks, lab duplicates, lab blank spike recovery, matrix spike recovery.

13. Analytical Methods and Limit of Reporting (LOR) for MPL Laboratory

Table 4 provides the MPL Laboratory method codes and limits of reporting (mg/L) for the measurement parameters selected for the Brockman River catchment sampling program. The measurement parameters cannot be detected below these limits provided.

Table 10: Analytical methods and limit of reporting (LOR) for MPL Laboratories

Variable List	Limit of Reporting (LOR)	Variable Unit	Analysis Technique	Lab Reference- WILAB (based on APHA)
Cond (Comp25)	1	uS/cm	direct read	5
pH	0.05		direct read	5
TSS	1	mg/L	grav	5
PO4-P	0.003	mg/L	DA	18
NOx-N	0.005	mg/L	DA	18
NH4-N	0.005	mg/L	DA	18
DOrgN	0.05	mg/L	Combustion	10
TP	0.01	mg/L	DA	18
TN	0.05	mg/L	DA	18
Na	1	mg/L	ICP OES	17
K	0.1	mg/L	ICP OES	17
Ca	0.1	mg/L	ICP OES	17
Mg	0.1	mg/L	ICP OES	17
DOC	1.0	mg/L	NIR	10
TOC	1.0	mg/L	ICP OES	18/5
Hard	1	mg/L	ICP OES	17
Al	0.005	mg/L	ICP OES	17
Cd	0.001	mg/L	ICP OES	17
Cr	0.001	mg/L	ICP OES	17
Cu	0.005	mg/L	ICP OES	17
Fe	0.01	mg/L	ICP OES	17
Ni	0.005	mg/L	ICP OES	17
Zn	0.005	mg/L	ICP OES	17
Hg	0.0001	mg/L	CV AAS	6
As	0.001	mg/L	GFAAS	6
Pb	0.001	mg/L	GFAAS	6

14. Sending samples to the laboratory

Collected samples will be stored in an esky chilled to 4 °C with ice bricks out in the field and overnight, as the sampling will be conducted over 2 days. The samples will be delivered to Tiwest on the afternoon of the second day. A courier will pick the samples up the following day and deliver them (chilled) to MPL laboratory for analysis. A completed chain of custody (COC) must be included in the esky for the laboratory and a copy kept at the Chittering Landcare Centre. Turnaround time is 10 days from sample date to completion of analysis.

Once the samples are received the results will be emailed directly to the Chittering Landcare Centre and to 'data in' at Water Measurement and Information Branch, Department of Water.

15. Management and Reporting of data

The sampling program and sampling sites will be registered with the Water Information Branch (WIN database managers) of the Department of Water. Water samples collected from the Brockman River catchment will be sent for analysis to MPL Laboratories, a laboratory accredited by the National Association of Testing Authorities (NATA). Analytical results will be returned to the Chittering Landcare Centre and to the Water Information Branch of the Department of Water to be entered onto their publicly accessible Water Information database (WIN). The water quality monitoring results will be collated, analysed and published as a Water Quality Snapshot Report for the Brockman River, where data will be compared to previous years sampling.

16. Comparison of Results with Guidelines

Water quality results of the Brockman River catchment sampling and analysis program will be compared to the Australian and New Zealand Water Quality Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000). This guideline provides trigger values for both ecosystems and human health protection, as well as the following environmental values: aquatic ecosystems; primary industries; recreation and aesthetics; and drinking water. This snapshot will compare the results to the guideline trigger values for aquatic ecosystems and for livestock drinking water where appropriate.

The Guidelines recognise three levels of protection for aquatic ecosystems: areas which 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 protection levels described above. Exceedance of the trigger value indicates that there is the *potential* for an impact to occur and should thus trigger a management response such as further investigation and possible remediation, or adaptation of the guidelines according to local conditions (ANZECC & ARMCANZ, 2000).

17. Roles and Responsibilities

- Ellen Brockman Integrated Catchment Group (EBICG)/Chittering Landcare Centre will have overall responsibility for this project.
- The Water Science Branch of the Department of Water and the Swan Catchment Council are responsible for assisting with the preparation of the SAP, registering new sampling sites, providing advice regarding the sampling program and the preparation of the report of the results.
- Tiwest will be responsible for provision of sample bottles, delivery to laboratory and analysis costs of the samples.

18. Costs of the Brockman River catchment sampling program

Table 11: Costs of water quality sampling of the Brockman River catchment in 2009 with MPL on two sampling occasions.

Parameter	Number of Sites	Number of Sampling Occasions	Cost of Analysis (\$)	Total Cost of Sampling (\$)
Nutrients	26	2	85.35	4438.2
<i>TSS</i>	26	2	<i>13</i>	
<i>TN</i>	26	2	<i>16.4</i>	
<i>TP</i>	26	2	<i>13.5</i>	
<i>Ammonia-N</i>	26	2	<i>9.75</i>	
<i>Nox-N (Total Ox N)</i>	26	2	<i>8.15</i>	
<i>SRP</i>	26	2	<i>8.15</i>	
<i>DOrganicN</i>	26	2	<i>16.4</i>	
<i>TorganicN</i>	26	2	<i>0 (Calculated)</i>	
Setup Cost		2	12.45	24.9
Metals	7	2	62.5	875
Setup Cost		2	14.15	28.3
<i>Al</i>	7	2	<i>6.25</i>	
<i>As</i>	7	2	<i>6.25</i>	
<i>Cd</i>	7	2	<i>6.25</i>	
<i>Cr</i>	7	2	<i>6.25</i>	
<i>Cu</i>	7	2	<i>6.25</i>	
<i>Fe</i>	7	2	<i>6.25</i>	
<i>Hg</i>	7	2	<i>6.25</i>	
<i>Ni</i>	7	2	<i>6.25</i>	
<i>Pb</i>	7	2	<i>6.25</i>	
<i>Zn</i>	7	2	<i>6.25</i>	
Total Water Hardness	7	2	13	182
DOC/TOC	1	2	69	138
Blanks		1	187.45	187.45
Replicates		1	187.45	187.45
Administration Fee		2	30.83	61.66
Total				6123

Table 12: Budget for the 2009 Brockman River catchment monitoring project.

Item	Days	People	Salary/annum	Cost
SALARY COSTS				
1. Preparation of SAP	1	1	\$59,750	\$229
2. Sampling preparation	1	2	\$59,750	\$458
3. Sample collection	4	2	\$59,750	\$1838.45
4. Data management (site & program registration, data entry, verification/validation)	2	1	\$59,750	\$458
5. Preparation/assistance with Report	5	2	\$59,750	\$2,290
6. Travel costs/courier costs	-	-	-	\$260
CONSUMABLE COSTS				
1. Analysis costs – Brockman River Monitoring Program 2009	-	-	-	\$6123
TOTAL				\$12,347

19. References

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- PPK Environment & Infrastructure (2000). *Ellen Brook Draft Catchment Management Plan* in association with Acacia Springs Environmental, Land Assessment, Hames Sharley, ERM Mitchell McCotter and V & C Semeniuk Research Group.

Appendix A: Analysis Requirements

(To be attached to all COC forms)

Project: SG-C-BROCKMANWQ

COC numbers: _____

Group	Analytes	Special instructions
A	Dissolved Nutrients:	To be reported at standard LORs
	Total Nitrogen	0.05mg/L
	Total oxidised nitrogen	0.01 mg/L
	Nitrogen as ammonia	0.01 mg/L
	Total Phosphorous	0.01mg/L
	Soluble reactive phosphorus	0.005 mg/L
	Dissolved organic nitrogen	0.025 mg/L
B	Total heavy metals:	To be reported at limits of reporting for analysis using ANZECC guideline trigger values:
	Cd & Hg	0.1 µg/L (0.0001 mg/L)
	As, Cu, Pb & Zn	1.0 µg/L (0.001 mg/L)
	Al, Cr, Fe, & Ni	5.0 µg/L (0.005 mg/L)
C	Total Organic Carbon & Dissolved Organic Carbon	1.0 mg/L (both)

Please note:

Total water hardness (LOR of 1.0 mg/L) to be extracted from TSS bottle.

Appendix B: Equipment List for Collecting Water Samples

- Twenty-six 500ml HDPE bottles. Two of the five sampling runs will require two extra for blanks and replicates. The metal sampling run will require an extra six bottles for Total Water Hardness.
- Calibrated Quanta probe for measurement of in-situ parameters, including the probe cover, protection cap and surveyor (provided by the Department of Water).
- Field filtering equipment – hand pump, filter tower, filter paper and tweezers.
- Deionised water for field blanks.
- Deionised water spray bottle for cleaning the filter tower.
- Tap water for filling the probe protection cap, and drinking water.
- Bucket for measurement probes/surveyor.
- Sampling and Analysis Plan (SAP)
- Safety Plan
- Chain of Custody (COC) forms
- Field Observation (FOF) forms
- Eskies with ice bricks.
- Masking tape
- Nitrile gloves, gumboots, waders, coveralls, safety glasses, sunscreen, hat, and other protective gear.
- Map of sites.
- GPS (if required)
- Permanent marker, pencil and pen

Appendix F - Safety Plan

Brockman River Catchment Water Quality Monitoring Snapshot 2009



Plate 1: Brockman River (2007).

Prepared by Ellen Brockman Integrated Catchment group: March 2009



This project is funded by Tiwest Joint Venture on behalf of the Ellen Brockman Integrated Catchment Group.

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1. Introduction

Collecting water, sediment and biota samples of unknown history potentially exposes sampling personnel to direct contact with material that may be hazardous to their health. The purpose of the safety plan is to provide personnel undertaking water quality sampling in the Brockman River catchment with safety and health requirements. The safety plan indicates all potential areas of risk to personnel before, during and after the sampling and recommends specific strategies to minimise this risk. Occupational health, safety and welfare in the workplace is a shared responsibility and the Chittering Landcare Centre relies on consultation, commitment and participation from all officers.

All employees have the responsibility for ensuring their own health, safety and welfare, reporting hazards in the work area and following established practices and procedures aimed at providing a safe and healthy work environment for all. This plan should be used in conjunction with the Chittering Landcare Centre's Occupational Health & Safety Policy, particularly the following protocol related to officers undertaking field work:

Before departing the office for field work, the worker must ensure that they:

- post their itinerary including specific details of times, location and contact mobile telephone on the staff notice board. If possible a contact landholder name and phone number should be provided.
- are suitably clothed with protective clothing and boots for the task.
- have all their safety equipment, adequate drinking water and first aid equipment in their vehicle.
- have their mobile phone with them and the battery is charged.
- have adequate fuel in their vehicle for the task.

The worker is to contact a staff member at the Chittering Landcare Centre no later than **1 hour** after their nominated time of return. The details of these checks are to be recorded next to the worker's name on the notice board.

If no contact has been made within one (1) hour of the lone worker's nominated time of return, Chittering Landcare Centre officers are instructed to attempt to make contact with the worker, either by using the contact details posted on the notice board, or the designated mobile telephone.

If no response is received from the worker following attempts to make contact, inform the staff, Chittering Landcare Centre Manager or a senior officer from the Shire of Chittering (CEO, Deputy CEO or Shire Ranger) whose contact details are posted on the notice board. A search will then be initiated using the lone worker's stated itinerary.

2. Site assessment

The purpose of the preliminary site assessment is to determine the best location to collect the sample. Site selection depends more on true representativeness of the area under investigation and any safety concerns associated with collecting the sampling. Site selection should not be determined primarily by ease of access although it is a factor contributing to site selection.

All sites involve foreshore environments and are accessed by road, and the issues involved for all sites are included in the "Hazard Identification" Table within this plan. Most sites are publicly accessible.

3. Sampling site locations

Table 13: Location and description of sampling sites in the Brockman River Catchment.

Site No.	Site name	Description of waterway (inc. old site number)	Easting	Northing
BRN1	Murphy Gully Creek	BR22 - Bindoon Moora Rd	409205	6561412
BRN2	Jackson Road (Wannamal Lake outlet)	BR21 - Jackson Road	409457	6555480
BRN3	West Point Creek	BR20 - West Point	409754	6555706
BRN4	Wannamal South	Wannamal South Road	407596	6552244
BRN5	Udumung Creek	BR18 - Hay Flat Road	410373	6551048
BRN6	Kangaroo Gully Creek	BR17A - Bindoon Moora Rd	412741	6547952
BRN7	Gooninong Romany Creek	BR17 - Waldeck West Road - Romany Creek	413360	6546355
BRN8	Longbridge Creek	BR16A - Ashman Rd to gate (2km) over fence & nth on fire break	414649	6542478
BRN9	Wootra Brook	BR15 - Owen's Road	416762	6537439
BRN10	Bindoon River	BR15A - Great Northern Highway small bypass road bridge	417372	6531777
BRN12	Flat Rocks Creek	Densley Road (off Flat Rocks)	415077	6524296
BRN13	Spoonbill Lake	BR12 - spillway from Spoonbill Reserve	412361	6523223
BRN14	Aquila, Hart Drive	BR12A - Flows through Aquila Reserve	412306	6522632
BRN15	Lake Road Brockman River	BR9 - Bridge on Lake Road below Lake Weir	414090	6521308
BRN16	Spice Brook	BR11A - off Lake Road across paddock to bridge	414509	6521156
BRN17	Toodyay Creek Toodyay Creek	100m north of Blue Plains Road on Chittering Road	414561	6518111
BRN18	Julimar/Chittering Bridge Brockman River	BR5 - Julimar Rd/Chittering Rd intersection	415996	6515275
BRN19	Julimar/Chittering Tributary Julimar Rd Creek	BR8 - Julimar Rd (500m up from intersection Chittering Rd)	417103	6515877
BRN20	Chittering Valley	Cnr Chittering Valley and Chittering Road	416288	6510308
BRN21	Keating Road	BR4 - 500m east on Keating Road to gateway - Bitney Springs	419248	6508210
BRN22	South Chittering Creek	Chittering Road just north of Wilson Road	415559	6500608
BRN23	Marbling Brook	Bridge on Chittering Road	414704	6506641
BRN24	Moondyne Brockman River	BR2 - from crossing	416623	6499996
BRN25	Yalliawirra Brockman River	BR1 Gauging Station	416450	6495160
BRN26	Marda Brook	Smith Road bridge/gate	414266	6496860
BRN27	Grey Road Bridge	Brockman River	413885	6528696

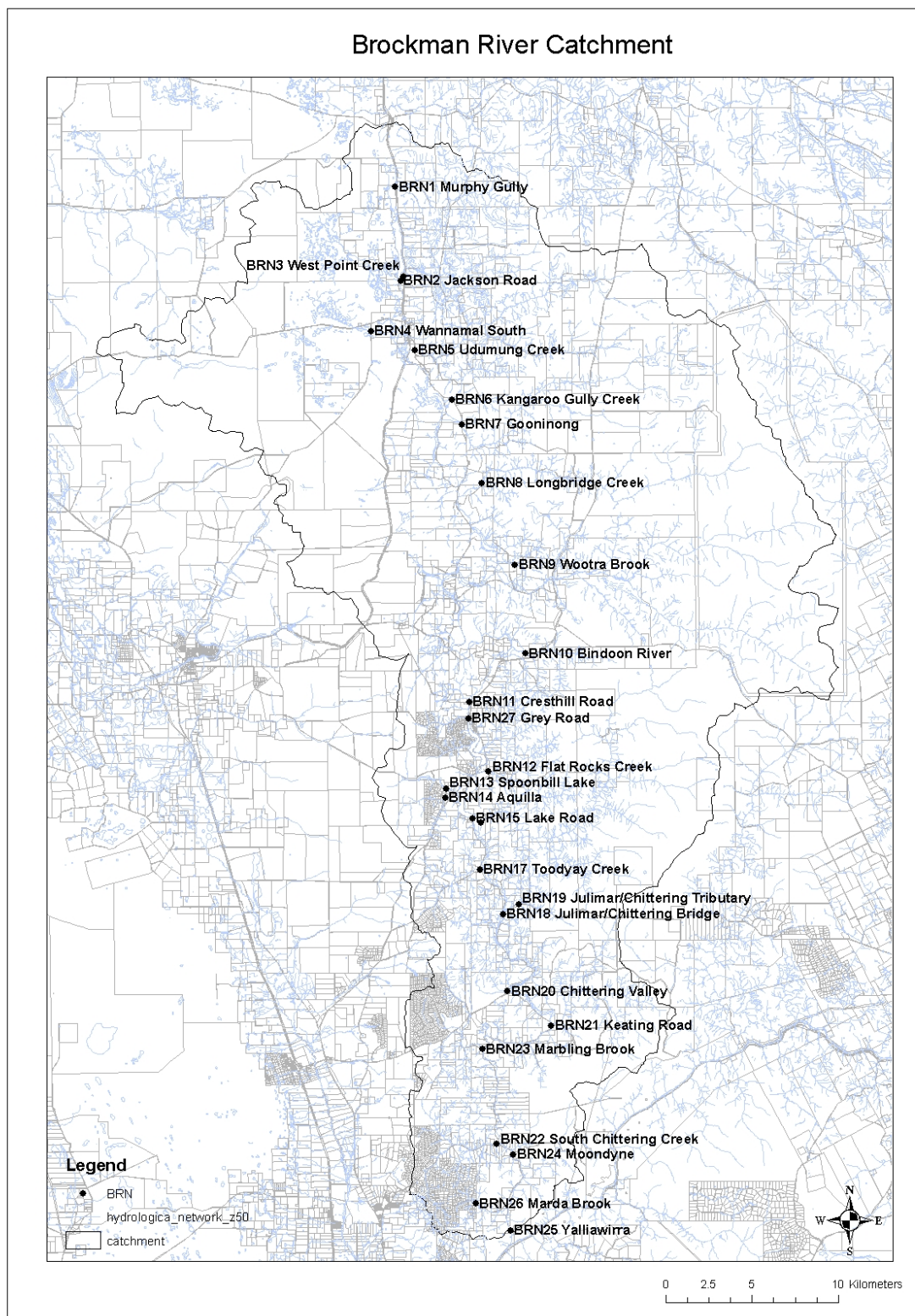


Figure 27: Location of sampling sites within the Brockman River Catchment.

4. Personal protection and equipment

Officers involved in water sampling activities should heed the following to ensure that their personal safety outside of the office is made a priority.

- A mobile phone should be carried so that contact can be made with the office at specified times or for emergency.
- All work vehicles should be equipped with a first aid kit.
- All work vehicles should be equipped with a current fire extinguisher.
- All workers who work in isolated conditions in the field should have a current Senior First Aid certificate or first aid training to suit their particular needs.
- Workers driving four wheel drive vehicles should be trained in driving in such conditions.
- Personnel should wear thin nitrile gloves and eye protection whilst collecting water samples.
- If entering the water, waders or gum boots should be worn. The alternative to gum boots if not entering the water is steel capped, enclosed leather boots.
- Normal sun-protection should be adopted (hat, long sleeves and sunscreen) as the sampling is an outdoor activity. In the case of rain, a raincoat or weatherproof jacket should be worn.

Adequate water (at least 5 litres) should be carried on board the vehicle at all times and is located in the tray section of the ute. Drinking water regularly when out in the field is vital to prevent dehydration, particularly in warmer months.

5. Access to medical help

At least one of the sampling officers must have a current first aid certificate. The car used for sampling always has a first aid kit – it is located in the tray of the vehicle in a plastic box. At least one operational mobile phone will be with the officers at all times. If more than simple first aid treatment is required then the **emergency number 000** should be dialled and an ambulance ordered to escort the injured person to hospital. A map showing direction and routes to the nearest hospital must be provided to all personnel prior to departure in the field.

The nearest hospitals are:

- 1. Swan District Hospital, Eveline Road, Middle Swan, 6056**
Tel: (08) 9347 5244

To get to the Swan District Hospital, follow Great Northern Highway south, then right onto Eveline Road.

- 2. Bindoon Medical Centre, Great Northern Highway, Bindoon WA 6502**
Tel: (08) 9576 1222

To get to the Bindoon Medical Centre, follow Great Northern Highway to Bindoon.

6. Important Contact Numbers:

Table 14: Emergency Contacts

Name/Service	Contact phone	Mobile
Chittering Landcare Centre - Bonny Dunlop-Heague	(08)95714351	0428434351
Chittering Landcare Centre - Kay Reid	(08)95710400	0428528030
Chittering Landcare Centre - Rosanna Hindmarsh (co-ordinator)	(08)95710400	0429887715
Chittering Landcare Centre – Amy Salmon	(08)95710300	0429030300
City of Swan – (Ranger)	(08)92679409	
Fire Brigade – Lower Chittering	(08)95718254	
Fire Station – Muchea	(08)95714465	
Medical Centre - Bindoon	(08)95761222	
Police Midland	(08)92221111	
Shire of Chittering – Anthony Martioich (Ranger)	(08)95760282	0427699700
Shire of Gingin – Michael Pimm (Ranger)	(08)6551286	
Perth Region NRM – Administration	(08)93743333	
Tiwest – Parveen Naidoo (Environmental Officer)	(08)95719246	0417174834
Tiwest – Reception	(08)95719333	

7. Hazard identification

All personnel must be trained in identification of potential hazards at a sampling site. This involves listing potential dangers to sampling personnel when at the sampling site, such as collapse of stream bank, falling into the stream, and contact with water from the stream, exposure to heat, wind and rain.

All personnel must be briefed of potential hazards at sample sites. There is a potential for exposure to very acidic waters. Entry into the drains/waterways must be done wearing protective clothing unless pH has been determined to be within safe limits (pH 5.5-8).

Table 15: Risk Assessment

Identified Risk	Precautions
Exposure to chemicals and handling of contaminated samples & sampling or entering potentially low pH waters.	Wear protective clothing at all times: field boots or gum boots, nitrile gloves (waders if expecting to go into water at above ankle level).
Physical injury from falling (especially steep slopes with sandy banks)	Inspect accessibility to site before transferring equipment from car. If site is too steep, unstable or otherwise dangerous do not sample.
Insect, spider, rodent or snake bites.	Inspect site prior to sampling, especially drain culvert openings and wear long pants and high boots for walking through long grass.
Traffic on roads near sites	Bright safety vest with reflective strip should be worn when working along road sides and care should be taken to watch out for traffic at all times. Hazard lights should be left on vehicle whilst sampling.
Manual handling of heavy equipment and eskies/samples	Wear work boots and lift heavy objects ensuring no risk to back. If necessary, use two people to lift larger eskies.
Sampling at sites where algal scums are present	Always wear nitrile gloves when sampling and avoid contact with water. Take care when handling food after sampling.
Sunburn, exposure (dehydration and heat stroke, exposure to cold).	Apply sunscreen, wear hats, rain jackets, work pants, jumpers as appropriate. Take plenty of drinking water (labelled as drinking water and kept separate from sample bottles).

8. Experience of sampling personnel

Samples should only be collected by personnel who have received training from the Aquatic Science Branch of the Department of Water or a recognised authority.

Appendix G – Sampling Site Photo Points



BRN1 Murphy Gully



BRN3 West Point



BRN4 Wannamal South



BRN5 Udumung Creek



BRN6 Kangaroo Creek



BRN7 Romany Creek



BRN8 Longbridge Creek



BRN9 Wootra Brook



BRN10 Bindoon River



BRN11 Cresthill Road



BRN12 Flat Rocks Creek



BRN13 Spoonbill Lake



BRN14 Aquilla



BRN15 Lake Road



BRN16 Spice Brook



BRN17 Toodyay Creek



BRN18 Julimar/Chittering
Bridge



BRN19 Julimar/Chittering
Tributary



BRN20 Chittering Valley
Creek



BRN21 Keating Road



BRN22 South Chittering



BRN23 Marbling Brook



BRN24 Moondyne



BRN25 Yalliwirra

Brockman River Catchment Water Quality Monitoring Snapshot August & October 2009



BRN26 Marda Brook



BRN27 Grey Road

NB: No photo of BRN2 Jackson Road (Wannamal Lake Outlet).