Government of **Western Australia**
Department of **Water**

Nutrient loads, status and trends in the Leschenault catchment

Looking after all our water needs

Water *Science*
technical series

Report no. WST 9
August 2010

Nutrient loads, status and trends in the Leschenault catchment

Department of Water

Water Science Technical series

Report no. 9

August 2010

Department of Water
168 St Georges Terrace
Perth Western Australia 6000
Telephone +61 8 6364 7600
Facsimile +61 8 6364 7601
www.water.wa.gov.au

August 2010

ISSN 1836-2877 (online)
ISSN 1836-2869 (print)
ISBN 978-1-921549-80-9 (online)

Disclaimer

This document has been published by the Department of Water. Any representation, statement, opinion or advice expressed or implied in this publication is made in good faith and on the basis that the Department of Water and its employees are not liable for any damage or loss whatsoever which may occur as a result of action taken or not taken, as the case may be in respect of any representation, statement, opinion or advice referred to herein. Professional advice should be obtained before applying the information contained in this document to particular circumstances.

This document is available for people with disabilities in alternative formats such as audio tape, large print and Braille on request to the Department of Water, and in electronic format from the department's website <www.water.wa.gov.au>.

Acknowledgements

Leschenault Catchment Council
Working toward a healthy, productive and sustainable catchment.

SOUTH WEST CATCHMENTS COUNCIL

Australian Government

Funding was provided by the Australian and Western Australian governments through the South West Catchment Council and the Leschenault Catchment Council. The Water Science Branch, Department of Water would like to thank the Leschenault Catchment Council and the South West Catchment Council for their support during this project. In particular the contributions of Joanna Hughes-Dit-Ciles and Mike McKenna have been greatly appreciated. Thanks also to the Water Information Branch, Department of Water for its excellent data management and support.

Recommended reference

Kelsey, P & Hall, J 2010, *Nutrient loads, status and trends in the Leschenault catchment*, Water Science Technical series, Report no. 9, Department of Water, Western Australia.

For more information about this report, contact Peta Kelsey, Department of Water.

Cover photograph courtesy of the Leschenault Catchment Council.

Contents

Figures

Tables

Summary

The Leschenault catchment, which drains to the Leschenault Inlet and then the ocean, is located about 160 km south of Perth, in the south west of Western Australia. Its area is approximately 2020 km^2 and includes the catchments of the Wellesley, Brunswick, Ferguson and Preston rivers, as well the Collie River catchment below Wellington Dam. Artificial drains have been introduced in the flat Swan Coastal Plain areas to enable agricultural and urban land uses and to supply irrigation. This has led to a complex hydrological network of drains and natural rivers.

Although the catchment has a large area of native vegetation in its upper reaches, the land uses on the Swan Coastal Plain and in the broad river valleys east of the Darling Scarp include cattle raising for beef and dairy, horticulture and viticulture. The towns of Bunbury and Australind are located on the coast and Leschenault Inlet's eastern shore. The intense agricultural and urban land uses have eutrophied many of the catchment's waterways, which has led to algal blooms and fish kills in the Lower Collie and Brunswick rivers (DoW 2007).

This report discusses the catchment monitoring undertaken by the Department of Water on behalf of the Leschenault Catchment Council. The monitoring program's objectives were two-fold: firstly, to determine the nutrient status of the waterways and whether there had been significant changes in the nutrient status; and secondly, to provide nutrient data to support numerical modelling of catchment exports. The numerical modelling is discussed in this report's accompanying document: *Nutrient-export modelling of the Leschenault catchment* (DoW 2010).

Status and trends data for 42 monitoring sites are presented. The Wellesley River catchment displayed very poor nutrient status at all sites monitored. Increasing trends in total nitrogen (TN) and total phosphorus (TP) are evident at the catchment's outlet, indicating that water quality is deteriorating throughout the catchment. The upper reaches of the Brunswick, Collie and Preston rivers on the Darling Plateau had low concentrations of TN and TP, whereas the median TN and TP concentrations at most sites on the Swan Coastal Plain were moderate to very high. Generally the nutrient status of sites reflects the upstream land uses and soil types, although nutrient sources are not discussed in this report (see the accompanying document).

Trends in nutrient concentrations are difficult to detect because of the large natural variations inherent in the data. Aside from trends at sites within the Wellesley catchment, only four other sites exhibited trends in nutrient concentrations.

Annual TN and TP loads have been calculated at five flow sites in the Brunswick and Lower Collie catchments, including the output of Wellington Dam, and at four sites in the Ferguson and Preston catchments. These data have been used to calibrate the nutrient export model discussed in the accompanying document (DoW 2010), which estimates TN and TP loads to the estuary.

The current sampling regime for the Leschenault catchment includes 22 sites, of which status and trends have been analysed for 21 in this report. The new site – AWRC Reference 611006 (Preston River, Donnybrook) – has not been analysed. It may be appropriate to amend the sampling regime to include some of the sites highlighted in this report as having

high and very high status, such as 6121231 (Punchbowl Canal, Hayward Road), 6121230 (Taverner Road Canal, Hynes Road), 6121220 (Wellesley River, Hope Ave), 6110055 (Ferguson River, Canal), 6121226 (Collie River, Hands Street) and 6121162 (Brunswick River, Brunswick 2).

1 Introduction

1.1 Project description

During the past three years the Department of Water has monitored nutrients at 38 sites in the Leschenault catchment, as part of a project for the Leschenault Catchment Council (LCC). This report presents the loads, status and trends of total nitrogen (TN) and total phosphorus (TP) from the monitoring program, and updates the 2006 status and trends report (DoW 2006).

The monitoring program's objectives were two-fold: firstly, to determine the nutrient status of the waterways and whether there had been significant changes in the nutrient status; and secondly, to provide nutrient data to support numerical modelling of catchment exports. The numerical modelling is discussed in this report's accompanying document: *Nutrient-export modelling of the Leschenault catchment* (DoW 2010).

This report's purpose is to:

- review the nutrient monitoring program
- determine the TN and TP status of all sites sampled during the past three years
- determine short- and long-term trends in TN and TP using robust statistical methods
- where possible, determine flow/concentration relationships and use these to estimate loads
- recommend future sampling based on the data gaps and priority locations
- advise the LCC on changes that may have occurred due to rehabilitation projects
- provide feedback to the LCC on nutrient 'hotspots'.

1.2 Catchment description

The Leschenault catchment, which drains to the Leschenault Inlet and then the ocean, is located about 160 km south of Perth, in the south west of Western Australia. Its area is approximately 2020 km^2 and includes the catchments of the Wellesley, Brunswick, Ferguson and Preston rivers, as well as the Collie River catchment below Wellington Dam (Figure 1.1). Artificial drains have been introduced in the flat coastal plain areas to enable agricultural and urban land uses. An irrigation drainage network also supplies water to the catchment from the Stirling, Harvey and Wellington dams (Harvey and Collie irrigation districts) and the Glen Mervyn dam (Preston Valley Irrigation Cooperative). This has led to a complex hydrological network of drains and natural rivers.

Although the catchment has a large area of native vegetation in its upper reaches, the land uses on the Swan Coastal Plain and in the broad river valleys east of the Darling Scarp include cattle raising for beef and dairy, horticulture and viticulture. The catchment's population is approximately 65 000. Most people live between the lower reaches of the four major rivers and either the coast or the Leschenault Inlet's eastern shore in the towns of Australind and Bunbury.

The intense agricultural and urban land uses have resulted in the eutrophication of many of the catchment's waterways, which has led to algal blooms and fish kills in the Lower Collie and Brunswick rivers (DoW 2007). The monitoring program has highlighted many sites on the coastal plain that have high or very high status for TN and TP.

This report's accompanying document, *Nutrient-export modelling of the Leschenault catchment* (DoW 2010), describes in detail the catchment's topography, climate, soils, hydrology and land use, including the point sources of wastewater treatment plants and septic tanks.

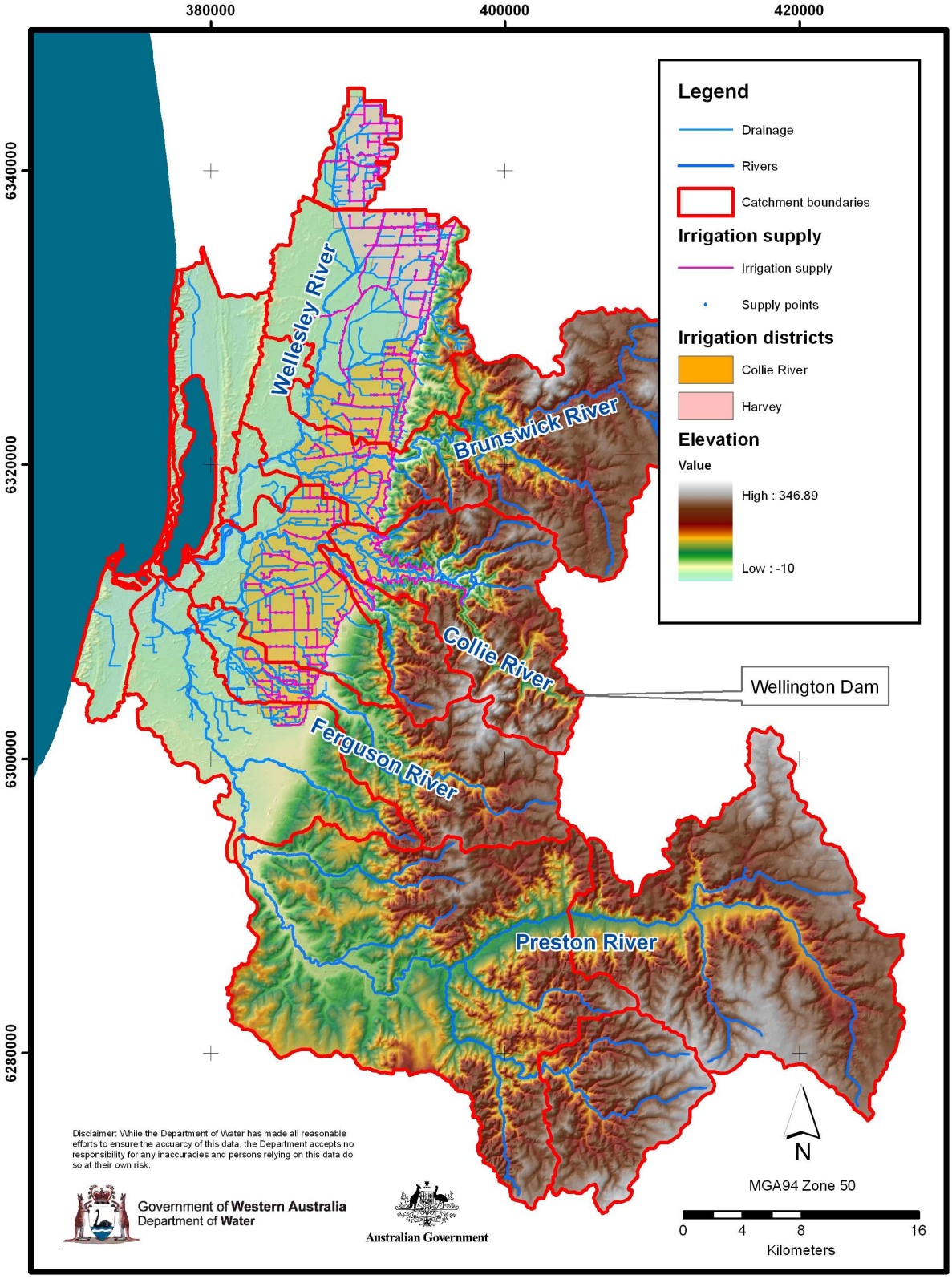


Figure 1.1 Rivers, drains and catchments of the Leschenault catchment

2 Methods

2.1 Data analysis techniques

2.1.1 Assessing nutrient status

The TN and TP concentrations at the monitored sites are classified according to the nutrient classifications from the *Statewide river water quality assessment* (DoW 2009). These are shown in Table 2.1. Depending on trends, chance sampling and sources of natural variation, the nutrient concentrations sampled from a monitored site will change with time.

Table 2.1 Classification used to assess the status of TN and TP concentrations in monitored waterways.

TN	Status	TP
> 2.0 mg/L	Very high	> 0.2 mg/L
> 1.2 – 2.0 mg/L	High	> 0.08 – 0.2 mg/L
0.75 – 1.2 mg/L	Moderate	0.02 – 0.08 mg/L
< 0.75 mg/L	Low	< 0.02 mg/L

The nutrient status for a waterway is assigned by using the median of nutrient concentrations over a three-year period to diminish the influence of natural variation between years. The most recent period of analysis (2006, 2007 and 2008) was used to determine the current nutrient status at each monitored site.

2.1.2 Trend analysis

Nutrient data series contain the following sources of variation:

- flow variation
- seasonal variation
- random components
- changes due to anthropogenic pollution.

It is difficult to ascertain the changes in water quality brought about by human activity, since these are superimposed on natural sources of variability. Before analyses for trends, the data are corrected for the influence of flow and seasonal variations. Thus the observed trends in nutrient concentrations are (more than likely) linked to human intervention or land use practices within the catchment.

This report uses non-parametric tests to identify statistically significant trends in the nutrient data series. Non-parametric techniques are used because they are not affected by a non-normal distribution of data, and they are not sensitive to outliers, or affected by missing or censored data (Loftis et al. 1991). An assumption of the trend analyses is that the trends are monotonically increasing or decreasing (Helsel & Hirsch 1992). If concentrations vary non-monotonically over the period analysed, the results of linear tests for trend may be misleading (Robson & Neal 1996). Two parametric trend tests are used in this work: the

Mann-Kendall test and the Seasonal-Kendall test (Gilbert 1987). Both these tests are applied to the raw TN and TP data and to the flow-corrected TN and TP data.

A trend in the nutrient data series is significant only when two criteria are met. Firstly, the Mann-Kendall or Seasonal-Kendall test for trend on the data series must be statistically significant (i.e. $p < 0.05$). Secondly, the number of independent measurements collected (n^*) must be approximately equal to or exceed the 'estimated' number of independent measurements ($n^\#$) required to detect a trend. The statistical tests for the trend analyses are described in detail in Appendix A.

2.1.3 Load calculations

To estimate nutrient loads, a concentration-flow relationship is established using a locally estimated scatterplot smoothing (LOESS) fit (Cleveland 1979; Helsel & Hirsch 1992). This fit is then used to estimate daily nutrient concentration values for the days that lack water quality data. The daily load is then calculated by multiplying the flow by the concentration and summed to give an estimated annual load.

The errors in loads derived from fixed-interval water quality sampling are generally large. To estimate these errors at any particular site, intensive water quality sampling is necessary, typically using automatic samplers (Donohue & Nelson 1999). Intensive water quality sampling has not taken place in the Leschenault catchment. Other studies (WRC 2002; DA Lord & Associates 2001) estimate the accuracy of loads calculated from weekly and fortnightly water quality sampling to be about +/- 50%.

2.2 Available sites and data

This status and trend report updates a previous Water Science Branch publication, which reported status, trends and loads of sampling sites in the Leschenault catchment for the three-year period 2003 to 2005 (DoW 2006). Sites where data have not been collected since 2005 are not included in this report: for these the 2006 publication should be consulted. The sites analysed for the 2006 report and their corresponding status (2003–2005), trends and loads are displayed in Table 2.2.

Table 2.2 Status/median (2003–2005), trends and loads in the Leschenault catchment, from DoW (2006)

Site	Site name	Total nitrogen				Total phosphorus			
		Status/ median (mg/L)	Year[1]	Trend[3]	Load (T)	Status/ median (mg/L)	Year[1]	Trend[3]	Load (T)
Parkerfield Drain									
6121173	PARKFIELD DRAIN	1.1	2005	None		0.07	2005	None	
Upper Brunswick									
612047	BEELA	0.38	2005	None	16.1	0.017	2005	None	0.93
6121158	MORNINGTON RD	0.18	2002	None		0.008	2002	Decreasing	
Lower Brunswick/Wellesley									
612032	CROSS FARM	1.3	2005	None	176	0.135	2005	None	23.4
612039	JUEGENUP	1.533	2005	None		0.165	2005	None	
6121130	WELLESLEY ROAD XING	0.315	2005[2]			0.02	2005[2]		
6121156	WELLESLEY ROAD	1.6	2001	None	119	0.19	2001	None	15.1
6121162	BRUNSWICK 2	1.3	2005	None		0.12	2005	None	
6121163	BRUNSWICK 3	0.47	2000[2]			0.02	2000[2]		
6121203	ELVIRA GULLY	2.8	2005[2]			0.2	2005[2]		
6121195	CARAVAN PARK	0.32	2005[2]			0.017	2005[2]		
Lower Collie									
612043	ROSE ROAD	0.41	2005	Decreasing	65	0.013	2005	None	1.6
6121157	MILLERS ROAD	0.36	2001	None		0.007	2001	Decreasing	
6121167	COLLIE 3	0.48	2001	None		0.05	2001	None	
6121168	COLLIE 4	0.455	2005	None		0.04	2005	None	
6121169	COLLIE 7	0.57	1998[2]			0.01	1998[2]		
Ferguson									
611007	SOUTH WESTERN HWY	1.1	2005	None	40.5	0.041	2005	None	2.5
611017	DOUDELL ROAD BRIDGE	0.58	2001	None		0.02	2001	None	
6111041	FERGUSON 1	0.86	1998	None		0.043	1997	None	
Middle/Upper Preston									
6111044	PRESTON 2	0.43	1998	None		0.021	1997	None	
6111045	PRESTON 3	0.55	1998[2]			0.014	1998[2]		
6111046	PRESTON 4	0.58	2001	None		0.015	2001	None	
611111	WOODPERRY HOMESTEAD	0.671	2005	None	17	0.015	2005	None	0.2
Lower Preston									
611003	PICTON BRIDGE	0.45	2001	None		0.023	2001	None	
611004	BOYANUP BRIDGE	0.48	2005	Decreasing	87	0.026	2005	None	4

[1] *Refers to the last year of the three-year period used to assess status (unless otherwise indicated).*

[2] *Median value of all data (since there were not three consecutive years of data), year refers to last year of data (not coloured).*

[3] *Emerging trends were not reported.*

This report has slightly different data requirements for the reporting of medians, status, trends and loads compared with the previous report, as outlined below:

Where status and trend analyses are reported:

- the site must have at least 20 measurements spanning at least three consecutive years
- trends were calculated for sites 6121229 and 6121230, which had 32 and 28 measurements respectively for both TN and TP, although these were collected in only two consecutive years (2007 and 2008).

Where median data are reported:

- the site must have at least 10 measurements spanning at least two consecutive years
- insufficient data for status and trend analyses have been collected at the site
- the median quoted is for all data or for the most recent observations, as appropriate.

Where loads are reported:

- the site must meet the requirements for status and trend analyses
- there must be at least 20 data points for which flow is known.

Using these criteria, for this report a total of 42 sites (see Table 2.2) were analysed for status or median, trend and load.

Table 2.3 Sites analysed for this report

Site	Context name	Site name	Status	Median	Trend	Load
Parkerfield Drain						
6121173	Leschenault Estuary	Parkfield Drain	✓		✓	
Wellesley						
6121184	Mangosteen Drain	Leitch Road	✓		✓	
6121220	Wellesley River	Hope Ave	✓		✓	
6121221	Bindiup Creek	Bernies	✓		✓	
6121187	Mornington Creek	Campbell Road	✓		✓	
6121229	Wellesley River	Kemerton Bridge		✓	✓	
612039	Wellesley River	Juegenup Wellesley	✓		✓	✓
Upper Brunswick						
612047	Brunswick River	Beela	✓		✓	✓
Lower Brunswick						
6121195	Brunswick River	Caravan Park Brunswick	✓		✓	
6121130	Brunswick River	Wellesley Road Crossing	✓		✓	
6121203	Elvira Gully	Elvira Gully	✓		✓	
612032	Brunswick River	Cross Farm	✓		✓	✓
6121162	Brunswick River	Brunswick 2	✓		✓	
Lower Collie						
612013	Collie River	Wellington Flume	✓		✓	✓
612043	Collie River	Rose Road	✓		✓	✓
6121168		Collie 4	✓		✓	
6121222	Henty Brook	Henty	✓		✓	
6121223	Canal to Henty	Near Henty	✓		✓	
6121225	Millars Creek	Millars	✓		✓	
6121226	Collie River	Hands Street	✓		✓	
6121230	Taverner Road Canal	Hynes Road		✓	✓	
612015	Vindictive Drain	Harris Road	✓		✓	
Ferguson						
611017	Ferguson River	Doudell Road Bridge	✓		✓	
6110055	Ferguson River	Canal	✓		✓	
611007	Ferguson River	SW Hwy Ferguson	✓		✓	✓
Middle/Upper Preston						
611001	Preston River Trib	Mumballup Road	✓		✓	
6111002	Preston River	Bridge No 751	✓		✓	
6110059	Preston River South	Mandalay	✓		✓	
611009	Preston River	Lowden Road Bridge	✓		✓	✓*
611111	Thomson Brook	Woodperry Homestead	✓		✓	✓
6110058	Thomson Brook South	Brookhampton Road	✓		✓	
6111040	Thomson Brook	Donnybrook-Boyup Road	✓		✓	
611005	Preston River	Upstream Joshua Creek	✓		✓	
6110056	Joshua Creek	Joshua	✓		✓	
611004	Preston River	Boyanup Bridge	✓		✓	✓
6111043	Preston River	Preston 1	✓		✓	
Lower Preston						
6110060	Rec Rd	Recreation Road	✓		✓	
6111035	Crooked Brook	South West Hwy	✓		✓	
6111058	Preston River	Dardanup Road	✓		✓	
6111059	Canal	Meadow Road	✓		✓	
6121232	Charterhouse Street	St Marks Park Lake		✓		
Coastal						
6121231	Punchbowl Canal	Hayward Road		✓		

**includes 6111046 data for load calculation*

It is not uncommon for a gauging station to be registered in the Department of Water's Water Information database separately to a sampling site which is at, or near, the same location. Several such occurrences were identified in the Brunswick and Preston catchments and are listed in Table 2.4. Of these, the only sites that are close enough to be considered co-located are the Preston River sites 611004 and 6111043. Nevertheless, these have been analysed separately here, because they both have long data records: 611004 from 1980 to 2008 and 6111043 from 1996 to 2008.

The sampling sites 6121170, 6121164, 6111042 and 6111044 have data for the period 1995 to 1998; and 6111046 has data for 1995 to 2000. Load calculation for site 611009 was derived from a concentration-flow relationship using data from 611009 and 6111046.

Table 2.4 Co-located sampling and gauging stations in the Leschenault catchment

	Gauging station site		Sampling site (non-gauging)		
Context name	**AWRC ref**	**Name**	**AWRC ref**	**Name**	**Distance from gauging station site**
Wellesley River	612039	Juegenup	6121170	Wellesley 1	600 m upstream
Brunswick River	612047	Beela	6121164	Brunswick 4	800 m downstream
Ferguson River	611017	Doudell Road	6111042	Ferguson 2	400 m upstream
Preston River	611004	Boyanup Bridge	6111043	Preston 1	40 m downstream
Preston River	611006	Donnybrook	6111044	Preston 2	1200 m downstream
Preston River	611009	Lowden Bridge	6111046	Preston 4	400 m downstream

2.3 Known data issues

2.3.1 Summer versus winter sampling

For the purposes of this report, 'summer' is considered to be the dry months from November to April inclusive, and 'winter' the wet months from May and October inclusive. Generally, summer sampling tends to detect receding baseflow conditions, while winter sampling is more indicative of higher flow and stormflow conditions. For coarse sampling regimes, such as the fortnightly sampling in the Leschenault, very few stormflow, summer event or first-flush conditions are sampled. A peculiarity of the Leschenault catchment is discharge during the irrigation season, when irrigation provides substantial amounts of summer flow to all four of the major rivers. A sampling regime focused on the dry summer period is likely to be more reflective of conditions in irrigated areas than the catchment as a whole. The proportion of summer and winter sampling should be considered when analysing the data; however, the medians reported here are for all the data.

2.3.2 Limits of reporting

Between 1996 and 2003, many Leschenault sites were part of a sampling regime that used methods of analyses with very high limits of reporting (0.5 mg/L for TN; 0.4 mg/L for TP). As the streams and tributaries of the Leschenault catchments generally have TP concentrations less than 0.4 mg/L, this rendered most of the TP data collected during this period unusable.

Depending on whether a median, trend or load was being calculated, TN and TP concentrations below the limit of reporting were either discarded or halved to allow inclusion in the calculation of the parameter.

3 Results

3.1 Recent changes

Sites the Department of Water analysed in DoW (2006) – for which monitoring continued during 2006 to 2008 – are shown in Table 3.1. The TN and TP status are the same at all but three of these 14 sites.

Table 3.1 TN and TP concentrations for the period 2006 to 2008 for the sites analysed in DoW (2006)

Site	Site name	Total nitrogen		Total phosphorus	
		Status/ median (mg/L)		Status/ median (mg/L)	
		2005[1]	2008[2]	2005[1]	2008[2]
Parkerfield Drain					
6121173	PARKFIELD DRAIN	1.1	1.2	0.07	0.052
Upper Brunswick					
612047	BEELA	0.38	0.315	0.017	0.011
6121158	MORNINGTON RD	0.18		0.008	
Lower Brunswick/Wellesley					
612032	CROSS FARM	1.3	1.2	0.135	0.12
612039	JUEGENUP	1.533	1.45	0.165	0.17
6121130	WELLESLEY ROAD XING	0.315	0.38	0.02	0.014
6121156	WELLESLEY ROAD	1.6		0.19	
6121162	BRUNSWICK 2	1.3	1.2	0.12	0.11
6121163	BRUNSWICK 3	0.47		0.02	
6121203	ELVIRA GULLY	2.8	2.8	0.2	0.42
6121195	CARAVAN PARK	0.32	0.39	0.017	0.012
Lower Collie					
612043	ROSE ROAD	0.41	0.40	0.013	0.010
6121157	MILLERS ROAD	0.36		0.007	
6121167	COLLIE 3	0.48		0.05	
6121168	COLLIE 4	0.455	0.49	0.04	0.018
6121169	COLLIE 7	0.57		0.01	
Ferguson					
611007	SOUTH WESTERN HWY	1.1	0.805	0.041	0.026
611017	DOUDELL ROAD BRIDGE	0.58	0.74	0.02	0.021
6111041	FERGUSON 1	0.86		0.043	
Middle/Upper Preston					
6111044	PRESTON 2	0.43		0.021	
6111045	PRESTON 3	0.55		0.014	
6111046	PRESTON 4	0.58		0.015	
611111	WOODPERRY HOMESTEAD	0.671	0.73	0.015	0.016
Lower Preston					
611003	PICTON BRIDGE	0.45		0.023	
611004	BOYANUP BRIDGE	0.48	0.33	0.026	0.012

[1] *Status or median from Table 2.1*

[2] *Median value of data for period 2005 to 2008*

The TP concentration decreased at both 6121168 (Collie River, Collie 4) and 611004 (Preston River, Boyanup Bridge); the status of the sites decreasing from medium to low. At site 6121173 (Parkfield Drain) the TN status increased from moderate to high: this site drains a large horticultural area.

3.2 Status and trends

Tables 3.2, 3.3, 3.4 and 3.5 display the TN and TP status or median concentrations, and trends for all the sites monitored from 2006 to 2008 inclusive. Plots of the TN and TP data, the three-year median concentrations and the results of the short- and long-term trend analyses for each site are given in Appendix 2.

The TN and TP status (or median) are also shown in Figure 3.1 and Figure 3.2. Generally the sites located on the Darling Plateau have low status, except for two sites in the upper Preston River, which have moderate concentrations (6111002: Preston River, Bridge No. 7651; and 6110059: Preston River South, Mandalay). The TN and TP concentrations on the Swan Coastal Plain range from low to very high. The sites with low status in the main rivers are a result of the relatively unpolluted inflows from the plateau. All the sites on small coastal plain tributaries have moderate to very high TN and TP status, reflecting the intensive land uses and the inability of these sandy waterlogged soils to process nutrients. The inflows to the estuary from the Brunswick and Collie rivers have high status for both TN and TP. The inflow from the Preston River has moderate status for both TN and TP. The Wellesley River and associated tributaries have the highest TN and TP concentrations in the Leschenault. The predominant land uses in this region are ‘cattle for beef’ and ‘dairy’ with large areas of irrigated land.

The nature of water quality data makes it very difficult to demonstrate the statistical significance of an apparent trend in the observations. For this reason, emerging trends (as defined in Appendix 2) are also reported. Much of the TN and TP concentration data are correlated to flow and/or season, thus the data have been flow corrected at the sites that have overlapping flow and nutrient data records. For example, at site 612039 (Wellesley River, Juegenup) the observed trends in the flow-corrected TP data are statistically significant, whereas the trends in the uncorrected data are not. Measurement of flow at all sites – to enable flow correction – would enable the detection of more statistically significant trends.

Table 3.2 TN status and trends in the Brunswick and Collie river basin (612)

			TN			
Site	**Context name**	**Site name**	**Data record**	**Trend (All)**	**Status (2006-08)/ median**	**Trend (2006-08)**
Parkerfield Drain						
6121173	Leschenault	Parkfield Drain	1996-2008		1.2	
Wellesley						
6121184	Mangosteen Drain	Leitch Road	2006-2008		2.6	**Inc**
6121220	Wellesley River	Hope Ave	2006-2008		3.1	
6121221	Bindiup Creek	Bernies	2006-2008		1.8	
6121187	Mornington Creek	Campbell Road	2006-2008		1.6	
6121229	Wellesley River	Kemerton Bridge	2007-2008		1.85	
612039	Wellesley River	Juegenup	1992-2008		1.45	E Inc
	Trend in Residuals			E Inc		E Inc
Upper Brunswick						
612047	Brunswick River	Beela	1998-2008		0.315	
	Trend in Residuals					
Lower Brunswick						
6121195	Brunswick River	Caravan Park	2005-2008	E Inc	0.39	
6121130	Brunswick River	Wellesley Road	2004-2008	E Inc	0.38	
6121203	Elvira Gully	Elvira Gully	2004-2008		2.8	
612032	Brunswick River	Cross Farm	1992-2008		1.2	
	Trend in Residuals					
6121162	Brunswick River	Brunswick 2	1996-2008		1.2	
Lower Collie						
612013	Collie River	Wellington Flume	2005-2008		0.47	
612043	Collie River	Rose Road	1995-2008		0.4	
	Trend in Residuals					
6121168	Collie River	Collie 4	1996-2008	E Dec	0.49	
6121222	Henty Brook	Henty	2006-2008		0.67	
6121223	Canal to Henty	Near Henty	2006-2008		1.1	
6121225	Millars Creek	Millars	2006-2008		1.55	
6121226	Collie River	Hands Street	2006-2008		1.3	
6121230	Taverner Road	Hynes Road	2007-2008		2.05	
612015	Vindictive Drain	Harris Road	1992-2008		2.25	

E = Emerging, Inc = Increasing, Dec = Decreasing.

Table 3.3 TP status and trends in the Brunswick and Collie river basin (612)

			TP			
Site	**Context name**	**Site name**	**Data record**	**Trend (All)**	**Status (2006-08)/ median**	**Trend (2006-08)**
Parkerfield Drain						
6121173	Leschenault	Parkfield Drain	1996-2008		0.052	
Wellesley						
6121184	Mangosteen Drain	Leitch Road	2006-2008		0.365	E Inc
6121220	Wellesley River	Hope Ave	2006-2008		0.305	
6121221	Bindiup Creek	Bernies	2006-2008		0.135	
6121187	Mornington Creek	Campbell Road	2006-2008		0.15	
6121229	Wellesley River	Kemerton Bridge	2007-2008		0.205	
612039	Wellesley River	Juegenup	1992-2008		0.17	E Inc
	Trend in Residuals			**Inc**		**Inc**
Upper Brunswick						
612047	Brunswick River	Beela	2002-2008		0.011	
	Trend in Residuals			**Dec**		E Dec
Lower Brunswick						
6121195	Brunswick River	Caravan Park	2005-2008		0.012	
6121130	Brunswick River	Wellesley Road	2004-2008		0.014	
6121203	Elvira Gully	Elvira Gully	2004-2008		0.42	
612032	Brunswick River	Cross Farm	1992-2008		0.12	
	Trend in Residuals					
6121162	Brunswick River	Brunswick 2	1996-2008		0.11	
Lower Collie						
612013	Collie River	Wellington Flume	2005-2008		< 0.005	
612043	Collie River	Rose Road	1995-2008		0.01	
	Trend in Residuals					
6121168	Collie River	Collie 4	1996-2008	E Dec	0.018	
6121222	Henty Brook	Henty	2006-2008		0.017	
6121223	Canal to Henty	Near Henty	2006-2008		0.039	
6121225	Millars Creek	Millars	2006-2008		0.09	
6121226	Collie River	Hands Street	2006-2008		0.026	
6121230	Taverner Road	Hynes Road	2007-2008		0.18	
612015	Vindictive Drain	Harris Road	1992-2008		0.235	

E = Emerging, Inc = Increasing, Dec = Decreasing.

Table 3.4 TN status and trends in the Ferguson and Preston river basin (611)

			TN			
Site	**Context name**	**Site name**	**Data record**	**Trend (All)**	**Status (2006-08)/ median**	**Trend (2006-08)**
Ferguson						
611017	Ferguson River	Doudell Road	1998-2001		0.74	
6110055	Ferguson River	Canal	2006-2008		2.1	
611007	Ferguson River	SW Hwy Ferguson	1992-2008	E. Dec	0.805	
	Trend in Residuals			E. Dec		
Middle/Upper Preston						
611001	Preston River Trib	Mumballup Road	2006-2008		0.30	
6111002	Preston River	Bridge No 751	2006-2008		0.83	
6110059	Preston River	Mandalay	2006-2008		0.925	
611009	Preston River	Lowden Road	2006-2008		0.525	
	Trend in Residuals					
611111	Thomson Brook	Woodperry	1997-2008		0.73	
6110058	Thomson Brook	Brookhampton	2006-2008		0.53	
6111040	Thomson Brook	Donnybrook-Boyup	2006-2008		0.465	
611005	Preston River	Upstream Joshua	2006-2008		0.345	
6110056	Joshua Creek	Joshua	2006-2008		0.56	
611004	Preston River	Boyanup Bridge	1987-2008	E. Dec	0.33	E. Inc
	Trend in Residuals			E. Dec		
6111043	Preston River	Preston 1	1996-2008		0.42	E. Dec
Lower Preston						
6110060	Rec Rd	Recreation Road	2006-2008		0.8	
6111035	Crooked Brook	South West Hwy	2006-2008		1.5	
6111058	Preston River	Dardanup Road	2006-2008		0.335	
6111059	Canal	Meadow Road	2006-2008		1.9	
6121232	Charterhouse	St Marks Park Lake	2007-2008		1.1	
Coastal						
6121231	Punchbowl Canal	Hayward Road	2007-2008		2.1	

E = Emerging, Inc = Increasing, Dec = Decreasing.

Table 3.5 TP status and trends in the Ferguson and Preston river basin (611)

			TP			
Site	**Context name**	**Site name**	**Data record**	**Trend (All)**	**Status (2006-08)/ median**	**Trend (2006-08)**
Ferguson						
611017	Ferguson River	Doudell Road	1998-2001		0.021	
6110055	Ferguson River	Canal	2006-2008		0.17	
611007	Ferguson River	SW Hwy Ferguson	1992-2008		0.026	
	Trend in Residuals					
Middle/Upper Preston						
611001	Preston River Trib	Mumballup Road	2006-2008		0.006	
6111002	Preston River	Bridge No 751	2006-2008		0.01	E Inc
6110059	Preston River	Mandalay	2006-2008		0.028	
611009	Preston River	Lowden Road	2006-2008		0.011	
	Trend in Residuals					
611111	Thomson Brook	Woodperry	2002-2008		0.016	
6110058	Thomson Brook	Brookhampton	2006-2008		0.0165	
6111040	Thomson Brook	Donnybrook-Boyup	2006-2008		0.011	
611005	Preston River	Upstream Joshua	2006-2008		0.01	
6110056	Joshua Creek	Joshua	2006-2008		0.018	
611004	Preston River	Boyanup Bridge	1983-2008		0.012	
	Trend in Residuals					
6111043	Preston River	Preston 1	1996-2008		0.021	
Lower Preston						
6110060	Rec Rd	Recreation Road	2006-2008		0.023	
6111035	Crooked Brook	South West Hwy	2006-2008		0.06	
6111058	Preston River	Dardanup Road	2006-2008		0.011	
6111059	Canal	Meadow Road	2006-2008		0.12	
6121232	Charterhouse	St Marks Park Lake	2007-2008		0.028	
Coastal						
6121231	Punchbowl Canal	Hayward Road	2007-2008		0.066	

E = Emerging, Inc = Increasing, Dec = Decreasing.

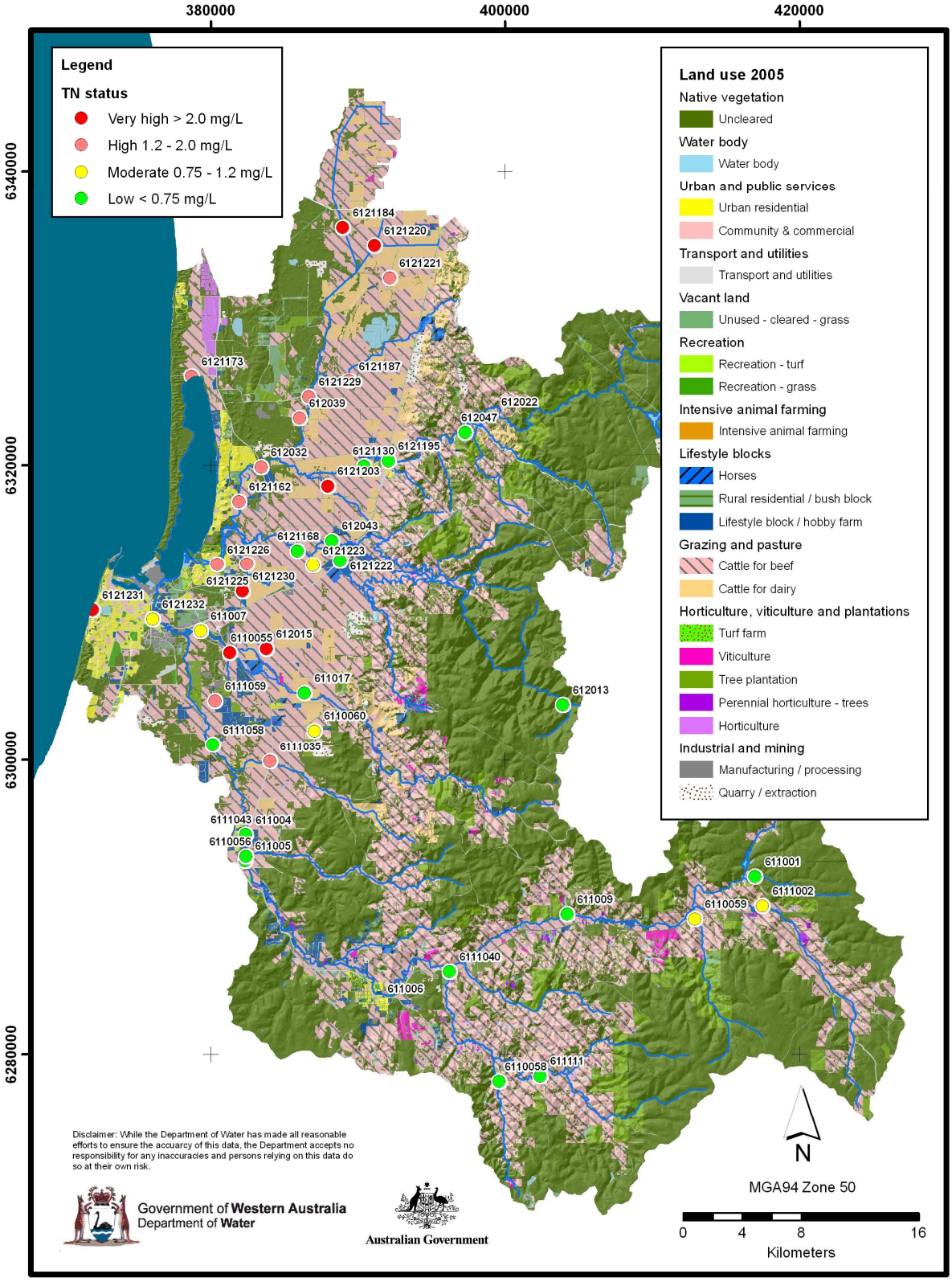


Figure 3.1 Land use and TN status in the Leschenault catchment

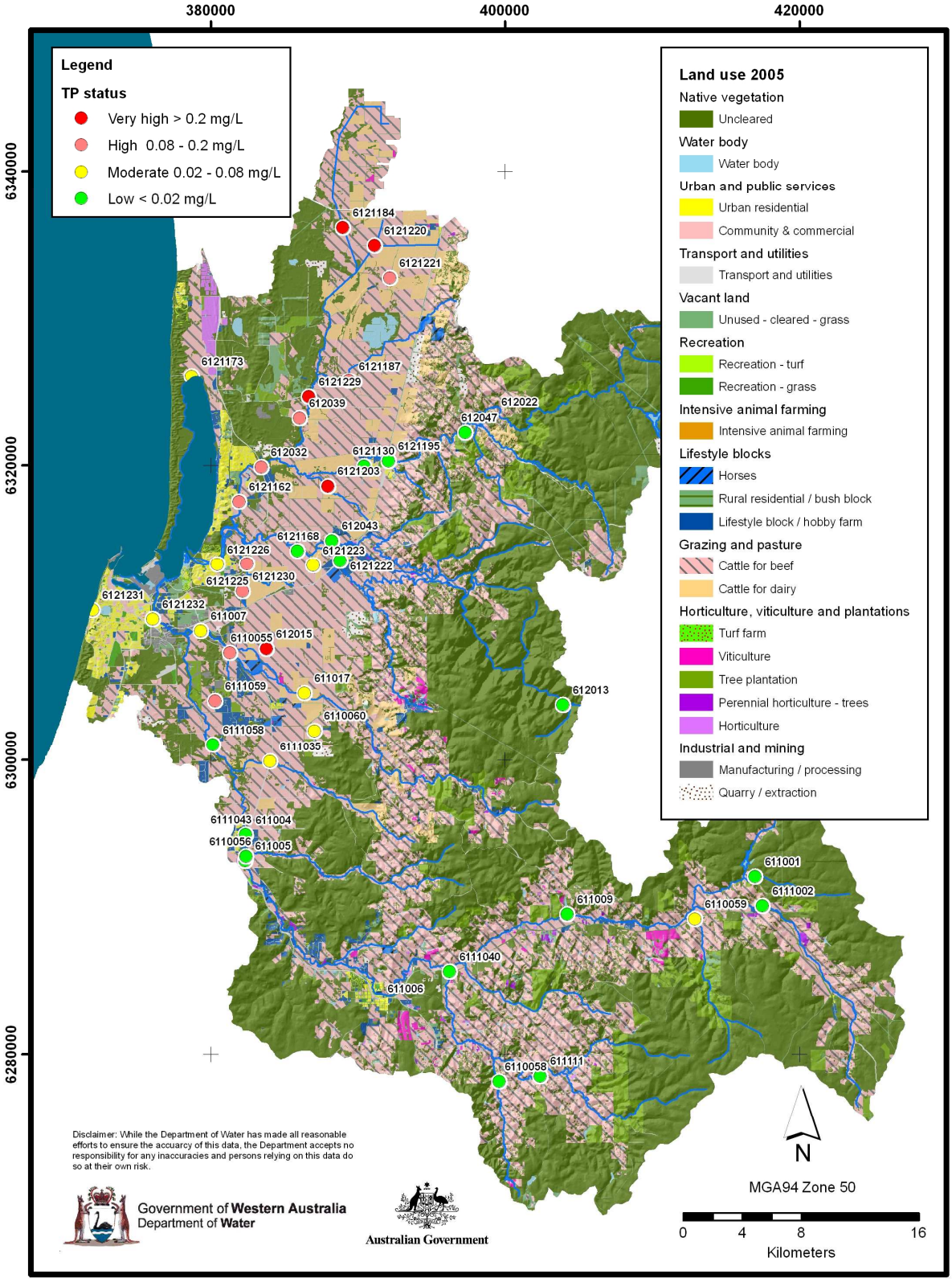


Figure 3.2 Land use and TP status in the Leschenault catchment

3.3 Loads

Loads were calculated using the LOESS algorithm, as discussed in Section 2.1.3, at the nine sites shown in tables 3.6 and 3.7. Load calculations for 611009 also included 11 TN and 12 TP data points from 6111046, which is 400 m downstream.

Table 3.6 TN and TP loads at gauging station sites in the Wellesley, Brunswick and Lower Collie catchments

612032 Brunswick River, Cross Farm

Year	Annual flow (ML)	Annual TN load (tonnes)	Annual TP load (tonnes)
1992	169 063	268	32
1993	136 601	203	23
1994	107 801	155	18
1995	158 640	263	33
1996	240 536	436	58
1997	94 499	128	14
1998	85 732	124	13
1999	135 914	200	22
2000	117 164	182	21
2001	36 714	47	4.6
2002	100 332	151	16
2003	103 692	151	18
2004	99 744	152	18
2005	168 254	271	35
2006	55 396	77	8.3
2007	117 053	181	21
Average (1998-2007)	**101 999**	**154**	**18**

612039 Wellesley River, Juegenup

Year	Annual flow (ML)	Annual TN load (tonnes)	Annual TP load (tonnes)
1992	83 557		**22**
1993	59 152		**13**
1994	52 416		**11**
1995	67 124		**17**
1996	98 517		**26**
1997	64 692		**15**
1998	50 089	102	**12**
1999	72 343	151	**18**
2000	68 332	154	**18**
2001	19 149	33	**4**
2002	53 710	115	**13**
2003	54 273	113	**14**
2004	52 993	113	**13**
2005	83 051	183	**21**
2006	26 952	53	**6**
2007	62 650	140	**17**
Average (1998-2007)	**54 354**	**116**	**14**

612043 Collie River, Rose Road

Year	Annual flow (ML)	Annual TN load (tonnes)	Annual TP load (tonnes)
1997	71 095	40	2.11
1998	43 405	26	0.89
1999	105 496	63	2.10
2000	95 295	59	1.92
2001	31 684	17	0.53
2002	44 950	25	1.00
2003	36 544	20	0.69
2004	39 336	22	0.70
2005	77 153	43	1.46
2006	23 207	12	0.38
2007	52 111	29	0.94
Average (1998-2007)	**54 918**	**32**	**1.1**

612013 Collie River, Wellington Flume

Year	Annual flow (ML)	Annual TN load (tonnes)	Annual TP load (tonnes)
1998	75 687	37	0.34
1999	134 025	59	0.46
2000	121 935	57	0.46
2001	79 305	39	0.35
2002	64 179	32	0.29
2003	64 778	32	0.30
2004	65 543	33	0.30
2005	88 645	41	0.35
2006	54 170	27	0.26
2007	74 177	37	0.34
Average (1998-2007)	**82 244**	**40**	**0.34**

612047 Brunswick River, Beela

Year	Annual flow (ML)	Annual TN load (tonnes)	Annual TP load (tonnes)
2001	15 405	7	
2002	33 267	19	0.7
2003	38 037	21	0.9
2004	44 915	27	1.2
2005	75 817	46	2.3
2006	22 915	12	0.5
2007	48 259	32	1.5
Average (2001-2007)	**39 802**	**24**	**1.2**

Table 3.7 TN and TP loads at flow sites in the Ferguson and Preston catchments

611004 Preston River, Boyanup Bridge

Year	Annual flow (ML)	Annual TN load (tonnes)	Annual TP load (tonnes)
1998	66 817	63	1.8
1999	146 247	155	4.7
2000	110 892	121	3.7
2001	14 268	8	0.3
2002	67 777	63	1.8
2003	71 666	66	2.0
2004	68 351	63	1.9
2005	104 142	98	3.4
2006	28 087	23	0.7
2007	77 279	76	2.3
Average (1998-2007)	**75 553**	**74**	**2.3**

611009/6111046* Preston River, Lowden Road Bridge

Year	Annual flow (ML)	Annual TN load (tonnes)	Annual TP load (tonnes)
2000	26 794	34	0.59
2001	3 956	2.1	0.04
2002	16 463	16	0.27
2003	20 650	23	0.40
2004	21 893	25	0.43
2005	34 325	41	0.70
2006	11 578	11	0.19
2007	28 820	35	0.60
Average (2000-2007)	**20 560**	**24**	**0.40**

**Sites 611009 and 6111046 are co-located*

611007 Ferguson River, SW Hwy Ferguson

Year	Annual flow (ML)	Annual TN load (tonnes)	Annual TP load (tonnes)
1992	47 597	67	5.0
1993	37 158	55	3.6
1994	28 158	37	2.0
1995	28 684	41	2.6
1996	52 363	87	6.8
1997	22 226	27	1.3
1998	10 335	11	0.4
1999	12 953	15	0.7
2000	35 050	55	4.1
2001	11 864	12	0.5
2002	18 967	25	1.2
2003	17 659	21	1.1
2004	23 530	32	1.8
2005	30 656	45	3.5
2006	15 189	22	1.7
2007	29 126	46	3.4
Average (1998-2007)	**20 533**	**28**	**1.8**

611111 Thomson Brook, Woodperry Homestead

Year	Annual flow (ML)	Annual TN load (tonnes)	Annual TP load (tonnes)
1997	9 657	10	*
1998	6 906	7.5	*
1999	17 615	21	*
2000	19 546	27	*
2001	1 424	1.1	*
2002	8 666	10	0.20
2003	7 583	8.0	0.18
2004	6 314	6.6	0.14
2005	10 991	12	0.29
2006	2 848	3.0	0.07
2007	7 948	8.6	0.20
Average (1998-2007)	**8 984**	**10**	**0.18**

**TP 1996-2001 LOR=0.4mg/L*

4 Recommendations for future sampling

The current sampling regime (from October 2008) is specified in the current sampling and analysis plan (SAP) (Kelsey 2008, unpubl.). In summary, the following analytes are to be determined in water samples collected from each site or by in-situ measurement:

- total nitrogen (TN)
- total phosphorus (TP)
- total suspended solids (TSS)
- dissolved organic nitrogen (DON)
- dissolved organic carbon (DOC)
- total organic carbon (TOC)
- ammonia (NH_3)
- nitrate + nitrite (NOx)
- soluble reactive phosphorus (SRP)
- colour (hazen)
- in-situ measurements – pH, turbidity, dissolved oxygen, temperature, uncompensated conductivity, salinity (Hydrolab).

The 22 sites included in the SAP are listed in Table 4.1 and their locations are shown in Figure 4.1. Six additional sites are shown in Table 4.1: these have been omitted from the current SAP, but should be re-considered for future sampling based on their TN and TP status, which are included below.

Coastal catchment in Bunbury:

Punchbowl Canal (Hayward Road) AWRC Code: 6121231

	Period	Status	Trend
TN	2007–2008	2.1	None
TP	2007–2008	0.066	None

This site drains to the ocean and gives an indication of the water quality in ‘urban’ land use.

Lower Collie catchment:

Taverner Road Canal (Hynes Road) AWRC Code: 6121230

	Period	Status	Trend
TN	2007–2008	2.05	None
TP	2007–2008	0.18	None

This site is on a small tributary in the Collie Lower 1 catchment, downstream of ‘lifestyle’ and ‘cattle for beef’ land uses.

Wellesley River catchment:

Wellesley River (Hope Ave) AWRC Code: 6121220

	Period	Status	Trend
TN	2006–2008	3.1	None
TP	2006–2008	0.305	None

This site has the highest observed median TN concentration. The water quality in the Wellesley catchment seems to be worsening.

Ferguson River catchment:

Ferguson River (Canal) AWRC Code: 6110055

	Period	Status	Trend
TN	2006–2008	2.1	None
TP	2006–2008	0.17	None

This tributary of the Ferguson has the highest TN and TP concentrations in the Ferguson and Preston river basin. It is downstream of 'cattle for beef' and 'lifestyle' land uses.

The following two sites are in the estuarine portions of the Collie and Brunswick rivers.

Collie River (Hands Street) AWRC Code: 6121226

	Period	Status	Trend
TN	2006–2008	1.3	None
TP	2006–2008	0.026	None

This site is 1.7 km upstream of the estuary, and is a culvert in a drain delivering to the Collie River. It is extremely unlikely to be affected by tidal influence, and provides useful data on nutrient concentrations from 'urban residential' land use.

Brunswick River (Brunswick 2) AWRC Code: 6121162

	Period	Status	Trend
TN	2006–2008	1.2	None
TP	2006–2008	0.11	None

This site is in the Brunswick River's lower reaches, 7 km from the estuary and 3.6 km downstream of site 612032. It is approximately 3 km upstream of the confluence of the Brunswick and Collie rivers, and is unlikely to be affected by tidal influence. Thus it would provide useful data because it is situated in an urban residential area, downstream of 'cattle for beef' and 'urban residential' (Australind) land uses.

The inclusion of 611006 (Preston River, Donnybrook) in the current SAP should be examined. Although this site is a flow-gauging station, there are no time-series data for this

site in the Hydstra database. There are five measurements of each of TN and TP from September 2007, with average values of 0.37 mg/L and 0.011 mg/L respectively, indicating low status.

Table 4.1 Sampling sites included in the current SAP, and proposed new sites (in grey)

AWRC ref	Site name	River	Easting (m)	Northing (m)
611004	Boyanup Bridge	Preston River	382376	6294890
611006	Donnybrook	Preston River	391615	6283971
611007	SW Hwy Ferguson	Ferguson River	379339	6308748
611009	Lowden Road Bridge	Preston River	404229	6289535
611017	Doudell Road Bridge	Ferguson River	386366	6304542
611111	Woodperry Homestead	Thomson Brook	402389	6278548
612013	Wellington Flume	Collie River	403939	6303748
612032	Cross Farm	Brunswick River	383436	6319879
612039	Juegenup Wellesley	Wellesley River	386039	6323198
612043	Rose Road	Collie River	388239	6314898
612047	Beela	Brunswick River	397306	6322230
6111035	South West Hwy	Crooked Brook	384039	6299898
6110056	Joshua	Joshua Creek	382420	6293450
6111058	Dardanup Rd	Preston River	380149	6301016
6121173	Parkfield Drain	Leschenault Estuary	378716	6326063
6121184	Leitch Road	Mangosteen Drain	388990	6336128
6121187	Campbell Road	Mornington Creek	389393	6325756
6121195	Caravan Park Brunswick	Brunswick River	392075	6320303
6121203	Elvira Gully	Elvira Gully	387969	6318597
6121222	Henty	Henty Brook	388805	6313527
6121225	Millars	Millars Creek	382457	6313317
6121232	St Marks Park Lake	Charterhouse Street	376060	6309552
6121230	Hynes Road	Taverner Road Canal	382177	6311440
6121231	Hayward Road	Punchbowl Canal	371981	6310166
6121220	Hope Ave	Wellesley River	391136	6334920
6110055	Canal	Ferguson River	381310	6307274
6121226	Hands Street	Collie River	380459	6313284
6121162	Brunswick 2	Brunswick River	381946	6317536

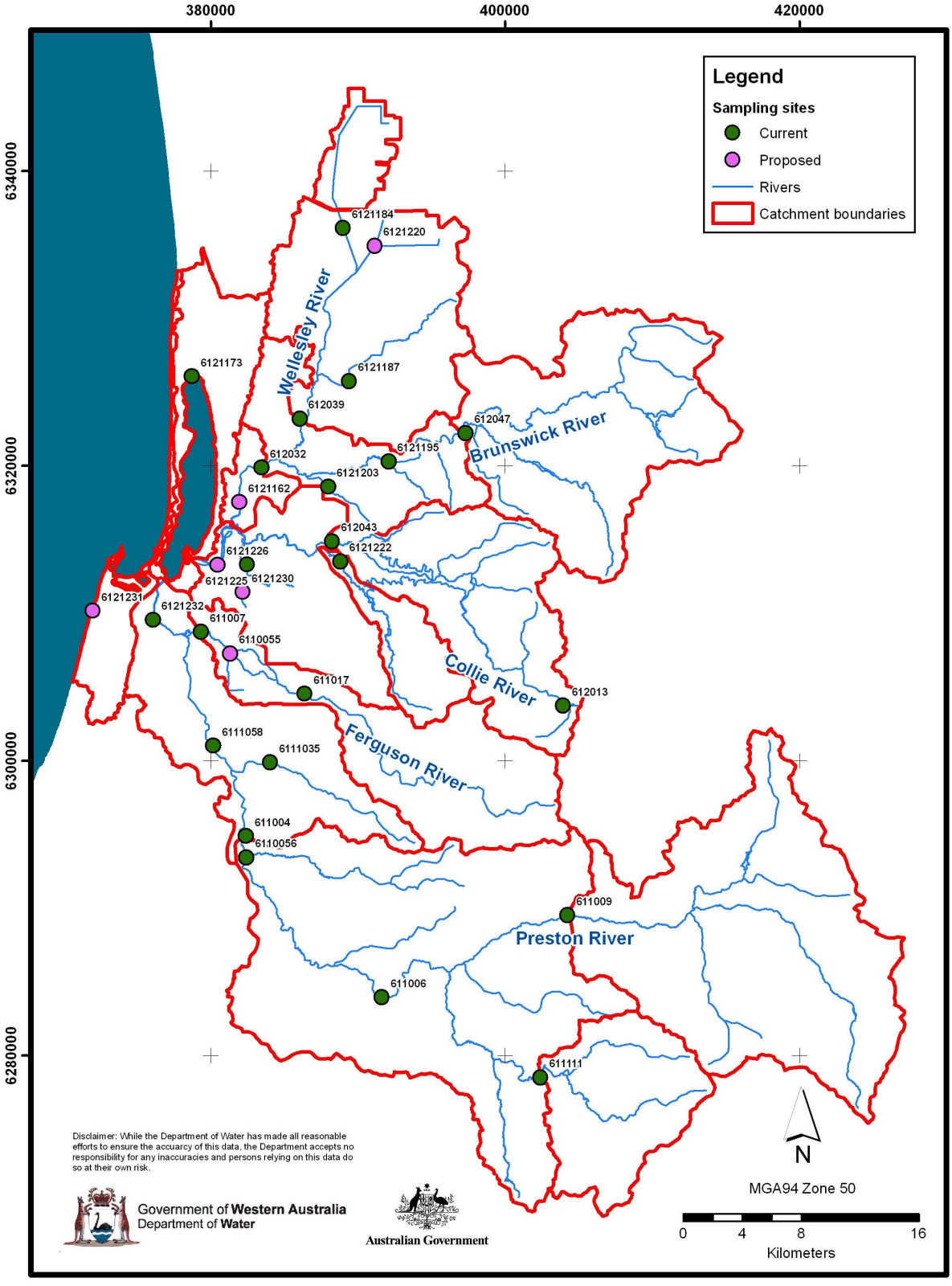


Figure 4.1 Current and proposed nutrient sampling sites in the Leschenault catchment

5 Conclusions

This report describes TN and TP status and trend analyses for 42 sites in the Leschenault catchment for the period 2006 to 2008. Generally, the sampling sites on the Darling Plateau display low status, indicating good water quality; while those on the coastal plain display moderate, high and very high status, indicating poor water quality. The coastal plain and the broad river valleys east of the plateau contain large areas of land used for cattle raising for beef and dairy, horticulture and viticulture. These land uses, along with urban areas, are usually associated with degraded water quality.

Of the 22 sites sampled in the Brunswick and Collie river basins, only seven have low status. The Wellesley catchment has the worst water quality due to intensive, irrigated land uses. 6121220 (Wellesley River, Hope Ave) has the highest median TN concentration of 3.1 mg/L (TP concentration is 0.30 mg/L) and 6121184 (Mangosteen Drain, Leitch Road) has the highest median TP concentration of 0.365 mg/L (TN concentration is 2.6 mg/L). The Leitch Road site also displays an increasing trend for TN and an emerging increasing trend for TP.

Of the 20 sites in the Ferguson and Preston river basin, 11 have low status. There are only two sites in this basin with very high TN status: 6110055 (Ferguson River, Canal) and 6121231 (Punchbowl, Hayward Road), which is sited in Bunbury and drains to the coast. There are no sites with very high status for TP.

Generally the nutrient status at the sampling sites can be linked to upstream land uses and soil type. Figure 3.1 and Figure 3.2 display the TN and TP status superimposed on the land use map. The sources of nutrient pollution are discussed in detail in the accompanying document, *Nutrient-export modelling of the Leschenault catchment* (DoW 2010).

Trends in nutrient concentration are difficult to detect because of the large natural variation inherent in the data. However, for the period 2006 to 2008 inclusive, increasing trends in TN and TP concentration are apparent at the Wellesley catchment sites 6121184 (Mangosteen Drain, Leitch Road) and 612039 (Wellesley River, Juegenup). These sites have very high or high status for both TN and TP. Because 612039 is located 4 km upstream of the confluence of the Wellesley and Brunswick rivers, the water quality at this site is representative of most of the Wellesley catchment. The high status for both TN and TP is a result of the intensive irrigated land uses, with the increasing trends indicating recent intensification of land use.

There is only one other trend in the catchment that is statistically significant – the decreasing trend in flow-corrected TP data at 612047 (Brunswick River, Beela), for 2002 to 2008 inclusive. However this downward trend is not apparent in the uncorrected data, with the three-year median TP values remaining fairly static for the past three years; that is, 0.012 mg/L (2004 to 2006), 0.011 mg/L (2005 to 2007) and 0.012 mg/L (2006 to 2008).

Three other (not statistically significant) trends are evident in the 2006 to 2008 data. Interestingly there is an emerging increasing TN trend in the 611004 (Preston River, Boyanup Bridge) data, whereas an emerging decreasing trend is apparent in the TN data from 6111043 (Preston River, Preston 1), which is 40 m downstream. This is evidence of the variability of river nutrient data. To determine exactly what is happening, intensive sampling at both sites in all flow regimes would need to be undertaken. There is also an emerging increasing TP trend at 6111002 (Preston River, Bridge No. 751) in the upper Preston River.

Annual TN and TP loads have been calculated at five gauging-station sites in the Brunswick and Lower Collie catchments, including the output of Wellington Dam, and at four sites in the Ferguson and Preston catchments. These data have been used to calibrate the nutrient export model discussed in *Nutrient-export modelling of the Leschenault catchment* (DoW 2010).

The current sampling regime for the Leschenault catchment includes 22 sites. Status and trends have been analysed for 21 of these in this report; site 611006 (Preston River, Donnybrook) has not been analysed. It may be appropriate to amend the sampling regime to include some of the sites highlighted in this report that have high or very high status, including 6121231 (Punchbowl Canal, Hayward Road), 6121230 (Taverner Road Canal, Hynes Road), 6121220 (Wellesley River, Hope Ave), 6110055 (Ferguson River, Canal), 6121226 (Collie River, Hands Street) and 6121162 (Brunswick River, Brunswick 2).

Appendices

A1 Data analysis techniques

A1.1 Trend analysis

Nutrient data series contain the following sources of variation:

- flow variation
- seasonal variation
- trend
- random components.

Changes brought about by human activity will usually be superimposed on natural sources of variation. In this report, the influence of flow and seasonal variation are examined and corrected for, before the analysis for trend. Thus the observed trends in nutrient concentration are (more than likely) linked to human intervention or influences within the catchment.

This report uses non-parametric tests to identify statistically-significant trending periods in the nutrient data series. Non-parametric techniques are used because they are not affected by a non-normal distribution of data, and they are not sensitive to outliers, or affected by missing or censored data (Loftis et al. 1991). An assumption of the trend tests is that the trends are monotonically increasing or decreasing (Helsel & Hirsch 1992). If concentrations vary non-monotonically over the period being analysed, the results of linear tests for trend may be misleading (Robson & Neal 1996). Another assumption of the trend tests is that measurements in the data series are independent. If the data are not independent (i.e. they exhibit auto-correlation), the risk of falsely detecting a trend is increased (Esterby 1996). A correlated data series contains surplus data and ultimately results in little or no net information gain. As a rule, the level of serial correlation in a data series increases as the frequency of sampling increases. The maximum sampling frequency possible without encountering serial correlation can be thought of as the point of information saturation.

A1.1.1 Testing for statistically significant changes

The Mann-Kendall test is used to determine the statistical significance of the trends in water quality over time (Gilbert 1987). It is a non-parametric test and is only used when the data series exhibits independence; that is, no correlation in the data series (Figure A1.1, (A) and (B)). The Mann-Kendall test involves calculating a statistic ‘S’ and testing the significance of this statistic. Each data pair is compared and assigned a plus or a minus depending on whether the value of the latter data point is higher than the former. ‘S’ is the sum of pluses and minuses (where one plus cancels out one minus) for the whole dataset. A negative value of S indicates the occurrence of more minuses than pluses. The Z-statistic, from which the ‘p-value’ is derived, is calculated as follows:

$$Z = \frac{S-1}{[Var(S)]^{1/2}} \qquad \text{if S > 0}$$

$$Z = 0 \qquad \text{if S = 0}$$

$$Z = \frac{S+1}{[Var(S)]^{1/2}} \qquad \text{if S < 0}$$

where Var(S) is the variance of the dataset used to derive 'S'. An increasing trend will have a large positive Z-statistic, while the Z statistic for a decreasing trend will be negative and have a large absolute value.

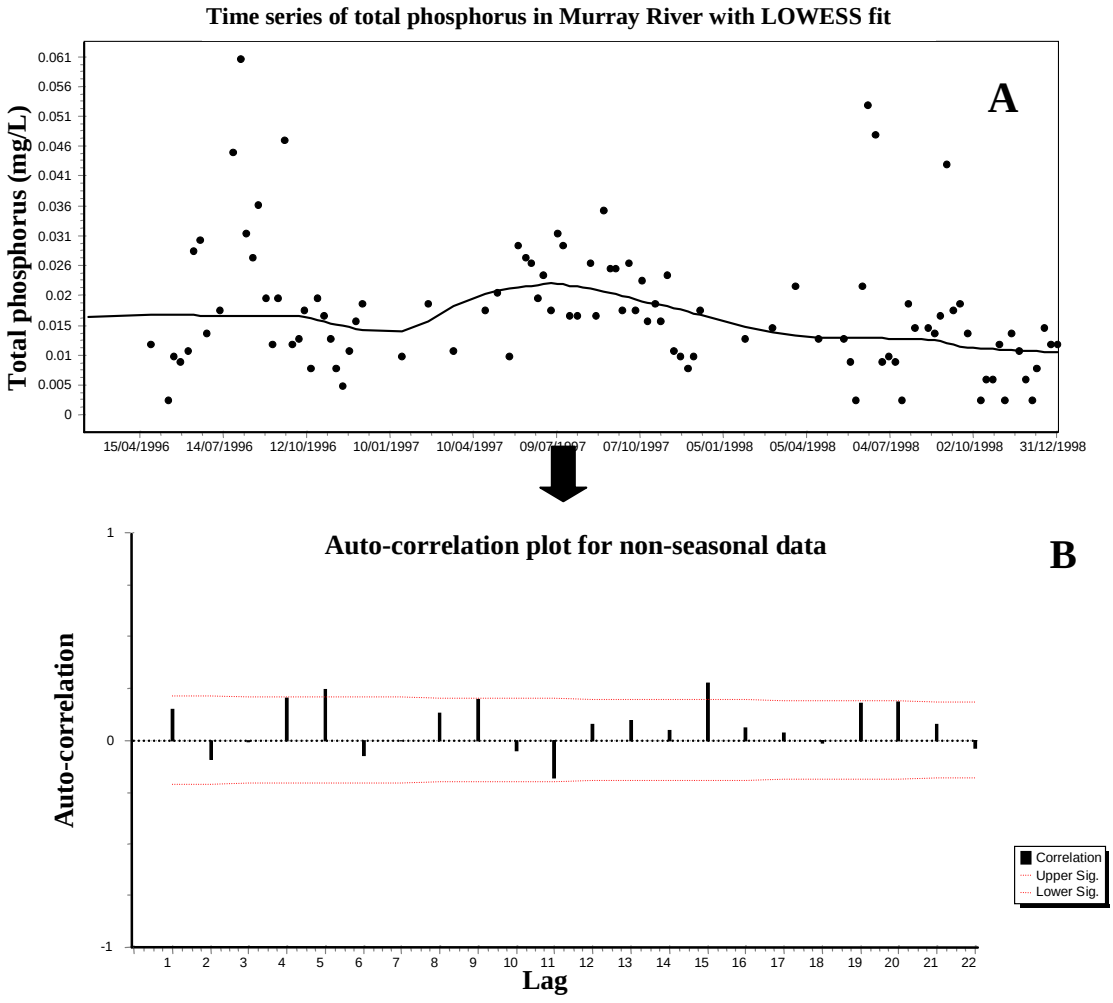


Figure A1.1*: Example of a time-series with little evidence of a seasonal pattern in total phosphorus concentration (A). The auto-correlation plot (B) shows that the data are independent of each other; hence, the Mann-Kendall test for trend is used.*

Seasonal cycles in nutrient concentration are common in waterways and can be introduced by natural cycles in rainfall, runoff, tributary hydrology and seasonal variation in groundwater. When seasonal cycles are evident in a data series (Figure A1.2 (A) and (B)) the Seasonal-

Kendell test is used to test for trend. The Seasonal-Kendell test is a variant of the Mann-Kendall test that accounts for the presence of seasonal cycles in the data series (Gilbert 1987). The 'S' value is calculated slightly differently in the Seasonal-Kendall test. Rather than comparing all data pairs, only data points falling in the same 'season' are compared. For example, if a weekly season is used, data points from the first weeks of the year are only compared with data points from the first week of all other years.

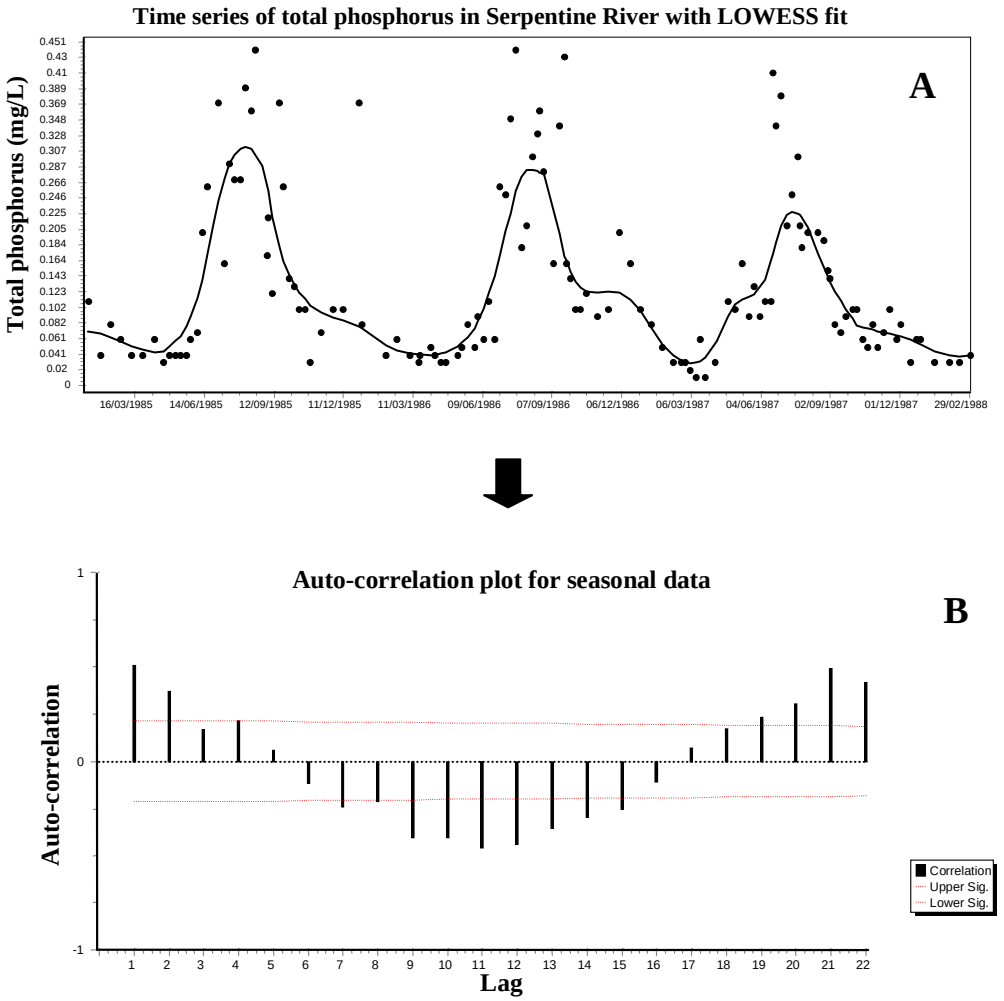


Figure A1.2: *An example of a pronounced seasonal pattern in total phosphorus concentration (A). The auto-correlation plot (B) shows an oscillating seasonal pattern and indicates that the data are dependent or contain memory). Hence, the Seasonal-Kendall test for trend is used.*

Nutrient concentrations in waterways can also be affected by changes in flow. The relationship between nutrient concentration and flow is modelled using locally estimated scatterplot smoothing (LOESS) or locally-weighted scatterplot smoothing (LOWESS) fit between the concentration and flow (Cleveland 1974; Helsel & Hirsch 1992). The difference of 'residuals' between the observed and LOESS or LOWESS modelled concentration are termed flow-adjusted concentrations (FAC), as shown in Figure A1.3(A) (Hipel & McLeod

1994). Trend analyses may then be performed on the flow-adjusted concentrations. The flow-adjustment process often helps to remove seasonal variation (as shown by comparing Figures A1.2(A) and A1.3(B)), although some evidence of seasonal variation often remains in the flow-adjusted data series.

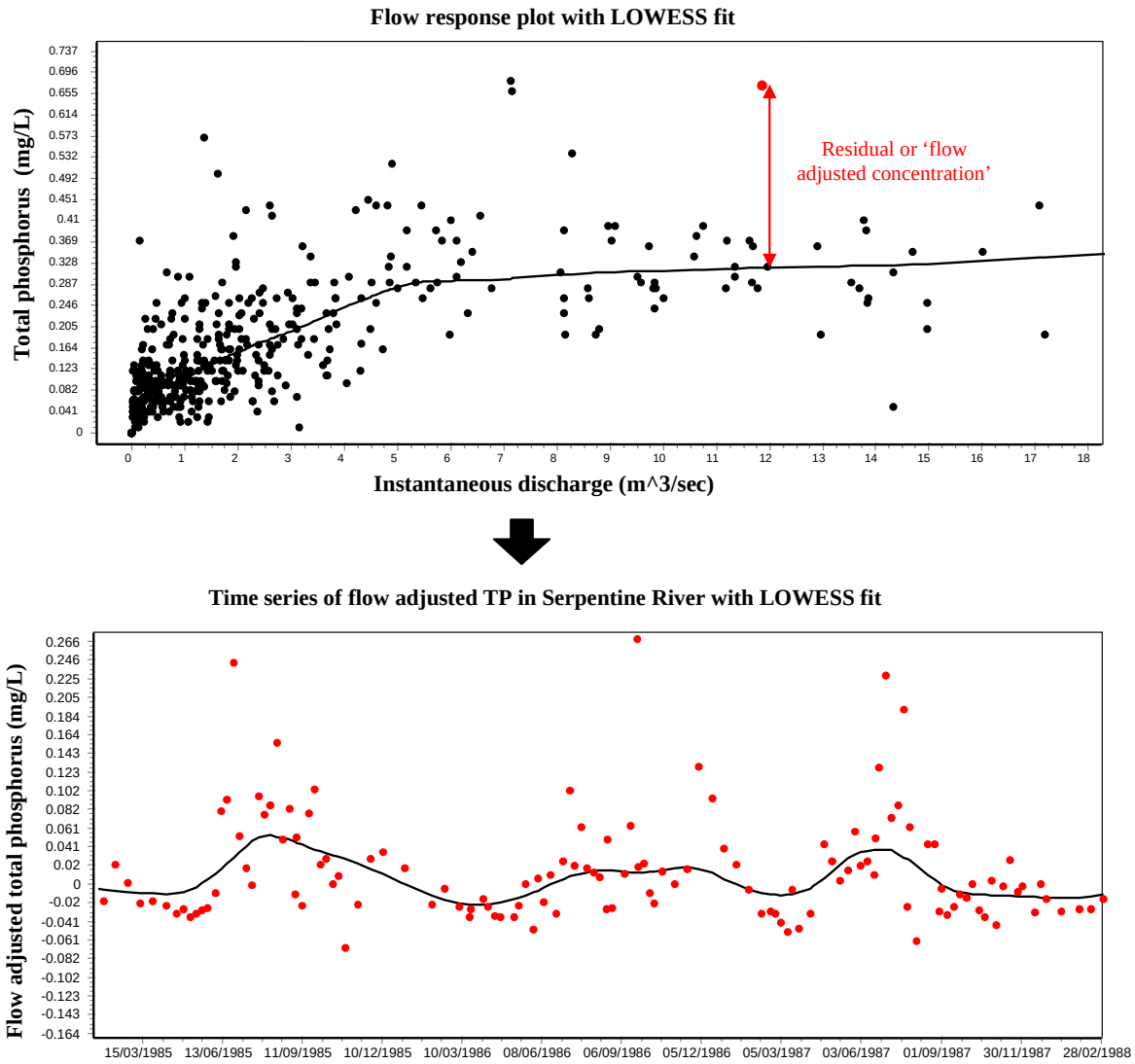


Figure A1.3: *The flow response plot (A) shows whether a relationship exists between discharge and nutrient concentration. If a relationship is evident (as in (A)) the series are adjusted for the effects of flow. The flow-adjusted concentration (or residuals) is the difference between observed and modelled (LOWESS) concentration. The flow adjustment processes tend to remove the effects of flow from the data, the effects of which can be shown by comparing Figure A1.2(A) with Figure A1.3(B), both constructed from the same raw dataset.*

A1.1.2 Estimating the rate of change

The Sen slope estimator is used to estimate the slope of the trend line (Gilbert 1987). The Sen estimate is calculated in a similar manner to the test statistic 'S' from the Mann-Kendell

test. Rather than comparing each data pair for an increase or decrease over time, a slope is calculated using each data pair. The Sen slope estimator is thus the median slope of all slopes calculated using all data pairs. Where seasonal cycles are evident, the Seasonal-Kendell slope estimator is used. This is similar to the seasonal test 'S' in the Season-Kendell test, in that slopes are only calculated for data pairs from the same season and the Sen slope estimator is the median of all these slopes. Figure A1.4 shows an example of a Sen slope estimated for a series showing seasonal variation.

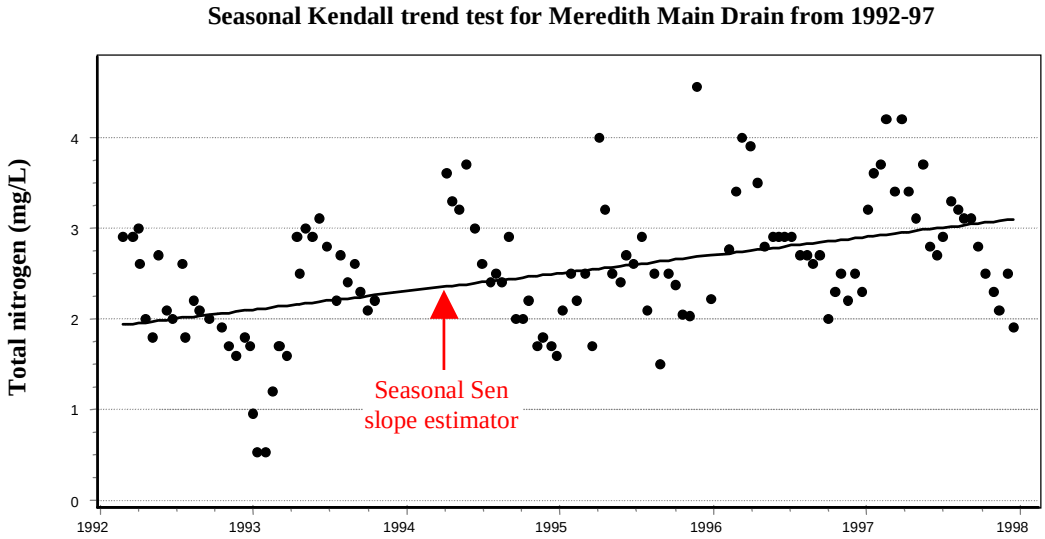


Figure A1.4: *An example of how the Seasonal Sen slope estimator represents the slope of the trend line in a seasonal nutrient data series. The Seasonal-Kendall test indicates that the trend is significant and has sufficient independent measurements. The Seasonal Sen slope estimator shows that total nitrogen concentration increased by approximately 0.006 mg/L per year between 1992 and 1998.*

A1.1.3 Detecting the trend

A trend in the nutrient data series is significant only when two criteria are met. Firstly, the Mann-Kendall or Seasonal-Kendall test for trend on the data series must be statistically significant (i.e. p <0.05). Secondly, the number of independent measurements collected (n^*) must be approximately equal to or exceed the 'estimated' number of independent measurements ($n^\#$) required to detect a trend.

The effective information content in the data series; that is, the effective number of independent measurements, is estimated for each of the data series analysed for trend using the following formula provided by Bayly and Hammersley (1946) (op. cit. Lettenmaier 1976; Lachance 1992; Close 1989; Zhou 1996).

$$n^* = \left[\frac{1}{n} + \frac{2}{n^2} \sum_{j=1}^{n-1} (n-j)\rho(jt) \right]^{-1}$$

where:

n^* = effective number of independent measurements

n = number of measurements

j = lag number

t = sampling interval

ρ = coefficient of correlation

Where seasonal cycles are evident, the nutrient data series are de-trended and de-seasonalised (using seasonal medians) before calculating the number of independent measurements (n^*). The estimated number of measurements needed to detect a linear trend (in a variable distributed normally about the trend line) is estimated using the following functions (Lettermair 1976; Ward et al. 1990):

$$n^{\#} = 12\sigma^2 \frac{\left[t_{\alpha/2,(n-2)} + t_{\beta,(n-2)} \right]^2}{\Delta^2}$$

where:

$n^{\#}$ = estimated number of measurements needed to detect a trend

σ = the standard deviation of the de-trended series

Δ = the magnitude of the trend

t = the critical values of the t-distribution where α = 0.05 and β = 0.1

This function relies on probabilities predicted by the t-distribution and is therefore from the parametric family of statistical procedures. Data requirements for parametric and the equivalent non-parametric tests are similar, so the equation will approximate the sample size needed for non-parametric tests of significance (Ward et al. 1990).

A2 Data for each site

Sites are ordered by AWRC ref number:

611001: Preston River Trib (Mumballup Road)
611004: Preston River (Boyanup Bridge)
611005: Preston River (Upstream Joshua Creek)
611007: Ferguson River (SW Hwy Ferguson)
611009: Preston River (Lowden Road Bridge)
611017: Ferguson River (Doudell Road Bridge)
611111: Thomson Brook (Woodperry Homestead)
6110055: Ferguson River (Canal)
6110056: Joshua Creek (Joshua)
6110058: Thomson Brook South (Brookhampton Road)
6110059: Preston River South (Mandalay)
6110060: Rec Rd (Recreation Road)
6111002: Preston River (Bridge No. 751)
6111035: Crooked Brook (South West Hwy)
6111040: Thomson Brook (Donnybrook-Boyup Road)
6111043: Preston River (Preston 1)
6111058: Preston River (Dardanup Road)
6111059: Canal (Meadow Road)
612013: Collie River (Wellington flume)
612015: Vindictive Drain (Harris Road)
612032: Brunswick River (Cross Farm)
612039: Wellesley River (Juegenup Wellesley)
612043: Collie River (Rose Road)
612047: Brunswick River (Beela)
6121130: Brunswick River (Wellesley Road Crossing)
6121162: Brunswick River (Brunswick 2)
6121168: Collie River (Collie 4)
6121173: Leschenault Estuary (Parkfield Drain)
6121184: Mangosteen Drain (Leitch Road)
6121187: Mornington Creek (Campbell Road)
6121195: Brunswick River (Caravan Park Brunswick)
6121203: Elvira Gully (Elvira Gully)
6121220: Wellesley River (Hope Ave)
6121221: Bindiup Creek (Bernies)
6121222: Henty Brook (Henty)
6121223: Canal to Henty (Near Henty)
6121225: Millars Creek (Millars)
6121226: Collie River (Hands Street)
6121229: Wellesley River (Kemerton Bridge)
6121230: Taverner Road Canal (Hynes Road)
6121231: Punchbowl Canal (Hayward Road)

Statistics for TN and TP data given for each site:

Status and trend in header are for 2006 to 2008 and are reported as:

- Increasing = statistically significant increasing trend
- E. Increasing = emerging increasing trend
- E. Increasing (S) = emerging increasing seasonal trend
- Decreasing = statistically significant decreasing trend
- E. Decreasing = emerging decreasing trend
- E. Decreasing (S) = emerging decreasing seasonal trend.

Data summary refers to all the TN and TP data collected at the site.

Statistics are for the whole data record.

611001: Preston River Trib (Mumballup Road)

	Period	Status	Trend
TN	2006–2008	0.3	None
TP	2006–2008	0.006	None

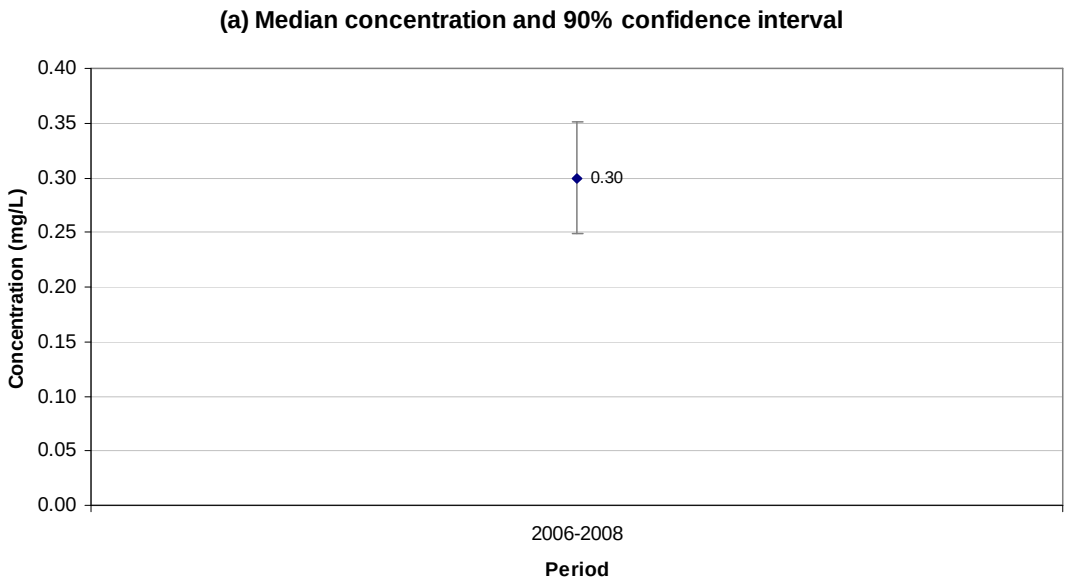
Data summary for 611001

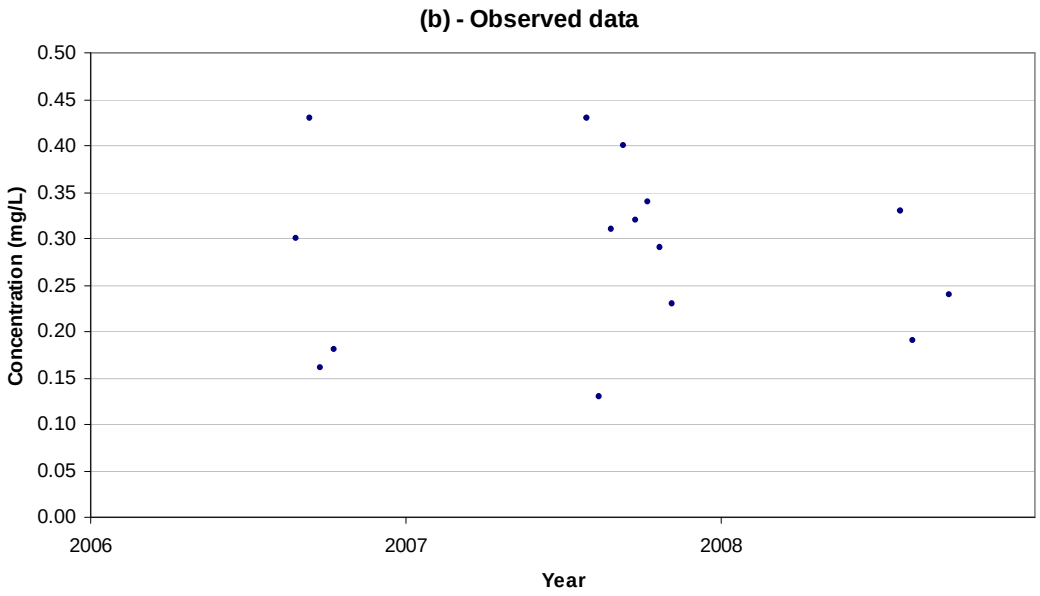
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	15	0	0	2006–2008
TP	15	0	4	2006–2008
Flow				1968–1973

Total nitrogen and total phosphorus statistics for 611001

Statistic	Total nitrogen	Total phosphorus
Median	0.3	0.006
5th percentile	0.151	< 0.005
95th percentile	0.43	0.014
Lowest concentration	0.13	< 0.005
Highest concentration	0.43	0.016

Total nitrogen – Preston River Trib (Mumballup Road)

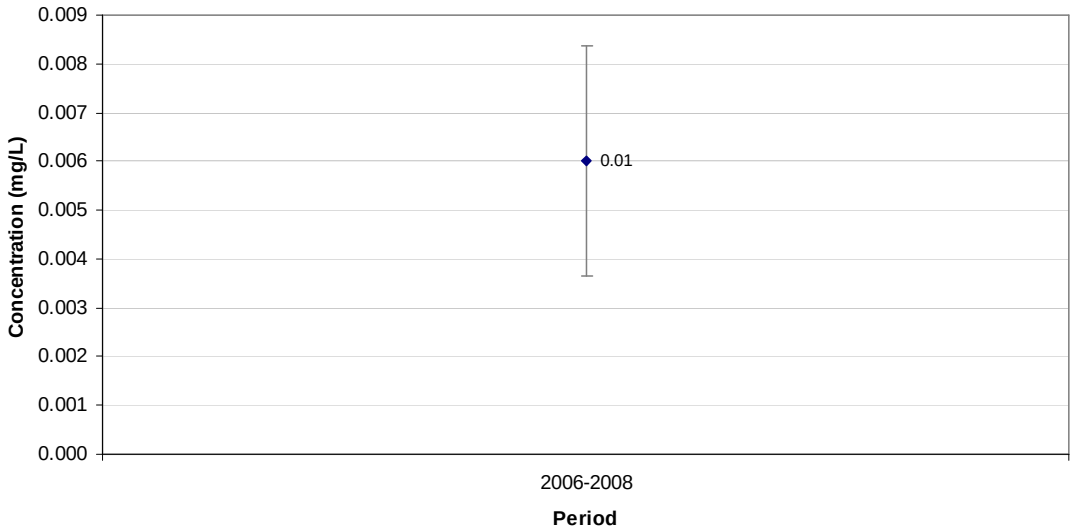




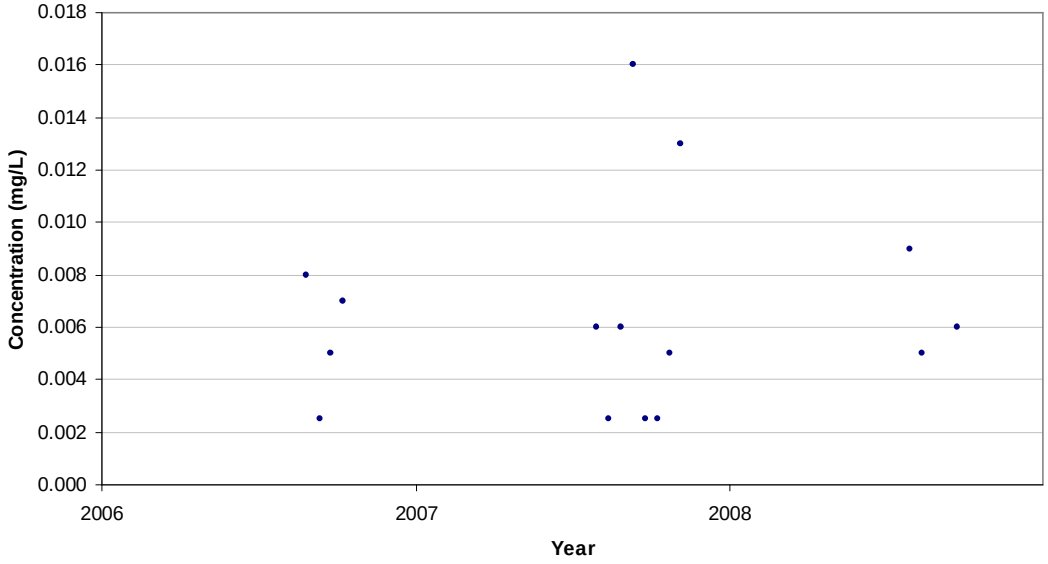
No trends

Total phosphorus – Preston River Trib (Mumballup Road)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

611004: Preston River (Boyanup Bridge)

	Period	Status	Trend
TN	2006–2008	0.33	E. Increasing
TP	2006–2008	0.012	None

Data summary for 611004

	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	490	8	47	1987–2008
TP	697	155	27	1983–2008
Flow				1980–2008

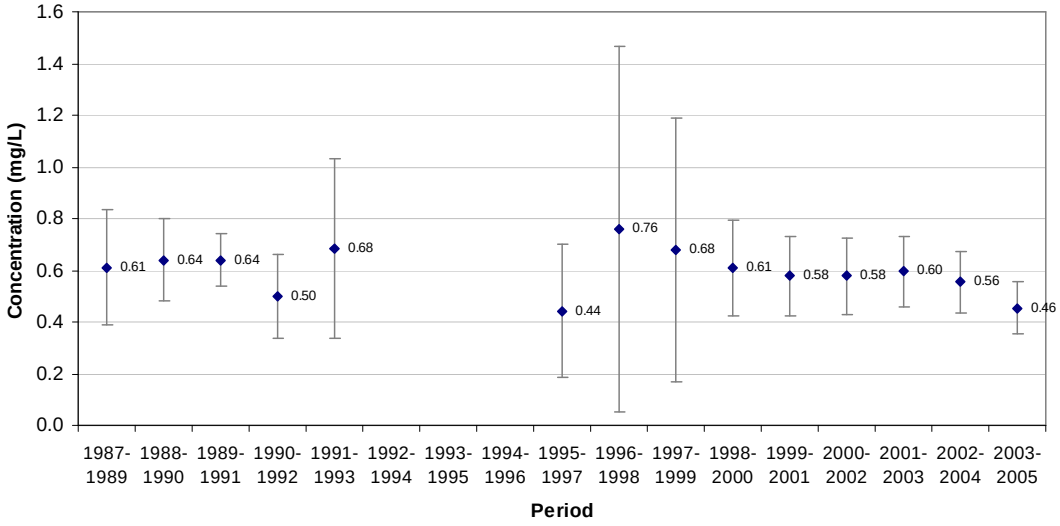
Total nitrogen and total phosphorus statistics for 611004

Statistic	Total nitrogen	Total phosphorus
Median	0.53	0.017
5th percentile	0.16	< 0.01
95th percentile	2.099	0.078
Lowest concentration	< 0.025	< 0.005
Highest concentration	6.06	3.8

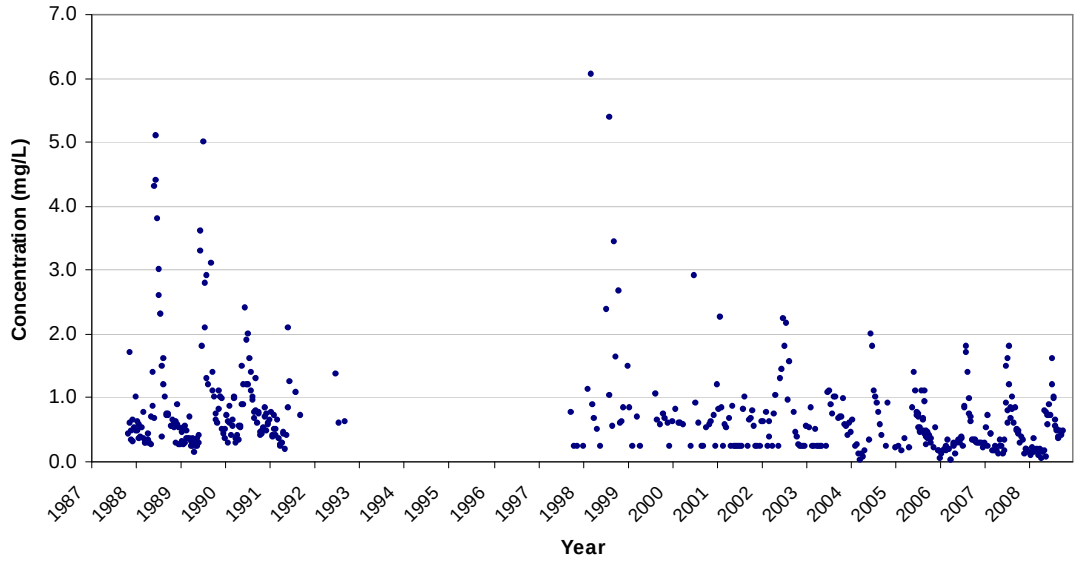
154 TP data with LOR = 0.4 mg/L were deleted

Total nitrogen – Preston River (Boyanup Bridge)

(a) Median concentration and 90% confidence interval



(b) - Observed data



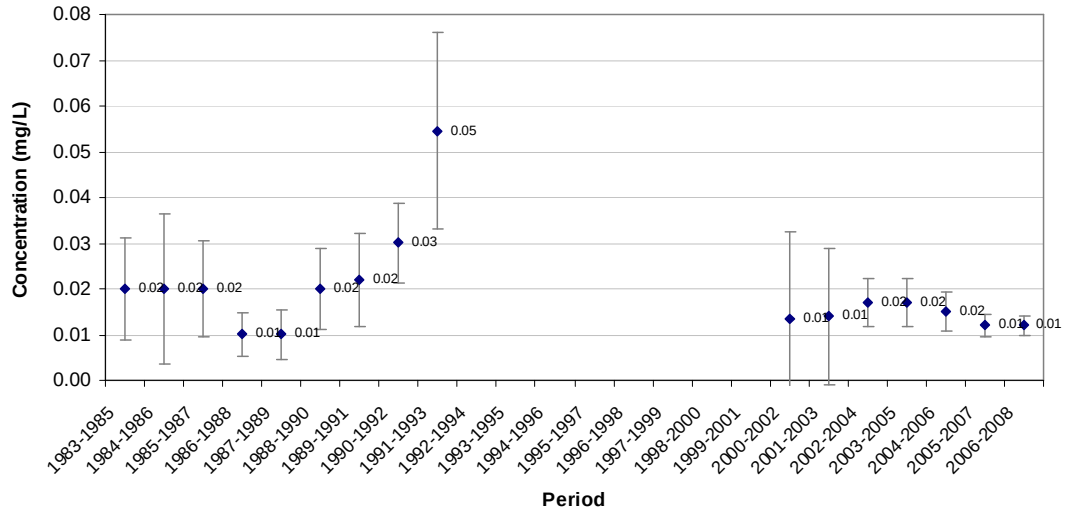
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	1987–2008	Obs.	SK	-0.017	-9.941	0	481	161	232	E. Decreasing

Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	2006–2008	Obs.	MK	0.07	2.14	0.032	121	29	216	E. Increasing

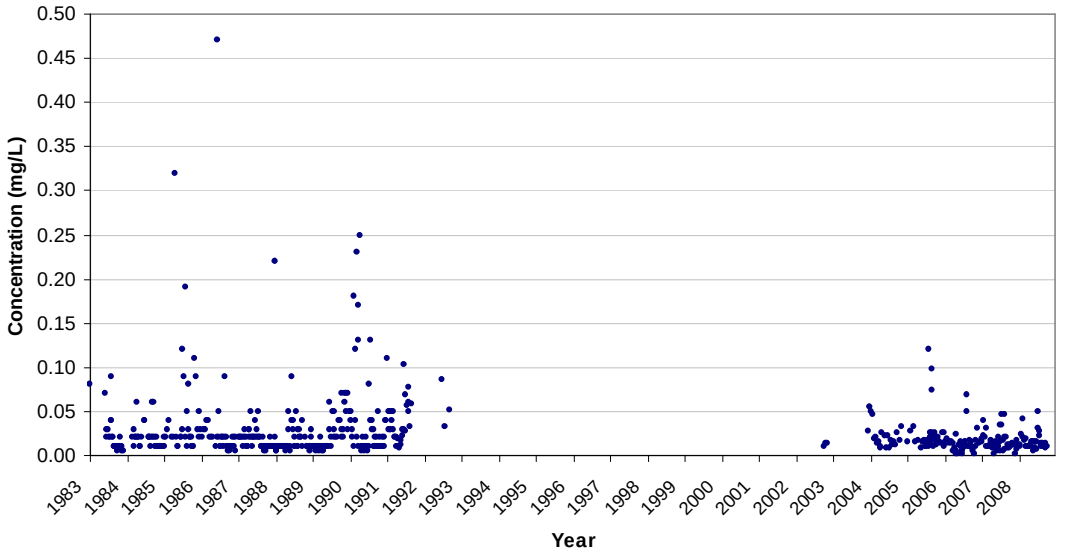
The table shows the trend statistics where Obs. = observed data, FAC = flow-corrected data, MK = Mann-Kendall test, SK = Seasonal-Kendall test, n = number of collected measurements, n* = number of independent measurements, n# = number of independent measurements required to detect a trend, and E. = emerging (trend).

Total phosphorus – Preston River (Boyanup Bridge)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

611005: Preston River (Upstream Joshua Creek)

	Period	Status	Trend
TN	2006–2008	0.345	None
TP	2006–2008	0.01	None

Data summary for 611005

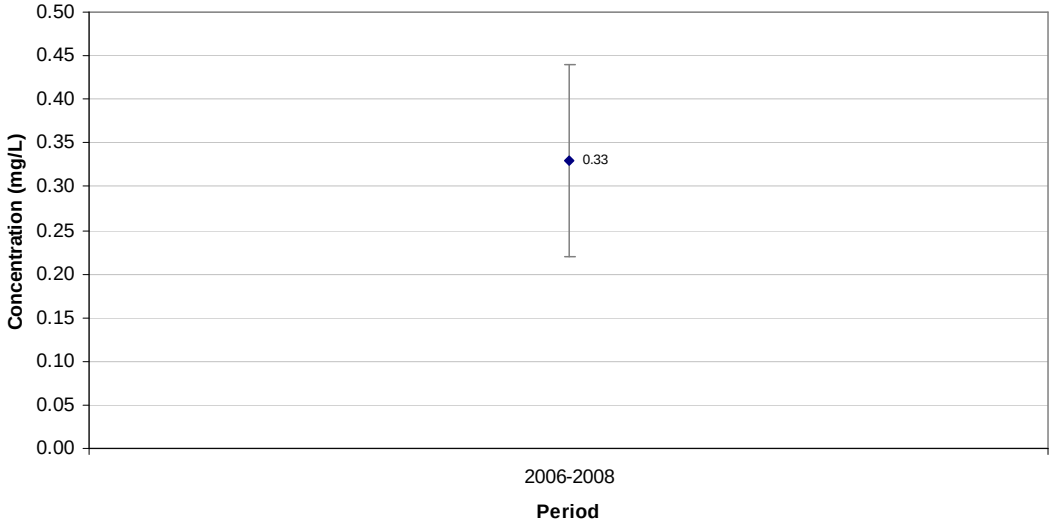
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	58	0	1	2006–2008
TP	60	0	5	2006–2008
Flow				1952–1959

Total nitrogen and total phosphorus statistics for 611005

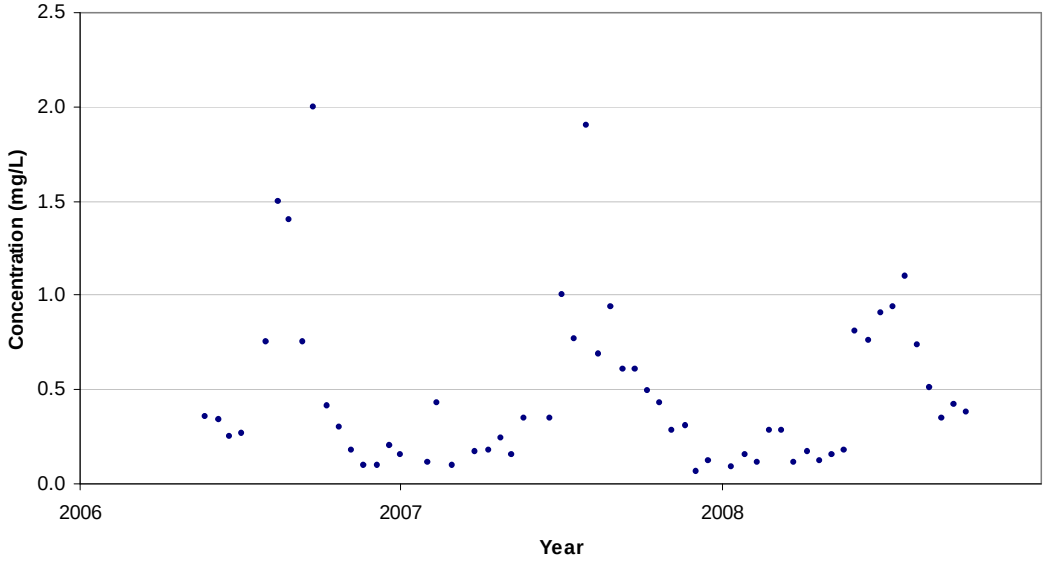
Statistic	Total nitrogen	Total phosphorus
Median	0.345	0.01
5th percentile	0.099	< 0.005
95th percentile	1.415	0.032
Lowest concentration	0.068	< 0.005
Highest concentration	2.0	0.20

Total nitrogen – Preston River (Upstream Joshua Creek)

(a) Median concentration and 90% confidence interval

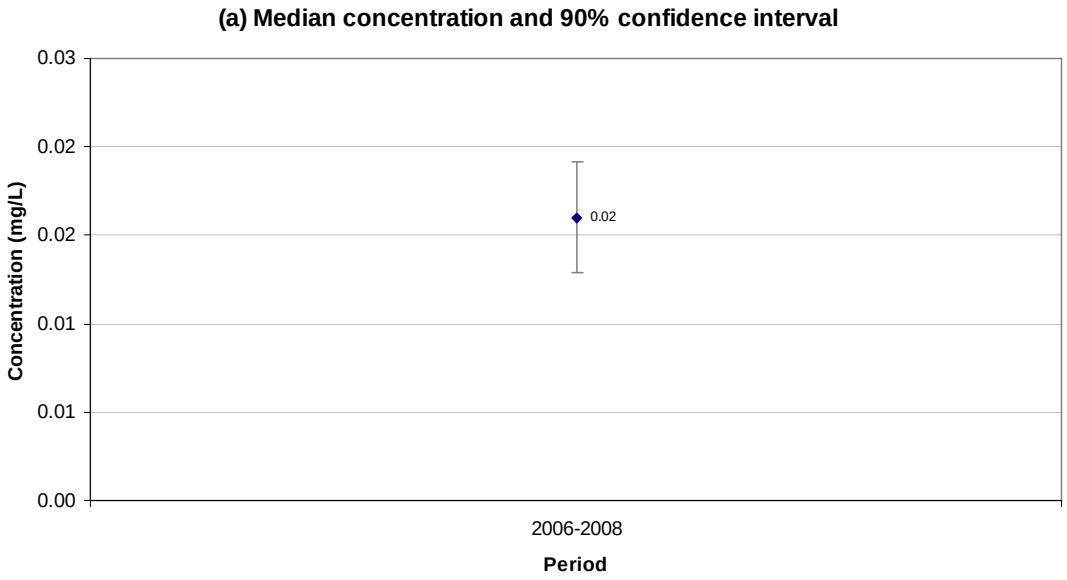


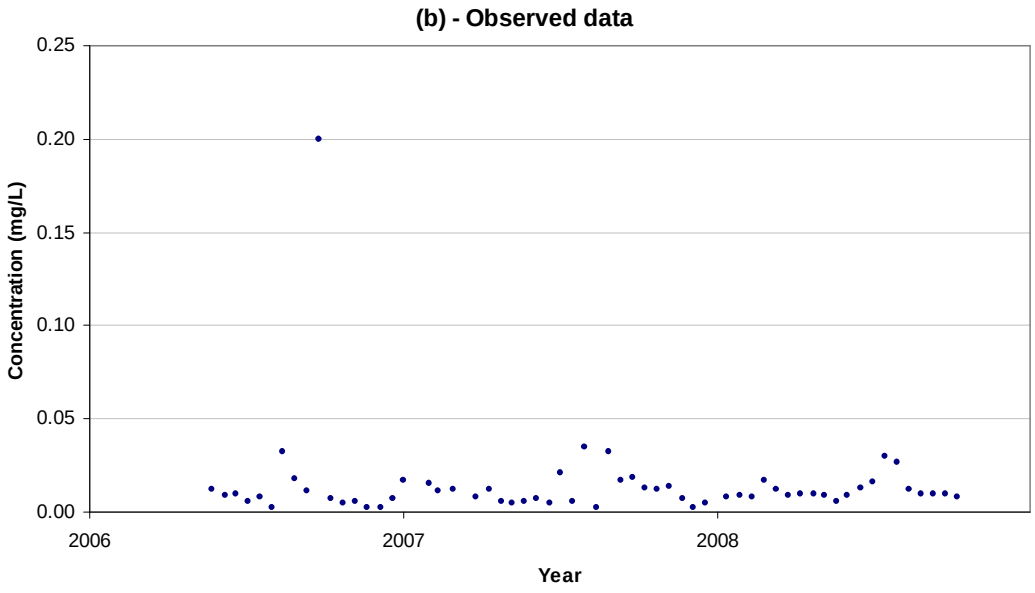
(b) - Observed data



No trends

Total phosphorus – Preston River (Upstream Joshua Creek)





No trends

611007: Ferguson River (SW Hwy Ferguson)

	Period	Status	Trend
TN	2006–2008	0.805	None
TP	2006–2008	0.026	None

Data summary for 611007

	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	350	7	22	1992–2008
TP	378	156	2	1992–2008
Flow				1991–2008

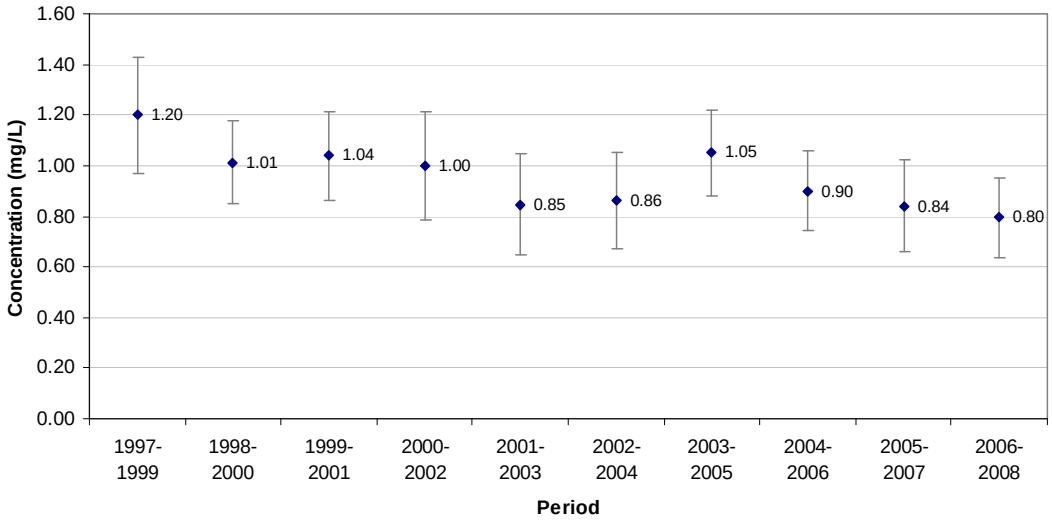
Total nitrogen and total phosphorus statistics for 611007

Statistic	Total nitrogen	Total phosphorus
Median	0.91	0.031
5th percentile	0.346	0.015
95th percentile	2.69	0.230
Lowest concentration	< 0.025	< 0.005
Highest concentration	6.3	0.662

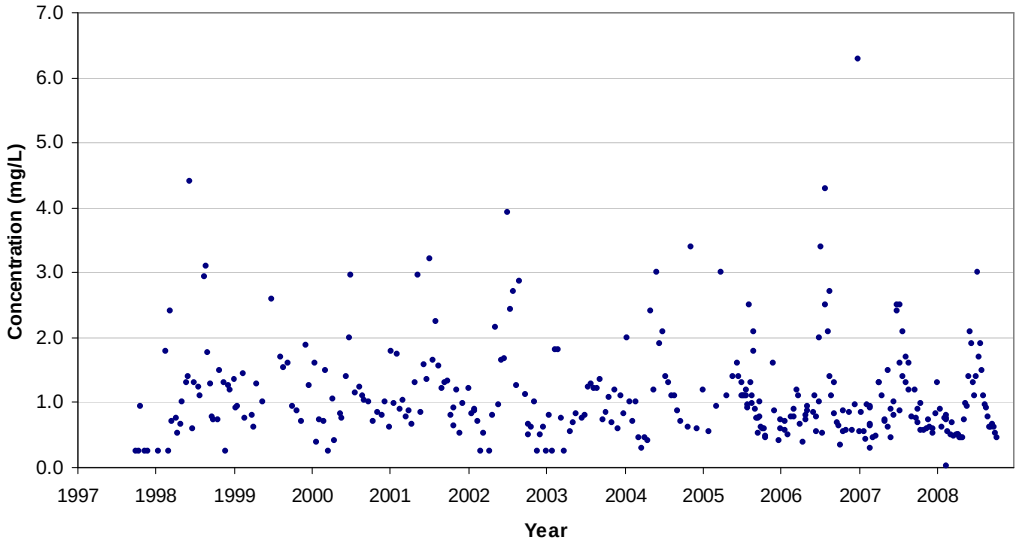
156 TP data with LOR 0.4 mg/L were deleted

Total nitrogen – Ferguson River (SW Hwy Ferguson)

(a) Median concentration and 90% confidence interval



(b) - Observed data

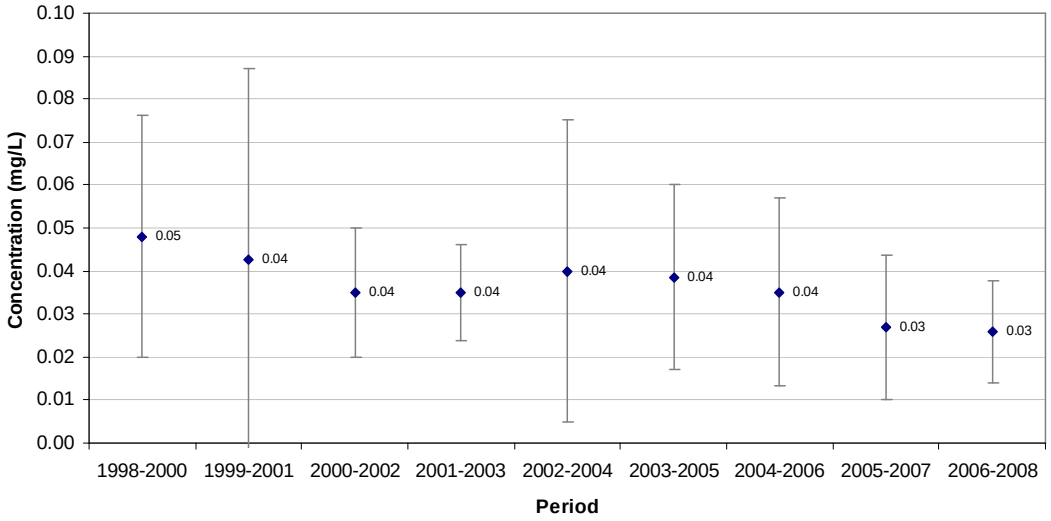


Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	1997–2008	Obs.	MK	-0.022	-2.633	0.008	341	148	621	E. Decreasing
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	1997–2008	Obs.	SK	-0.023	-4.068	0	341	250	402	E. Decreasing
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	1997–2008	FAC	MK	-0.02	-2.62	0.009	341	157	648	E. Decreasing
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	1997–2008	FAC	SK	-0.021	-3.003	0.003	341	206	505	E. Decreasing

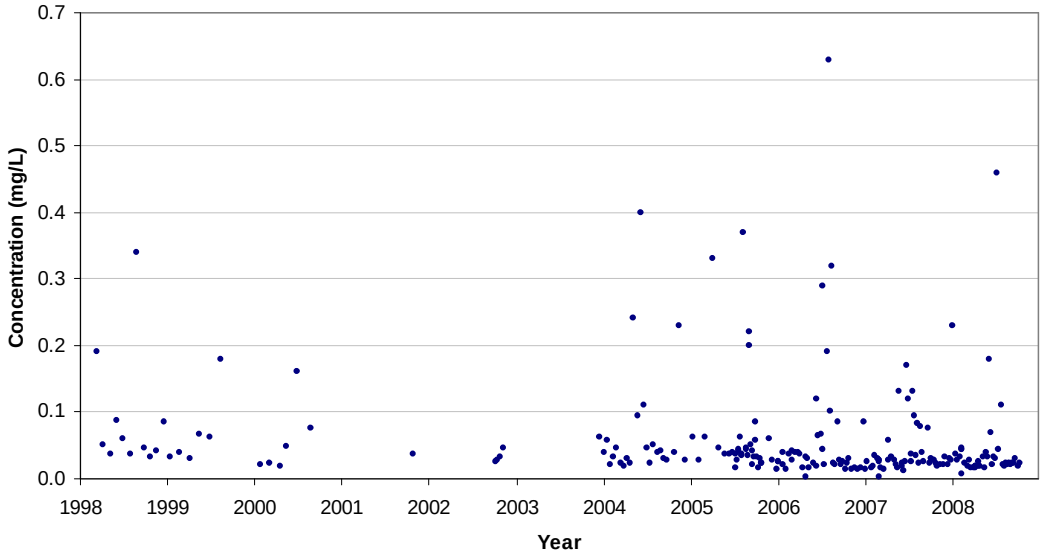
No trends for 2006 to 2008

Total phosphorus – Ferguson River (SW Hwy Ferguson)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

611009: Preston River (Lowden Road Bridge)

	Period	Status	Trend
TN	2006–2008	0.525	None
TP	2006–2008	0.011	None

Data summary for 611009

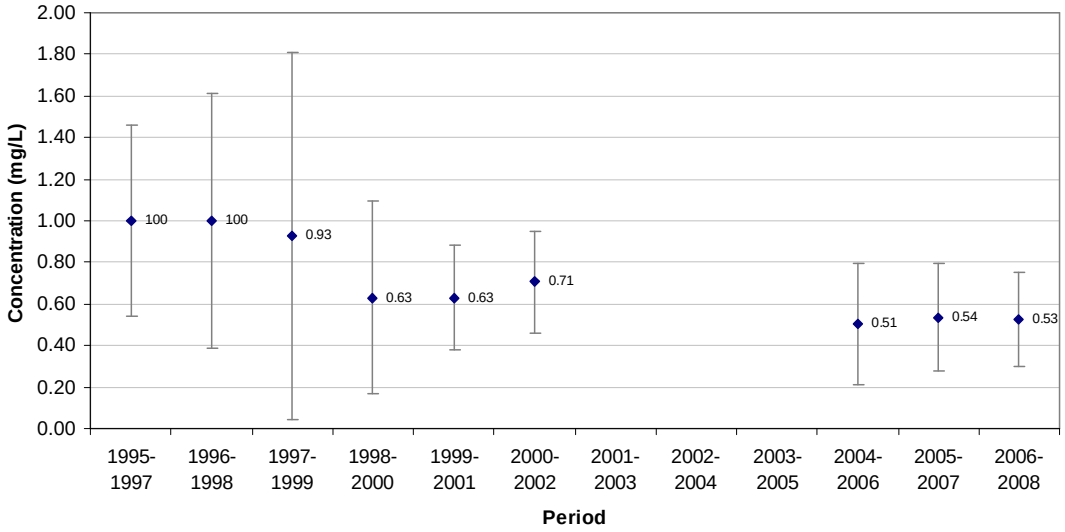
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	54	0	0	2006–2008
TP	54	0	3	2006–2008
Flow				1999–2008

Total nitrogen and total phosphorus statistics for 611009

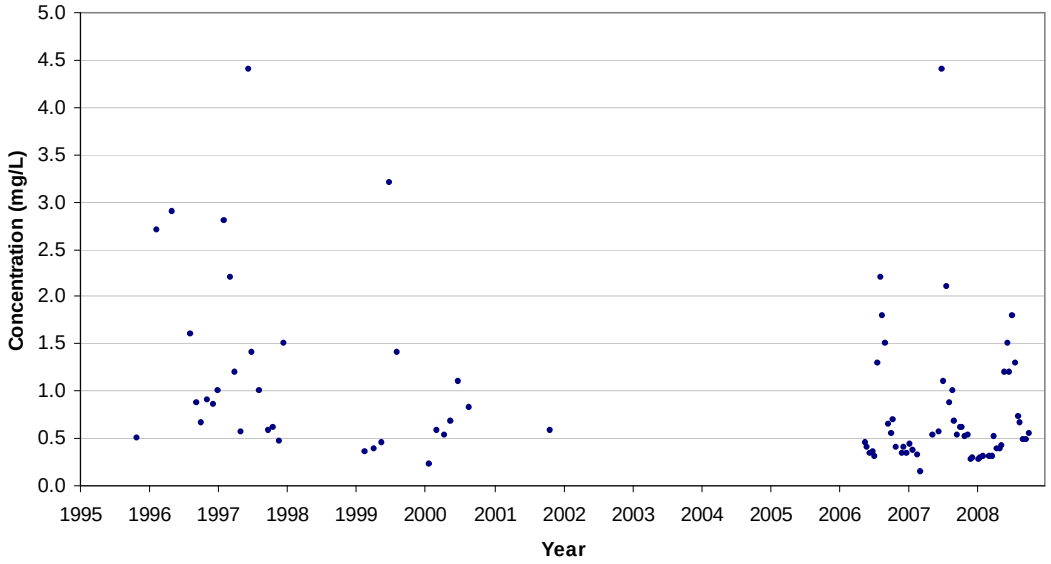
Statistic	Total nitrogen	Total phosphorus
Median	0.525	0.011
5th percentile	0.283	< 0.005
95th percentile	1.90	0.026
Lowest concentration	0.15	< 0.005
Highest concentration	4.4	0.042

Total nitrogen – Preston River (Lowden Road Bridge)

(a) Median concentration and 90% confidence interval



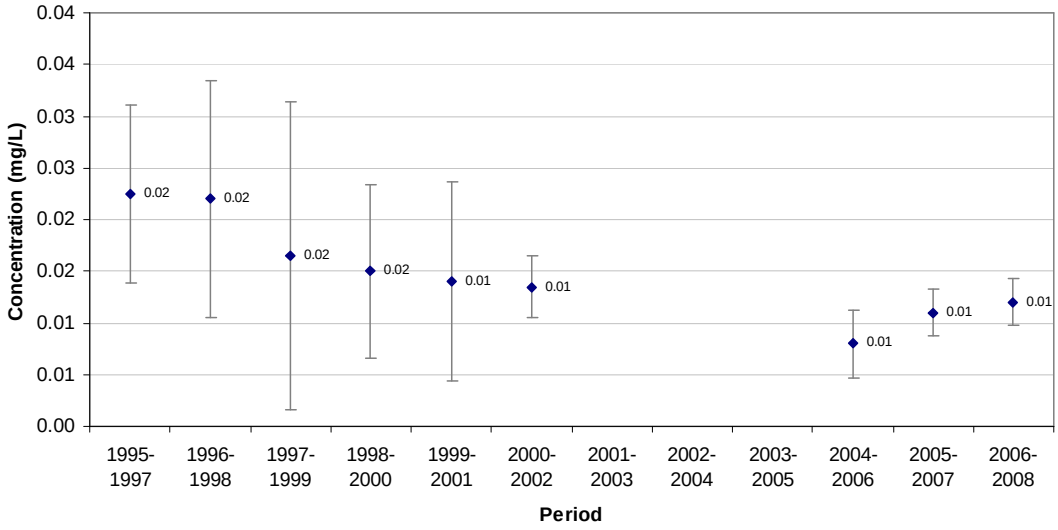
(b) - Observed data



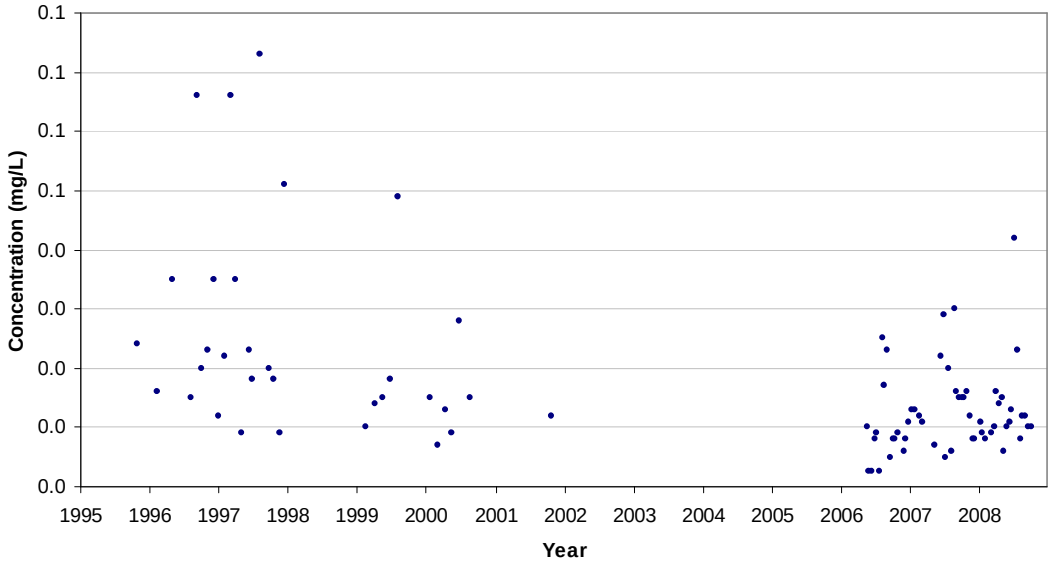
No trends

Total phosphorus – Preston River (Lowden Road Bridge)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

611017: Ferguson River (Doudell Road Bridge)

	Period	Status	Trend
TN	1998–2001	0.74	None
TP	1998–2001	0.021	None

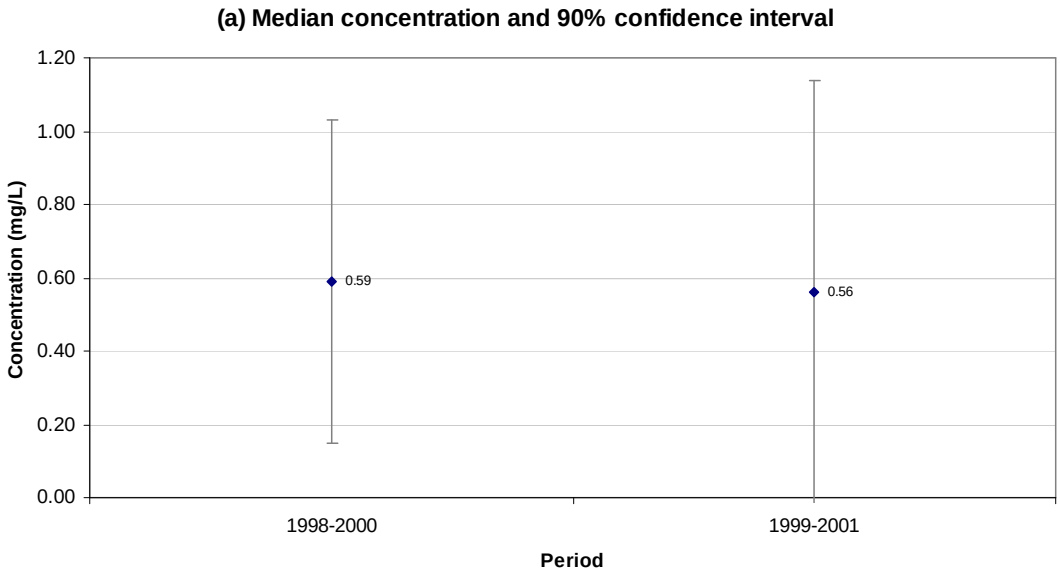
Data summary for 611017

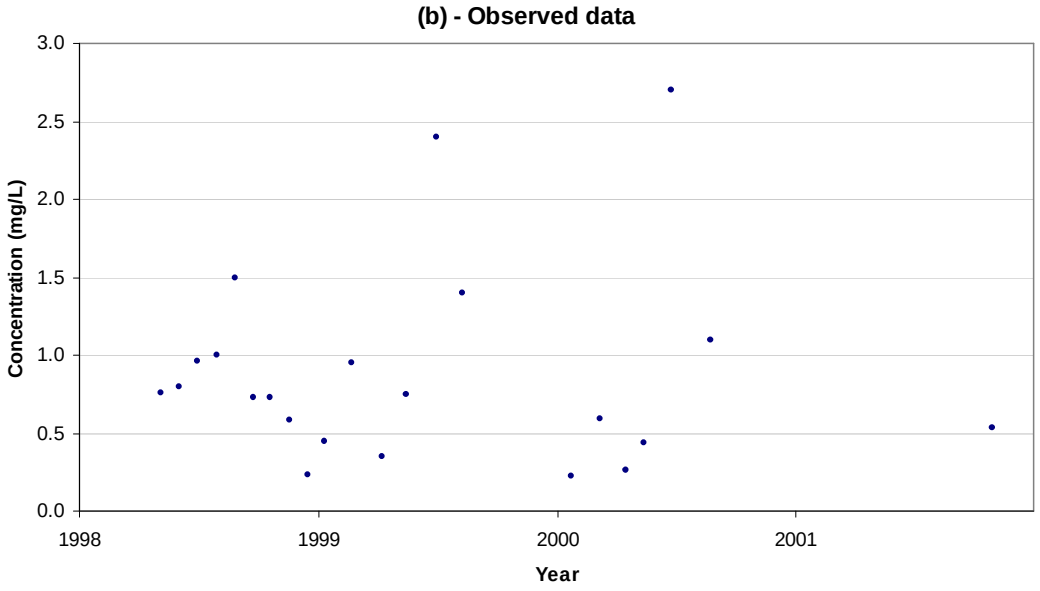
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	22	0	0	1998–2001
TP	22	0	0	1998–2001
Flow				1999–2007

Total nitrogen and total phosphorus statistics for 611017

Statistic	Total nitrogen	Total phosphorus
Median	0.74	0.021
5th percentile	0.232	0.010
95th percentile	2.36	0.128
Lowest concentration	0.22	0.009
Highest concentration	2.7	0.14

Total nitrogen – Ferguson River (Doudell Road Bridge)

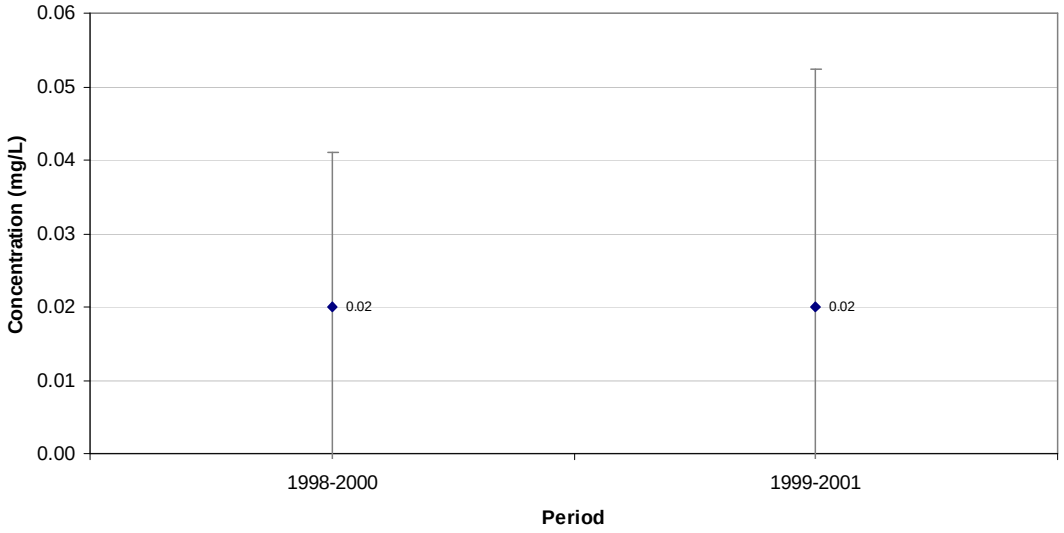




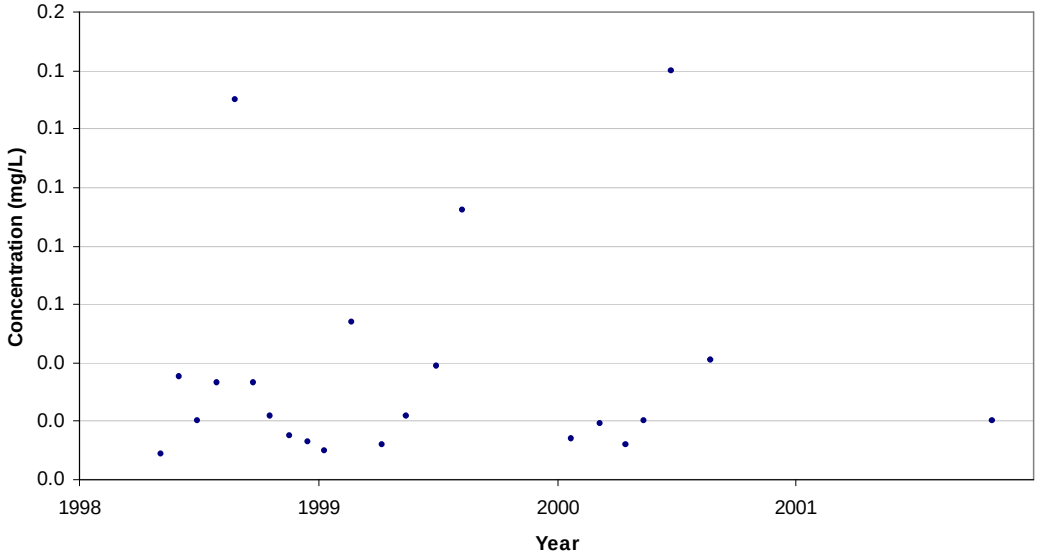
No trends

Total phosphorus – Ferguson River (Doudell Road Bridge)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

611111: Thomson Brook (Woodperry Homestead)

	Period	Status	Trend
TN	2006–2008	0.73	None
TP	2006–2008	0.016	None

Data summary for 611111

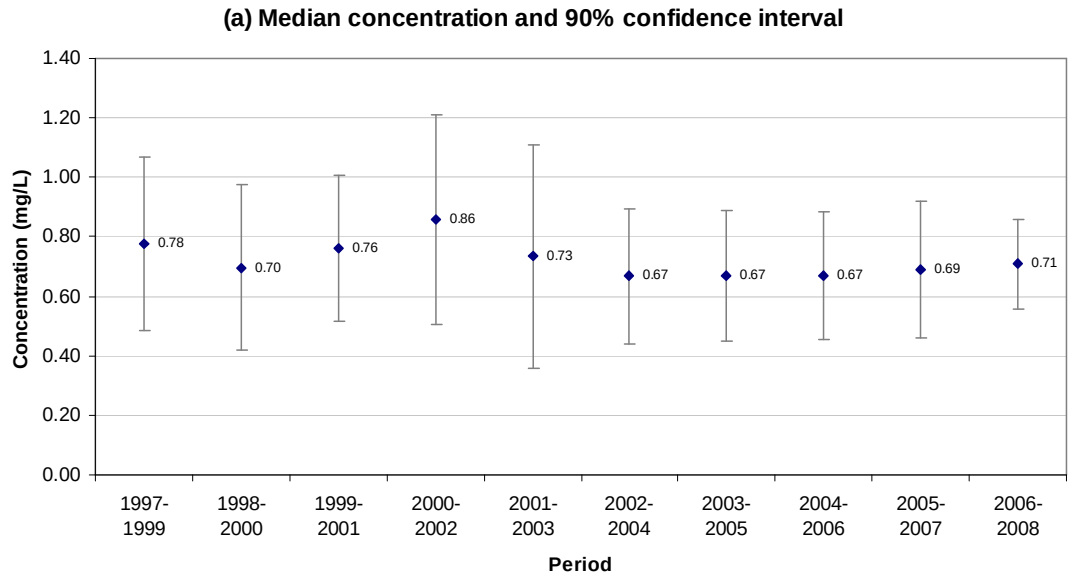
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	150	3	15	1997–2008
TP	177	110	0	2002–2008
Flow				1979–2008

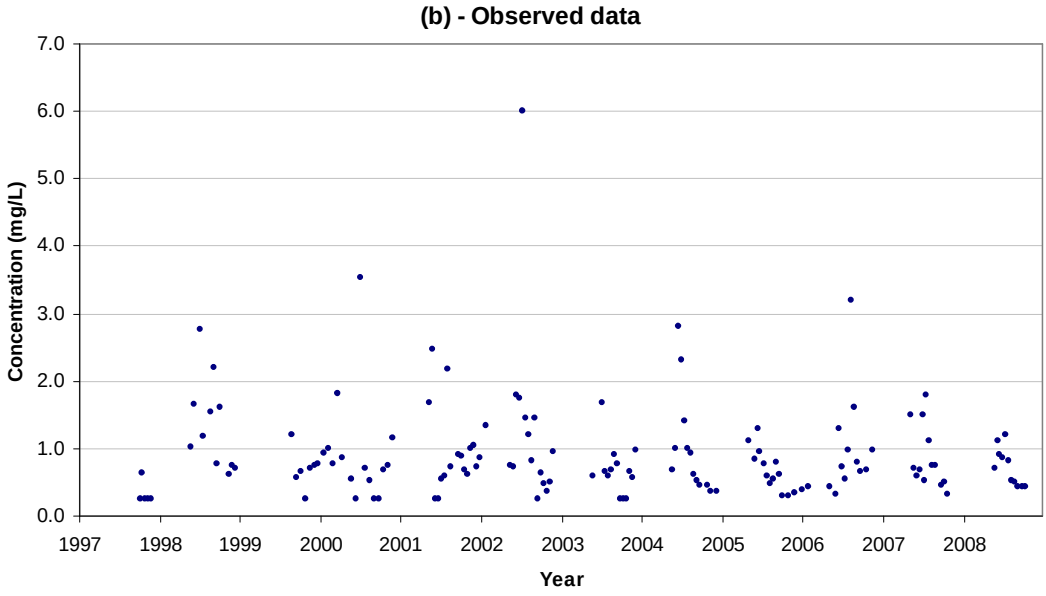
Total nitrogen and total phosphorus statistics for 611111

Statistic	Total nitrogen	Total phosphorus
Median	0.729	0.016
5th percentile	< 0.50	0.008
95th percentile	2.19	0.047
Lowest concentration	< 0.50	0.006
Highest concentration	6.01	0.092

110 TP data with LOR 0.4 mg/L were deleted (1996 to 2002)

Total nitrogen – Thomson Brook (Woodperry Homestead)

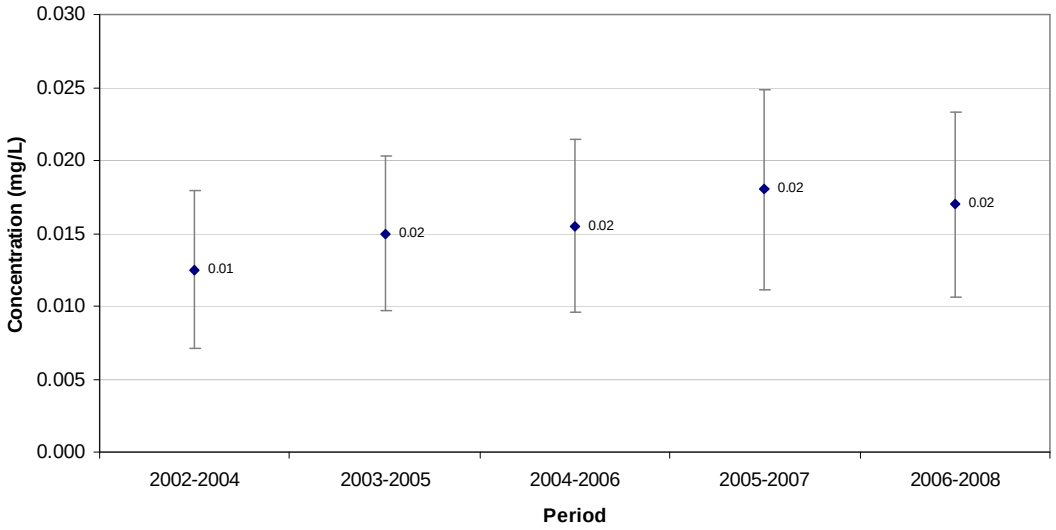




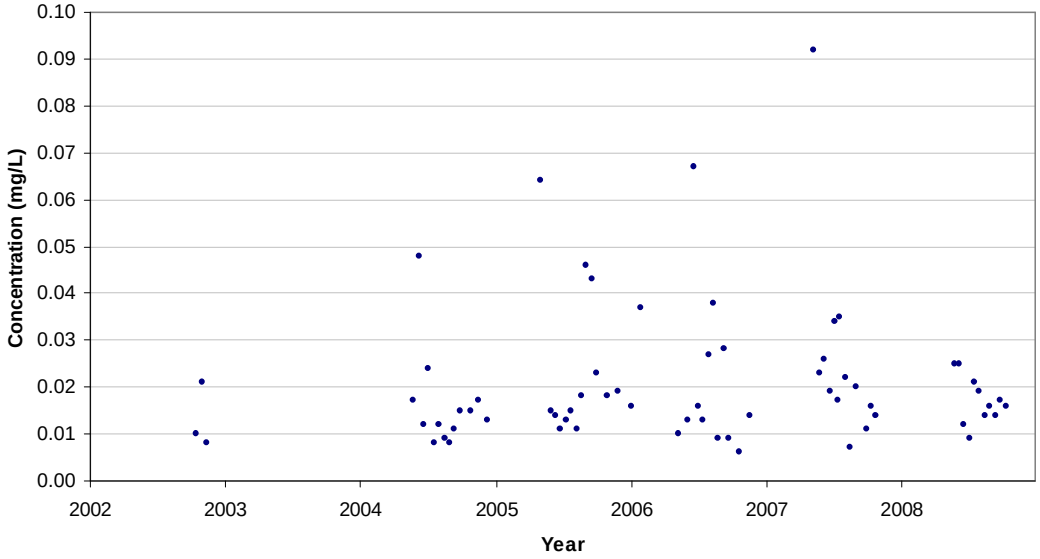
No trends

Total phosphorus – Thomson Brook (Woodperry Homestead)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6110055: Ferguson River (Canal)

	Period	Status	Trend
TN	2006–2008	2.1	None
TP	2006–2008	0.17	None

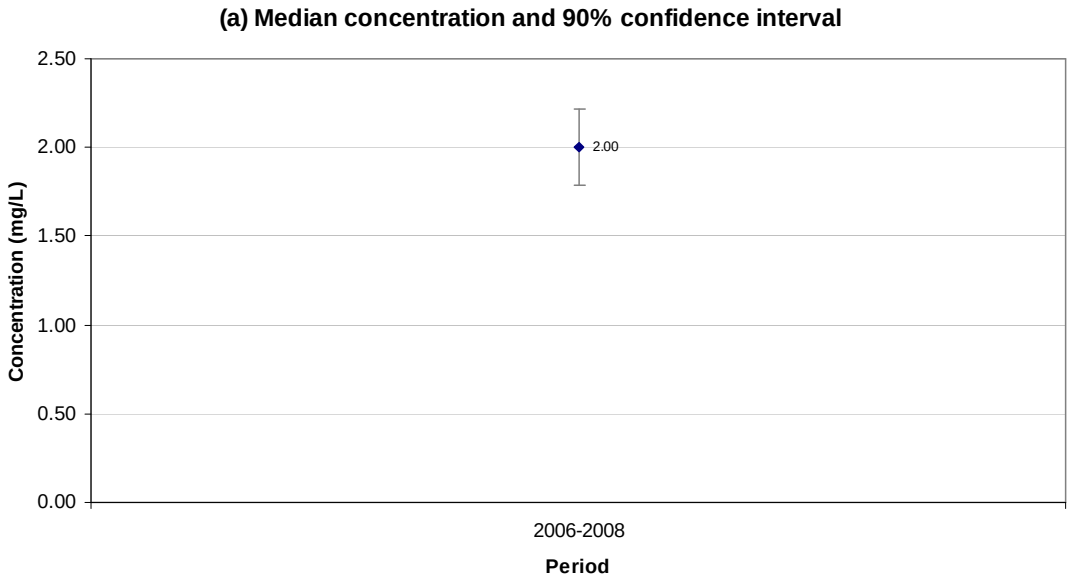
Data summary for 6110055

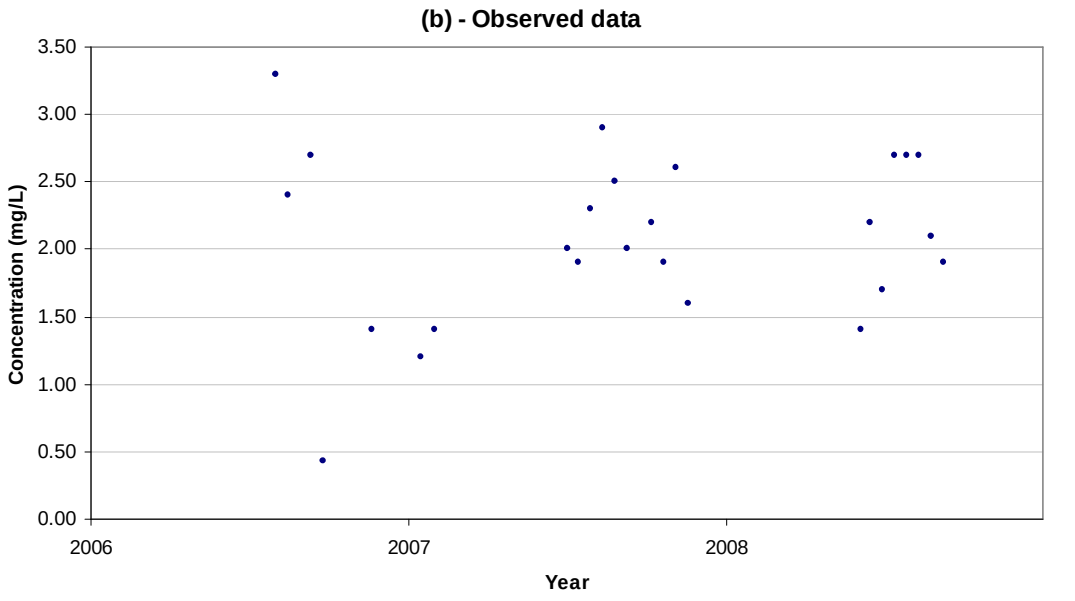
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	25	0	0	2006–2008
TP	25	0	0	2006–2008

Total nitrogen and total phosphorus statistics for 6110055

Statistic	Total nitrogen	Total phosphorus
Median	2.1	0.17
5th percentile	1.24	0.394
95th percentile	2.86	0.228
Lowest concentration	0.43	0.006
Highest concentration	3.3	0.33

Total nitrogen – Ferguson River (Canal)

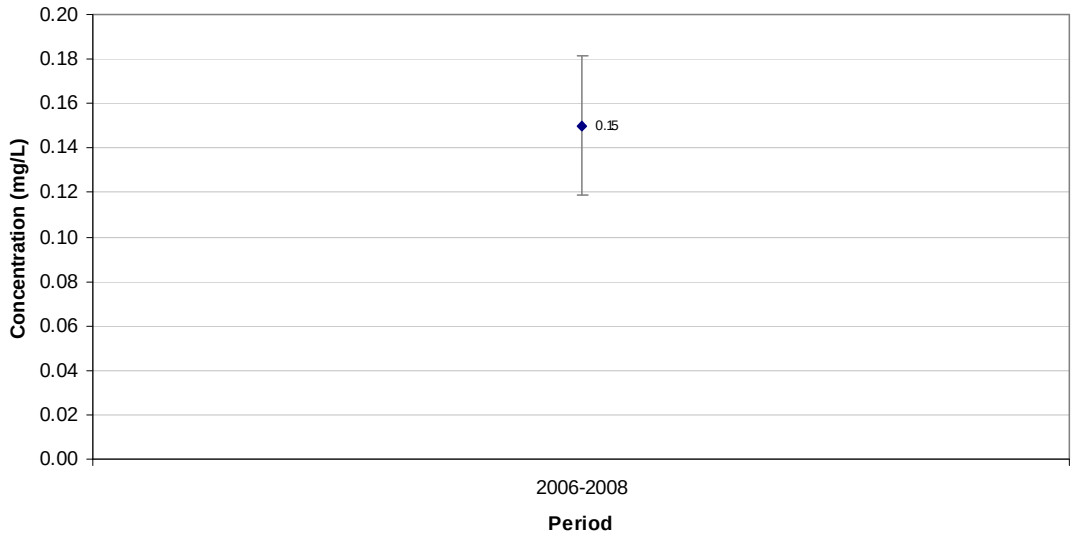




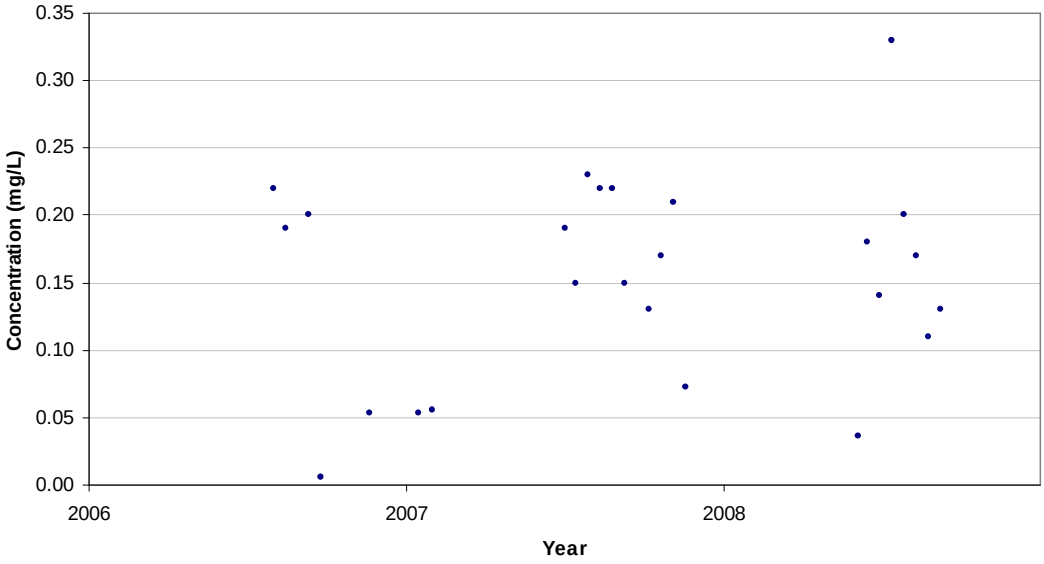
No trends

Total phosphorus – Ferguson River (Canal)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6110056: Joshua Creek (Joshua)

	Period	Status	Trend
TN	2006–2008	0.56	None
TP	2006–2008	0.018	None

Data summary for 6110056

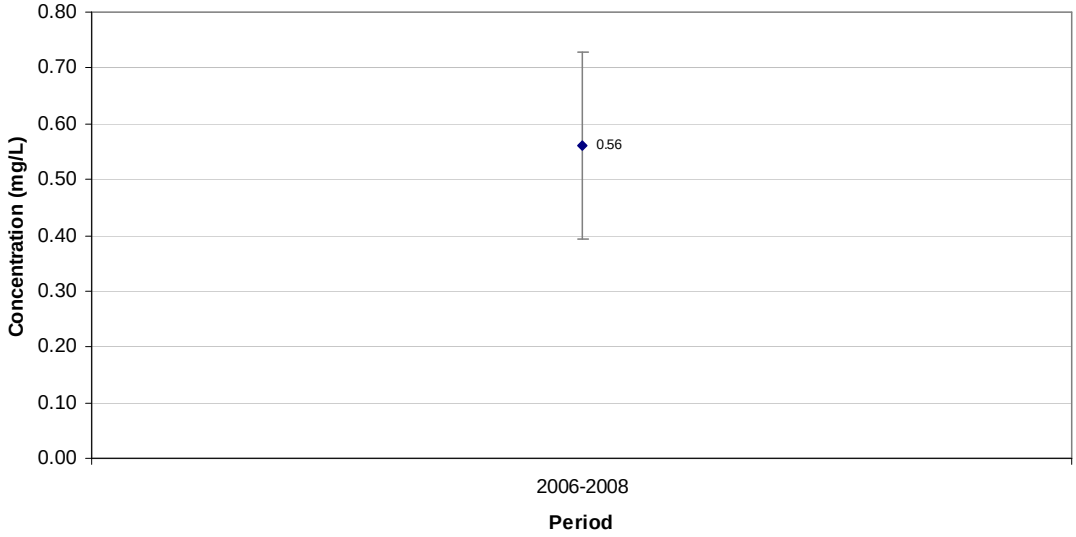
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	19	0	0	2006–2008
TP	19	0	0	2006–2008

Total nitrogen and total phosphorus statistics for 6110056

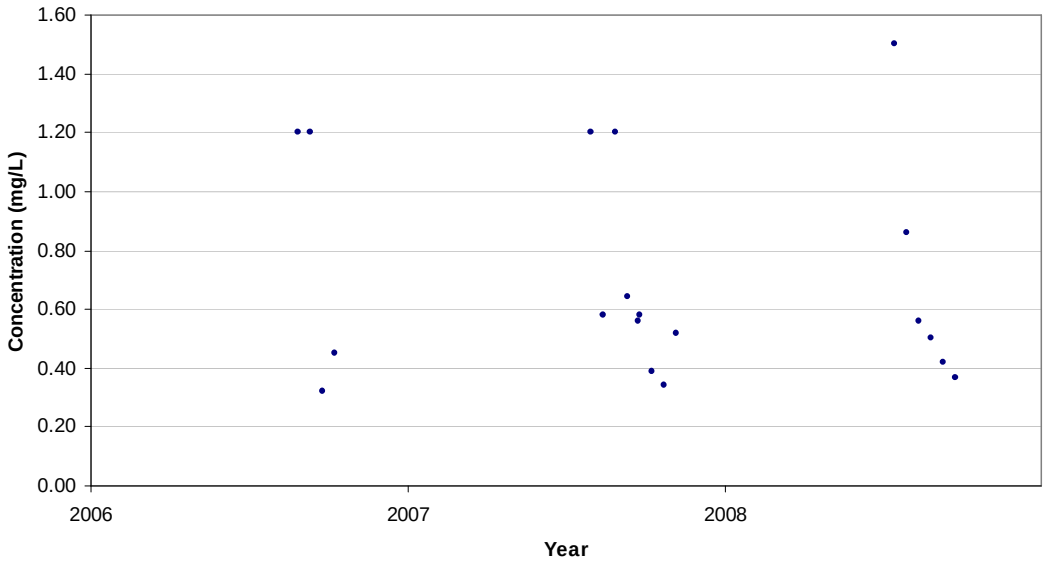
Statistic	Total nitrogen	Total phosphorus
Median	0.56	0.018
5th percentile	0.338	0.0079
95th percentile	1.23	0.079
Lowest concentration	0.32	0.007
Highest concentration	1.5	0.079

Total nitrogen – Joshua Creek (Joshua)

(a) Median concentration and 90% confidence interval



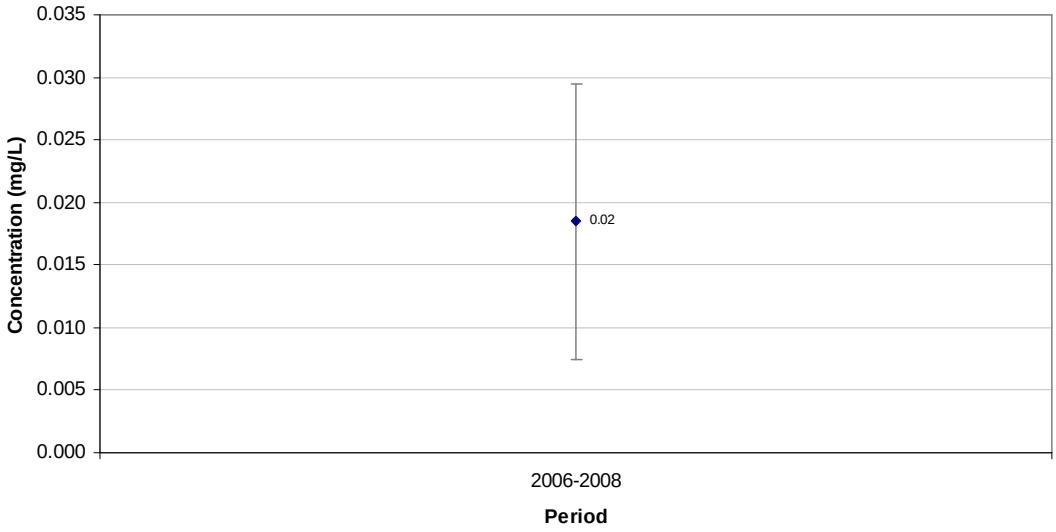
(b) - Observed data



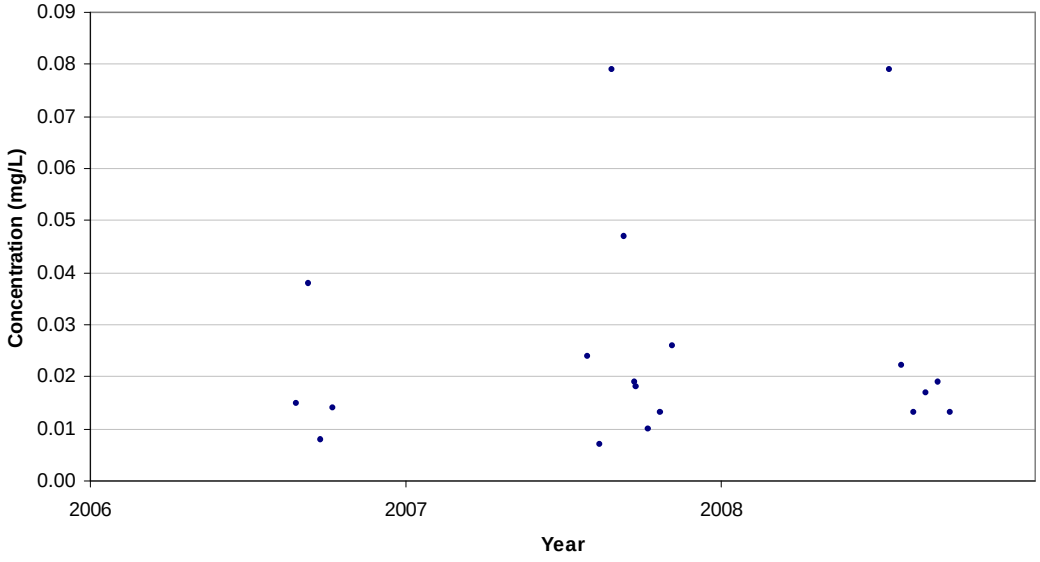
No trends

Total phosphorus – Joshua Creek (Joshua)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6110058: Thomson Brook South (Brookhampton Road)

	Period	Status	Trend
TN	2006–2008	0.53	None
TP	2006–2008	0.0165	None

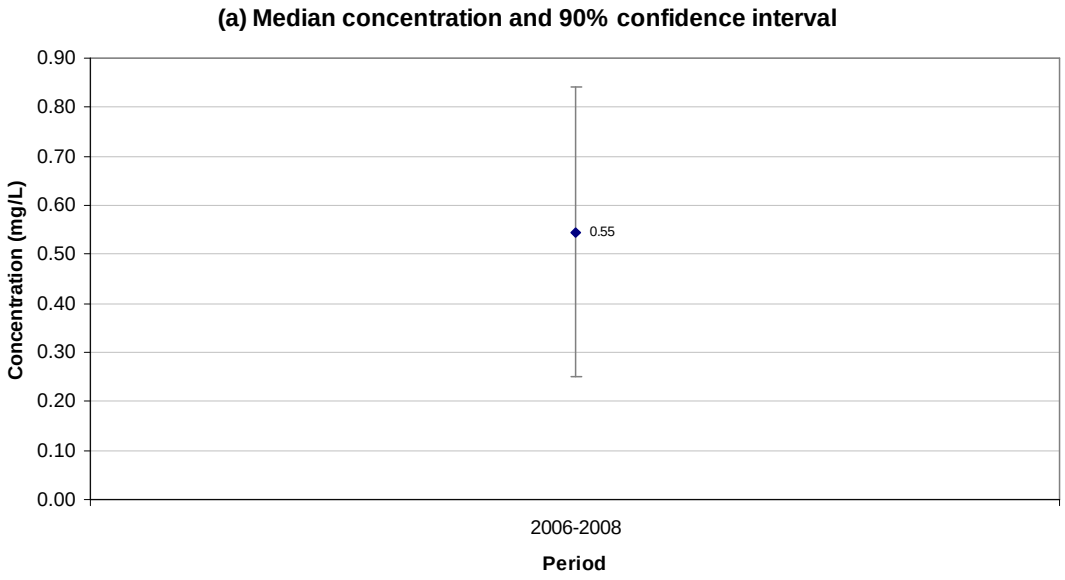
Data summary for 6110058

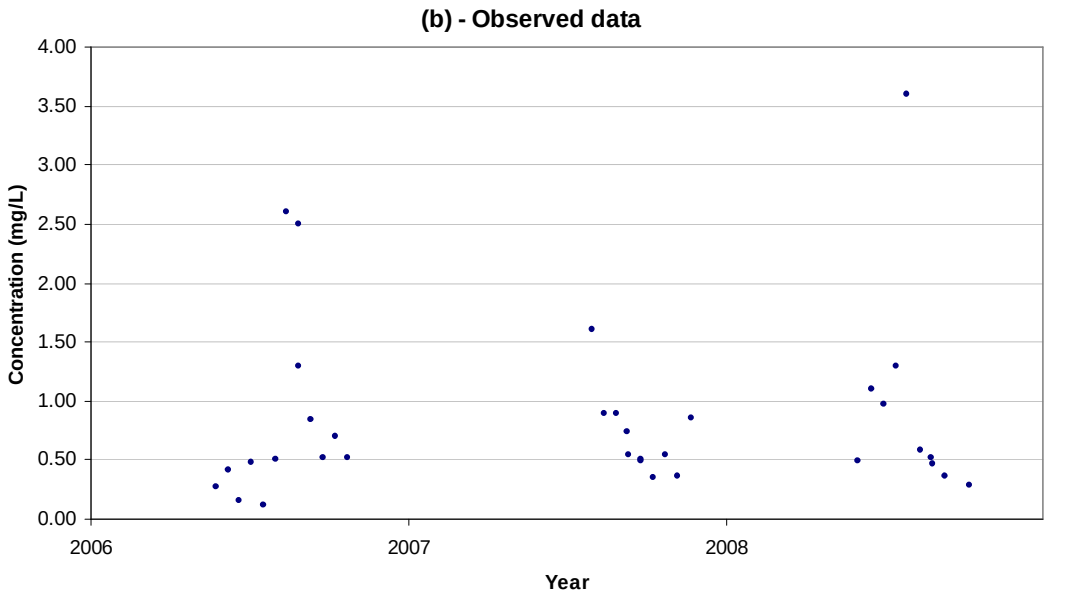
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	34	0	0	2006–2008
TP	34	0	1	2006–2008

Total nitrogen and total phosphorus statistics for 6110058

Statistic	Total nitrogen	Total phosphorus
Median	0.53	0.0165
5th percentile	0.228	0.008
95th percentile	2.53	0.117
Lowest concentration	0.12	< 0.005
Highest concentration	3.6	0.48

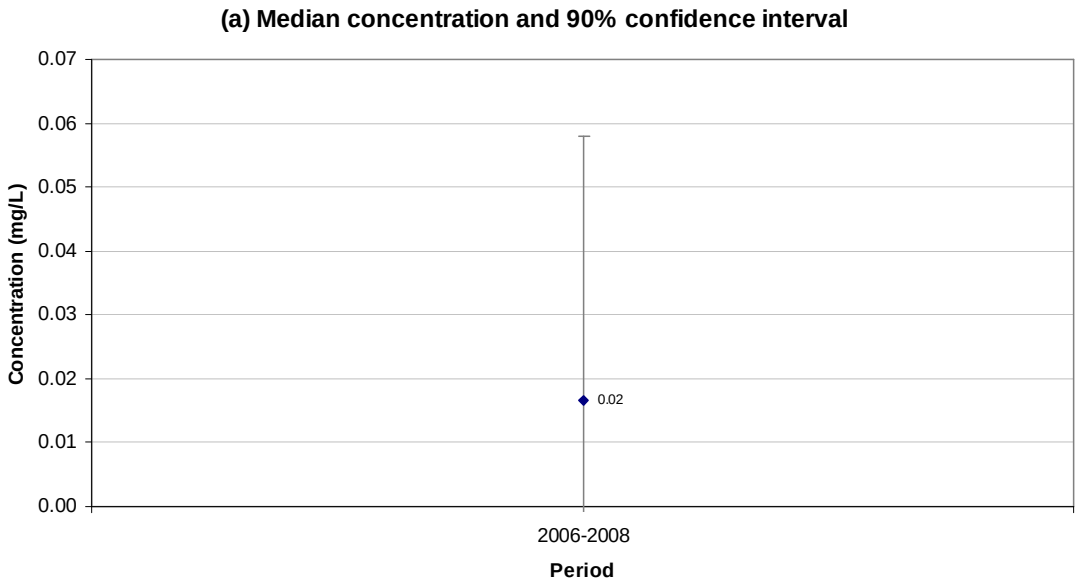
Total nitrogen – Thomson Brook South (Brookhampton Road)

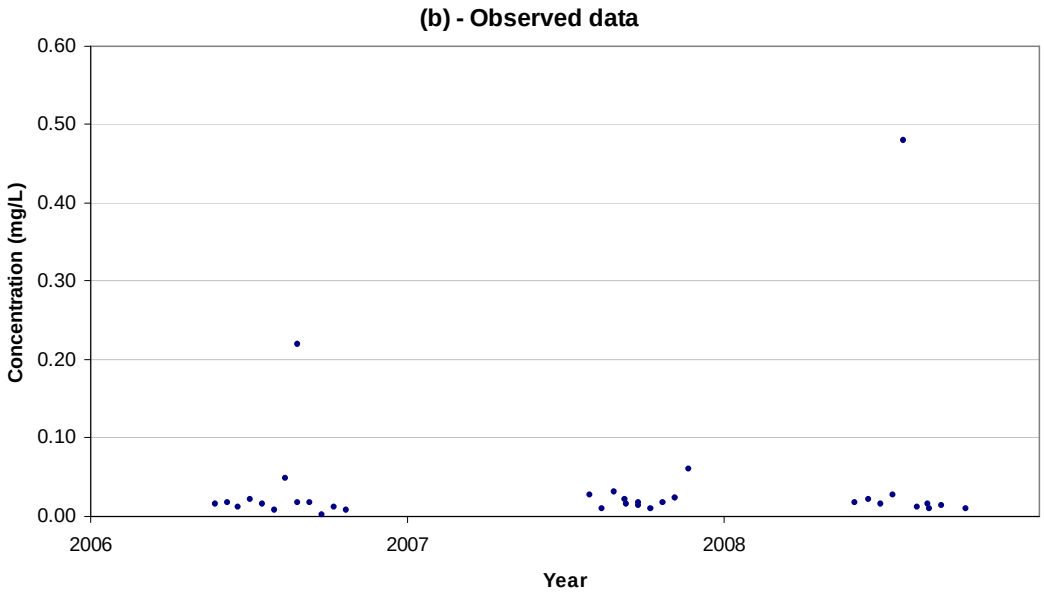




No trends

Total phosphorus – Thomson Brook South (Brookhampton Road)





No trends

6110059: Preston River South (Mandalay)

	Period	Status	Trend
TN	2006–2008	0.925	None
TP	2006–2008	0.028	None

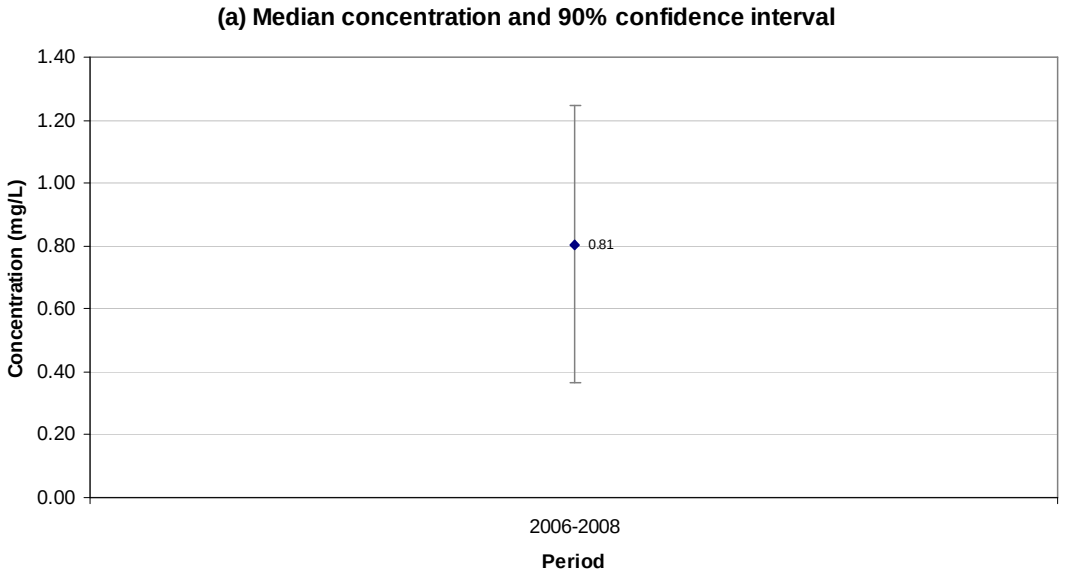
Data summary for 6110059

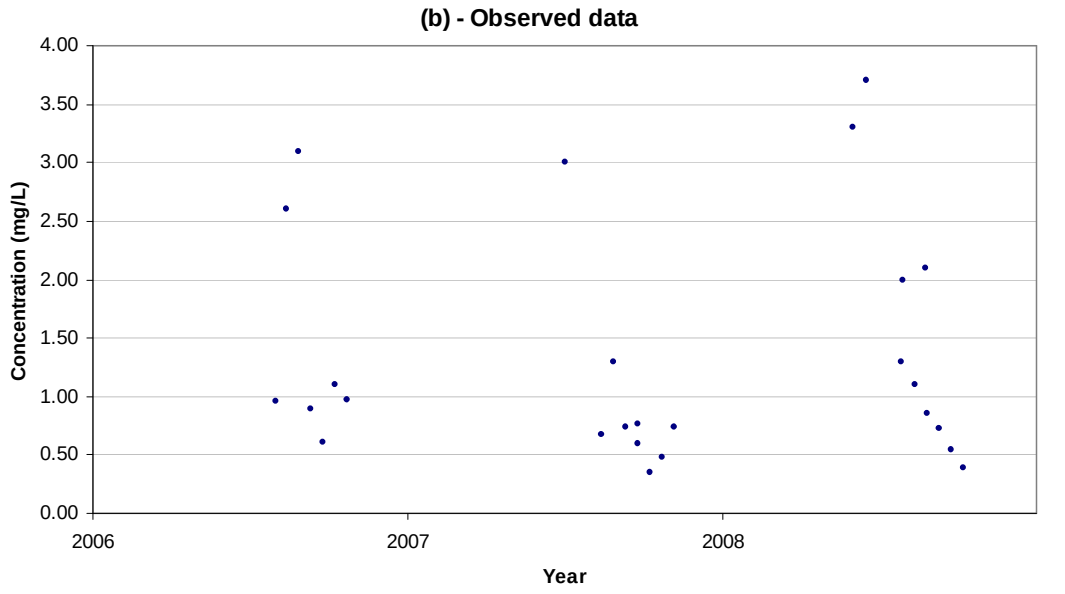
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	26	0	0	2006–2008
TP	26	0	0	2006–2008

Total nitrogen and total phosphorus statistics for 6110059

Statistic	Total nitrogen	Total phosphorus
Median	0.925	0.028
5th percentile	0.412	0.011
95th percentile	3.25	0.116
Lowest concentration	0.35	0.007
Highest concentration	3.7	0.420

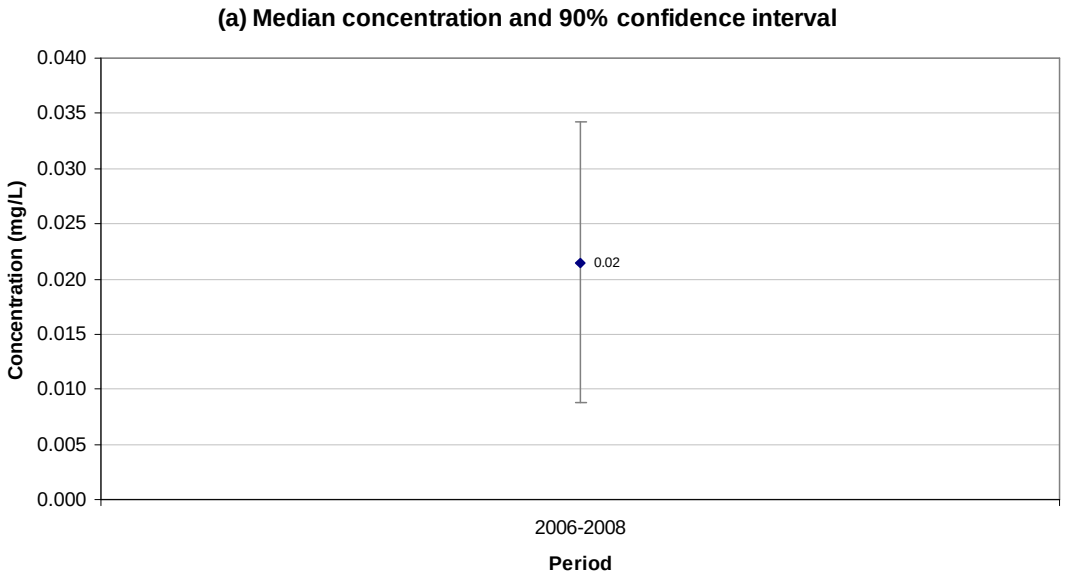
Total nitrogen – Preston River South (Mandalay)

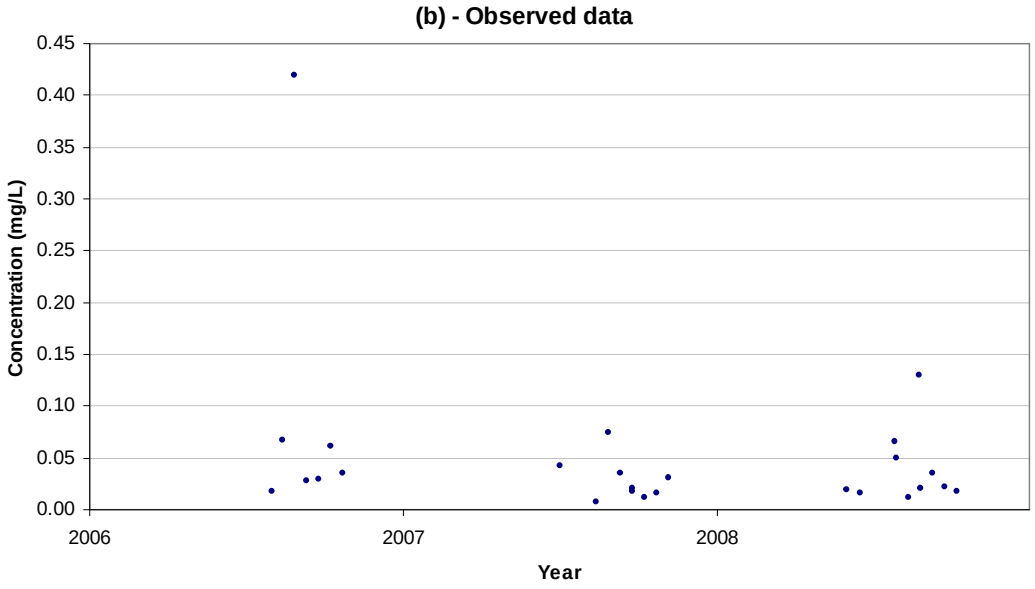




No trends

Total phosphorus – Preston River South (Mandalay)





No trends

6110060: Rec Rd (Recreation Road)

	Period	Status	Trend
TN	2006–2008	0.80	None
TP	2006–2008	0.023	None

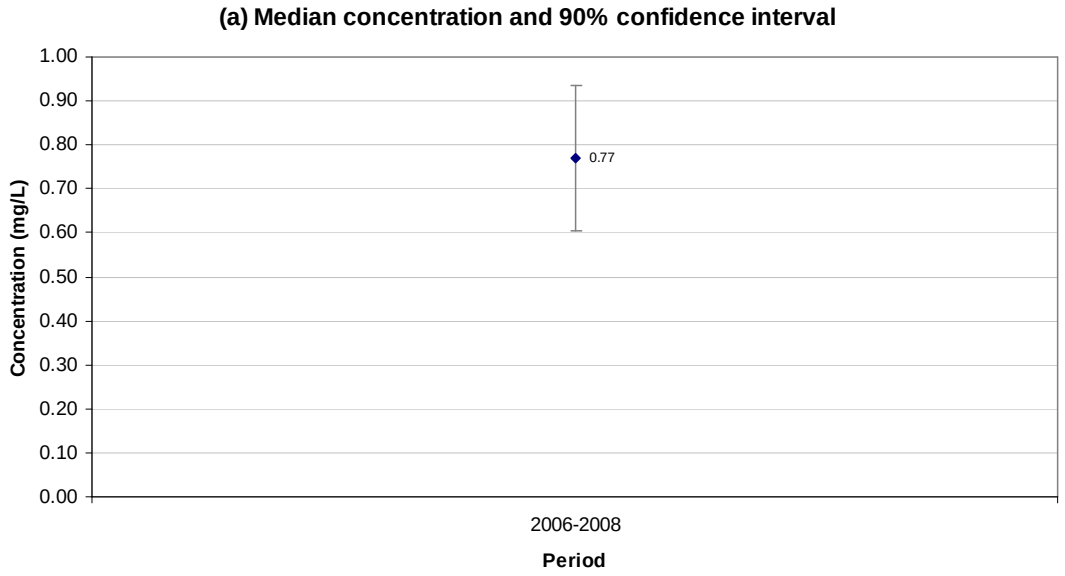
Data summary for 6110060

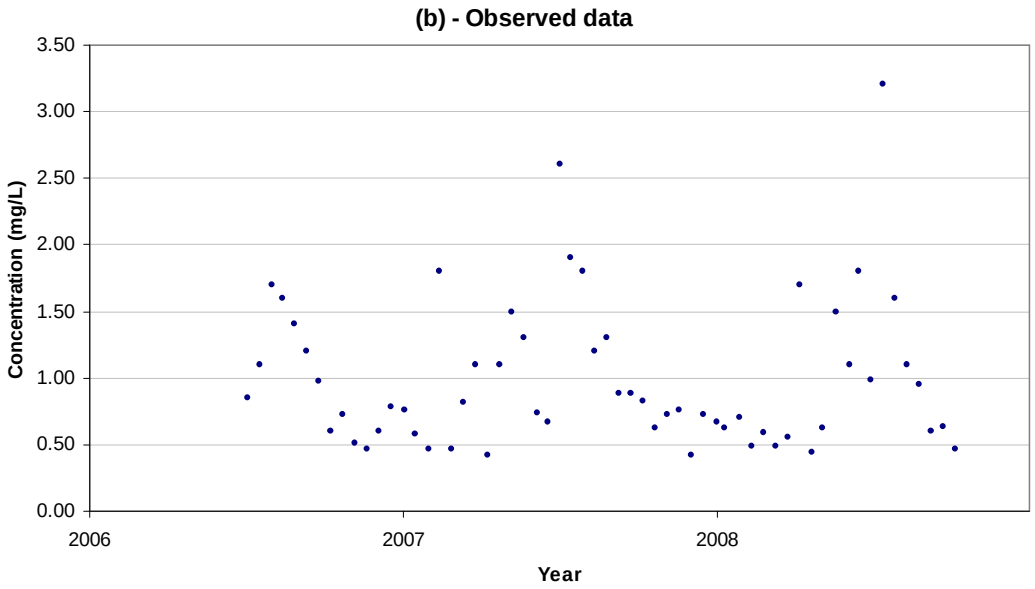
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	60	0	0	2006–2008
TP	60	0	1	2006–2008

Total nitrogen and total phosphorus statistics for 6110060

Statistic	Total nitrogen	Total phosphorus
Median	0.80	0.023
5th percentile	0.459	0.006
95th percentile	1.80	0.099
Lowest concentration	0.42	<0.005
Highest concentration	3.2	0.24

Total nitrogen – Rec Rd (Recreation Road)

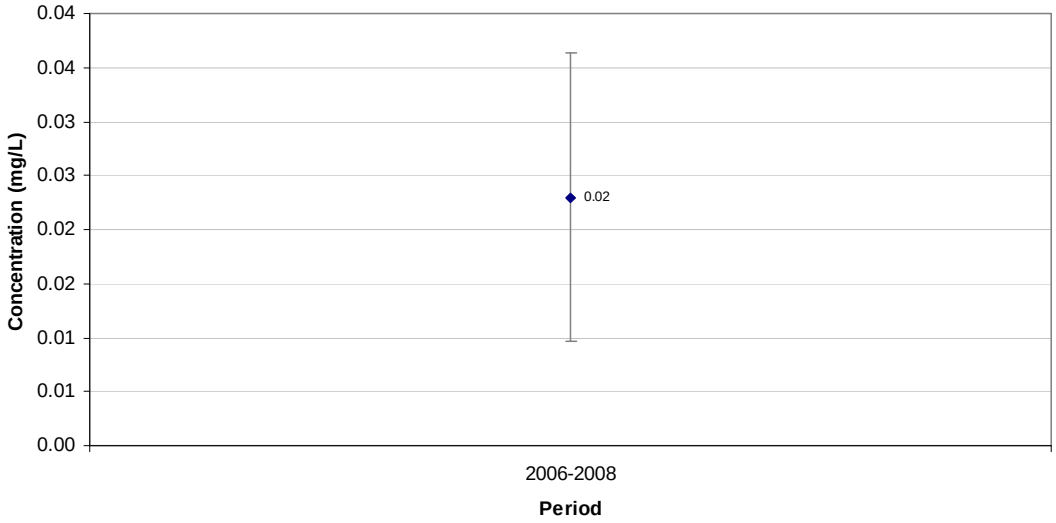




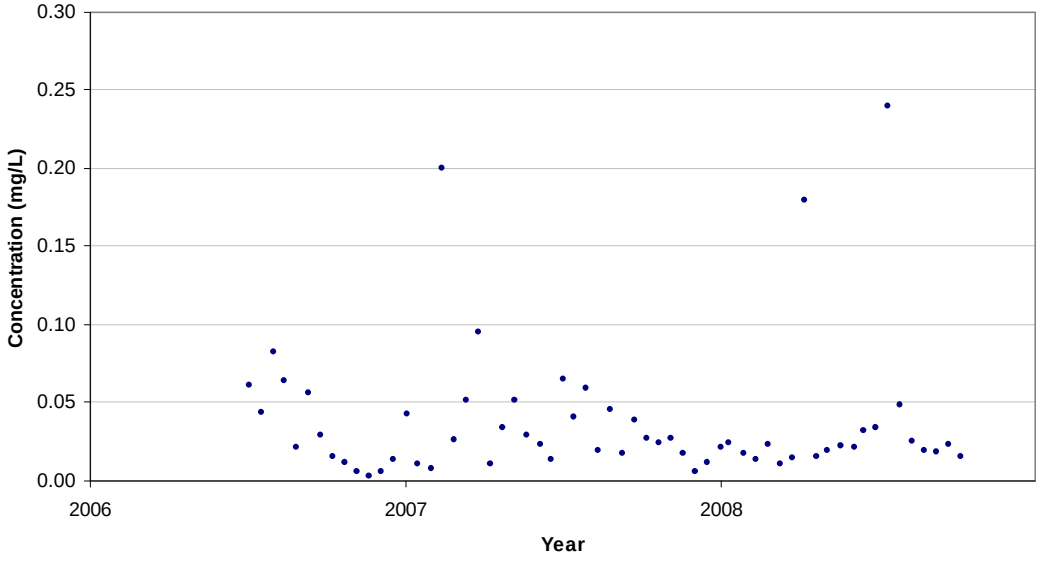
No trends

Total phosphorus – Rec Rd (Recreation Road)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6111002: Preston River (Bridge No 751)

	Period	Status	Trend
TN	2006–2008	0.83	None
TP	2006–2008	0.01	E. Increasing

Data summary for 6111002

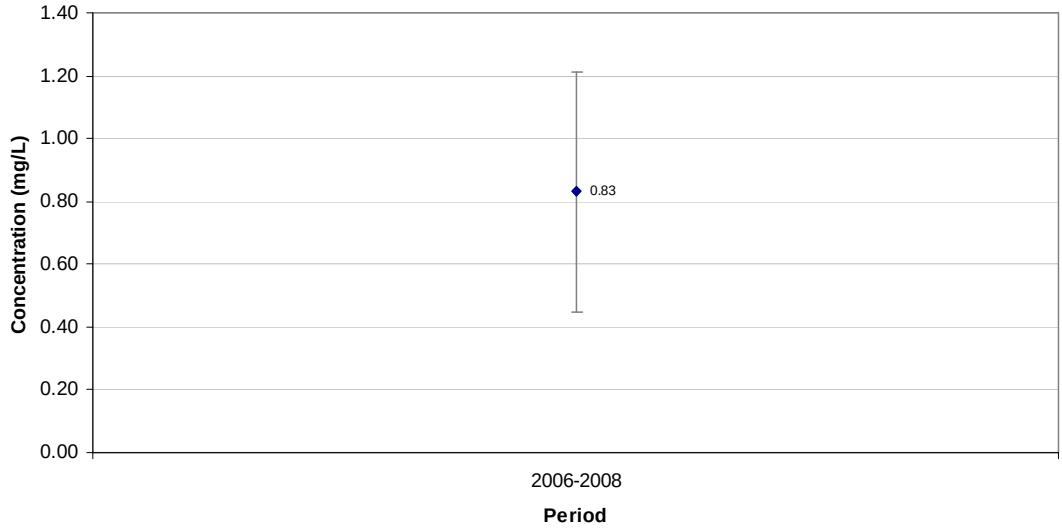
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	40	0	0	2006–2008
TP	40	0	4	2006–2008

Total nitrogen and total phosphorus statistics for 6111002

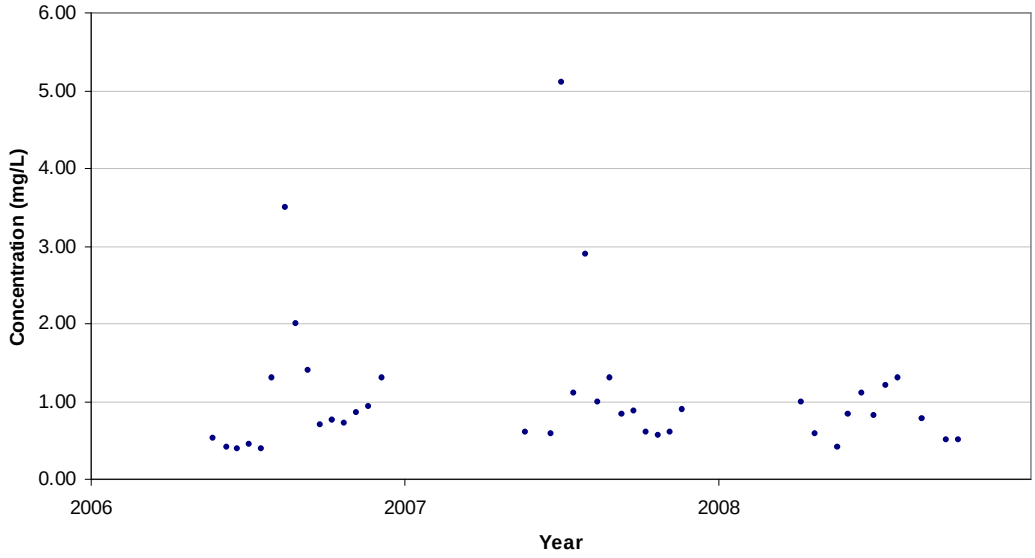
Statistic	Total nitrogen	Total phosphorus
Median	0.83	0.01
5th percentile	0.399	< 0.005
95th percentile	2.96	0.24
Lowest concentration	0.38	< 0.005
Highest concentration	5.1	0.027

Total nitrogen – Preston River (Bridge No 751)

(a) Median concentration and 90% confidence interval



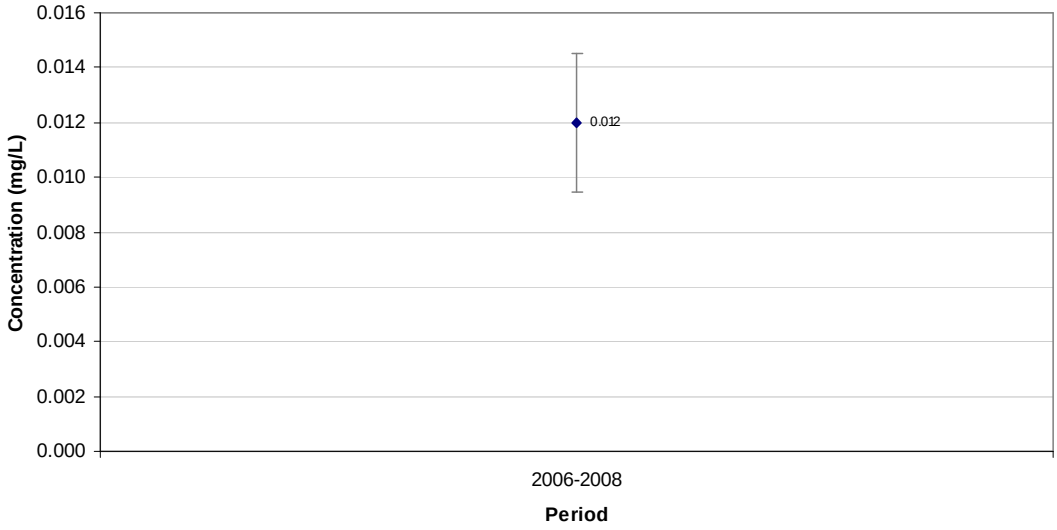
(b) - Observed data



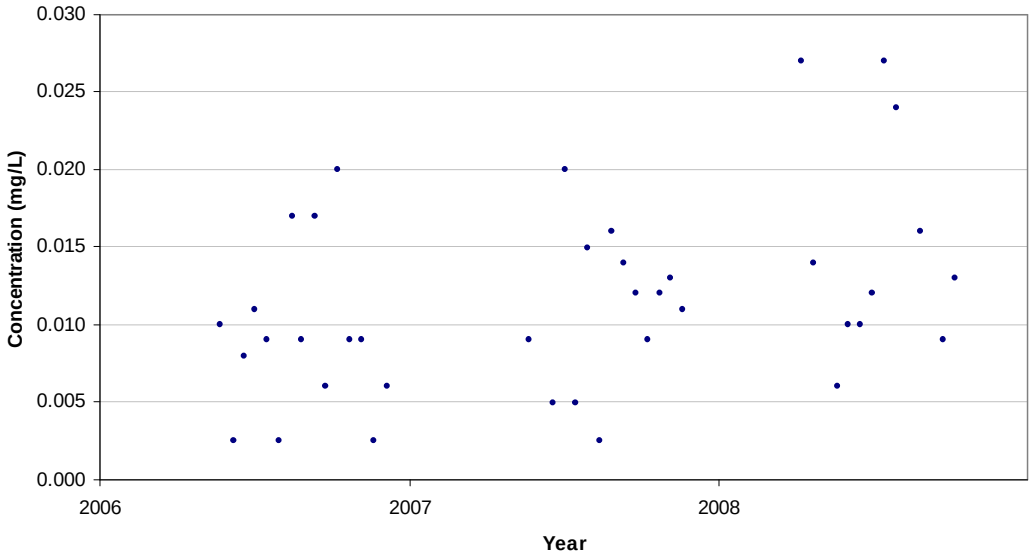
No trends

Total phosphorus – Preston River (Bridge No 751)

(a) Median concentration and 90% confidence interval



(b) - Observed data



Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TP	2006–2008	Obs.	MK	0.002	2.092	0.036	39	39	71	E. Increasing

The table shows the trend statistics where Obs. = observed data, FAC = flow-corrected data, MK = Mann-Kendall test, SK = Seasonal-Kendall test, n = number of collected measurements, n* = number of independent measurements, n# = number of independent measurements required to detect a trend, and E. = emerging (trend).

6111035: Crooked Brook (South West Hwy)

	Period	Status	Trend
TN	2006–2008	1.5	None
TP	2006–2008	0.06	None

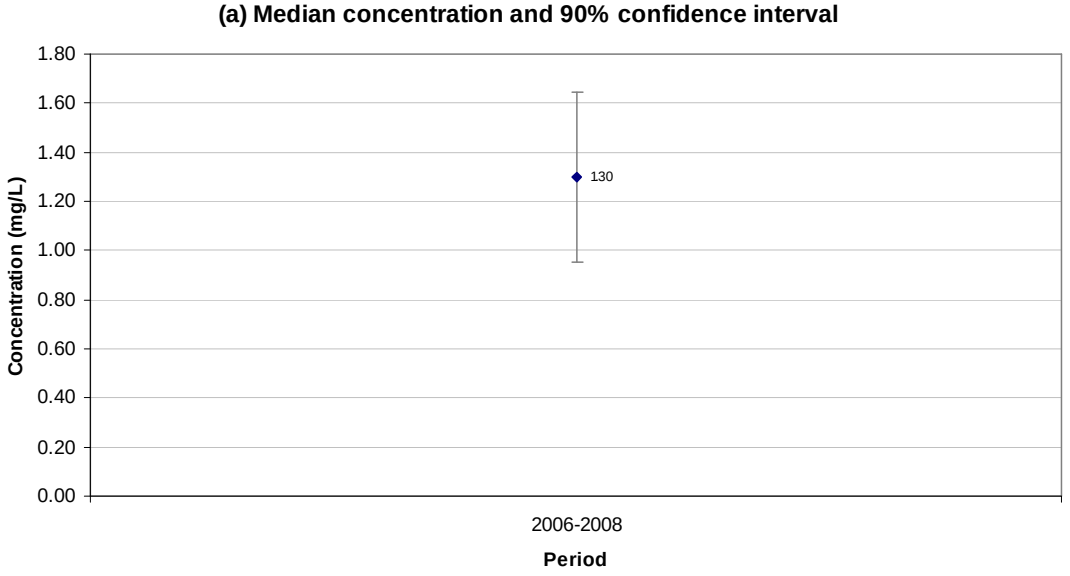
Data summary for 6111035

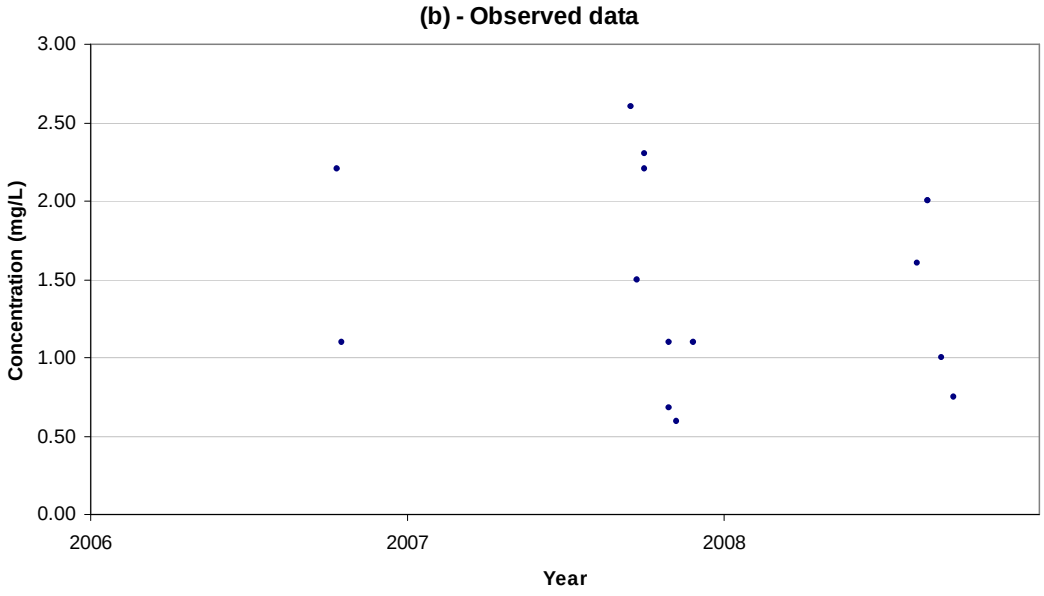
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	15	0	0	2006–2008
TP	15	0	0	2006–2008

Total nitrogen and total phosphorus statistics for 6111035

Statistic	Total nitrogen	Total phosphorus
Median	1.5	0.06
5th percentile	0.653	0.029
95th percentile	2.39	0.2
Lowest concentration	0.59	0.027
Highest concentration	2.6	0.2

Total nitrogen – Crooked Brook (South West Hwy)

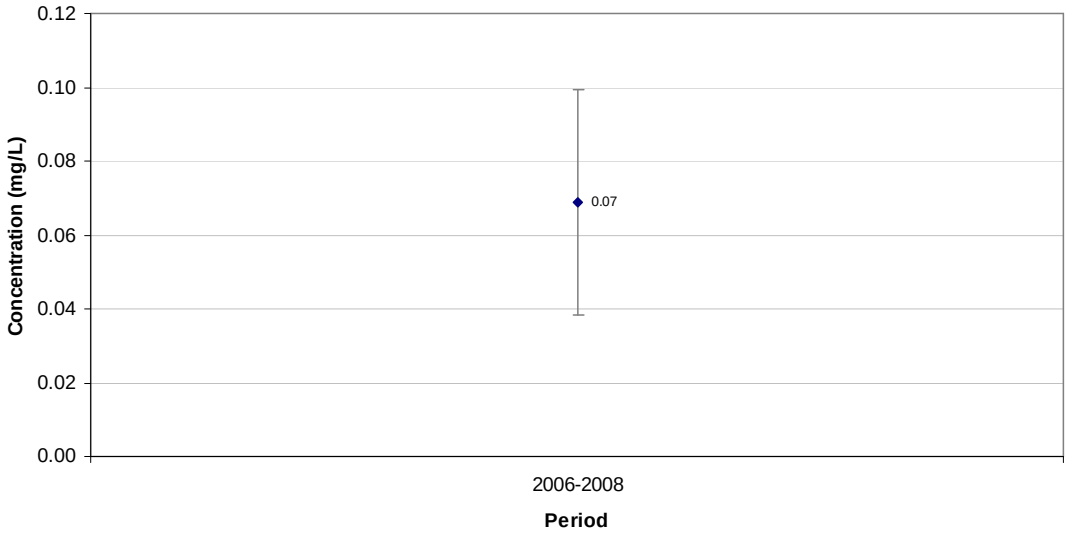




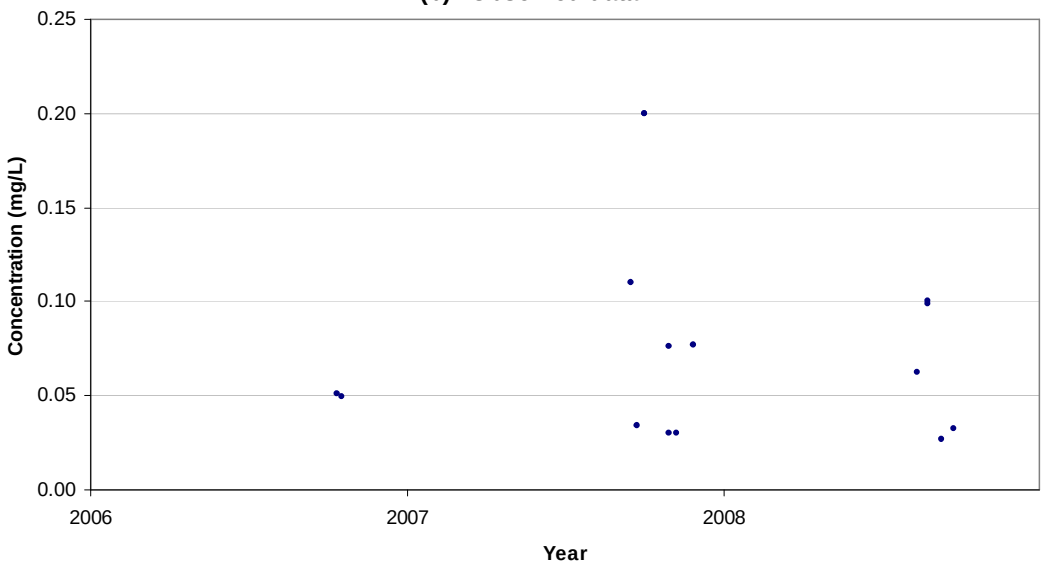
No trends

Total phosphorus – Crooked Brook (South West Hwy)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6111040: Thomson Brook (Donnybrook-Boyup Road)

	Period	Status	Trend
TN	2006–2008	0.465	None
TP	2006–2008	0.011	None

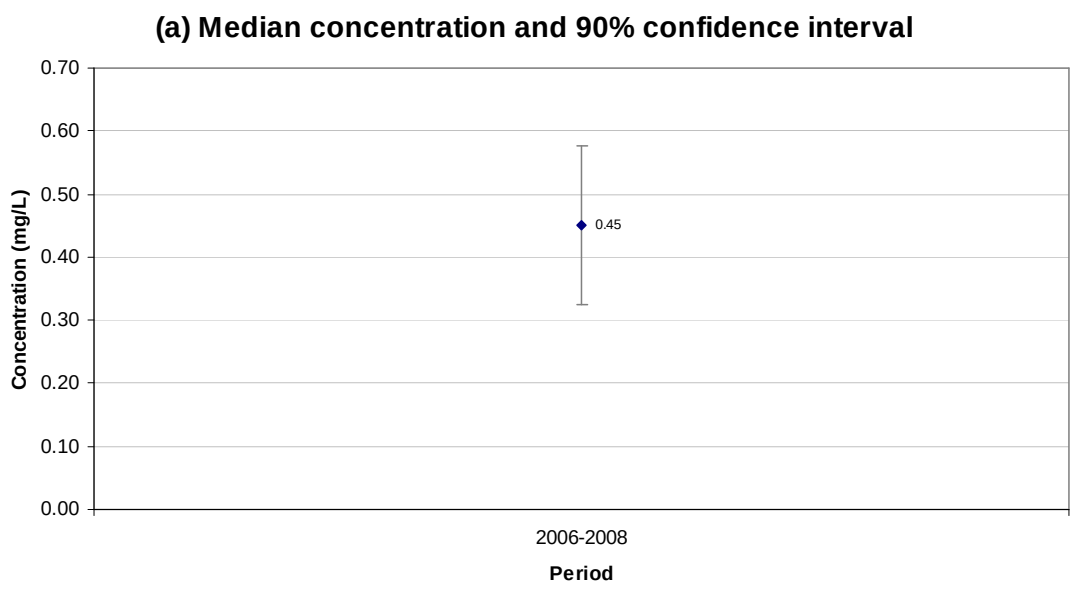
Data summary for 6111040

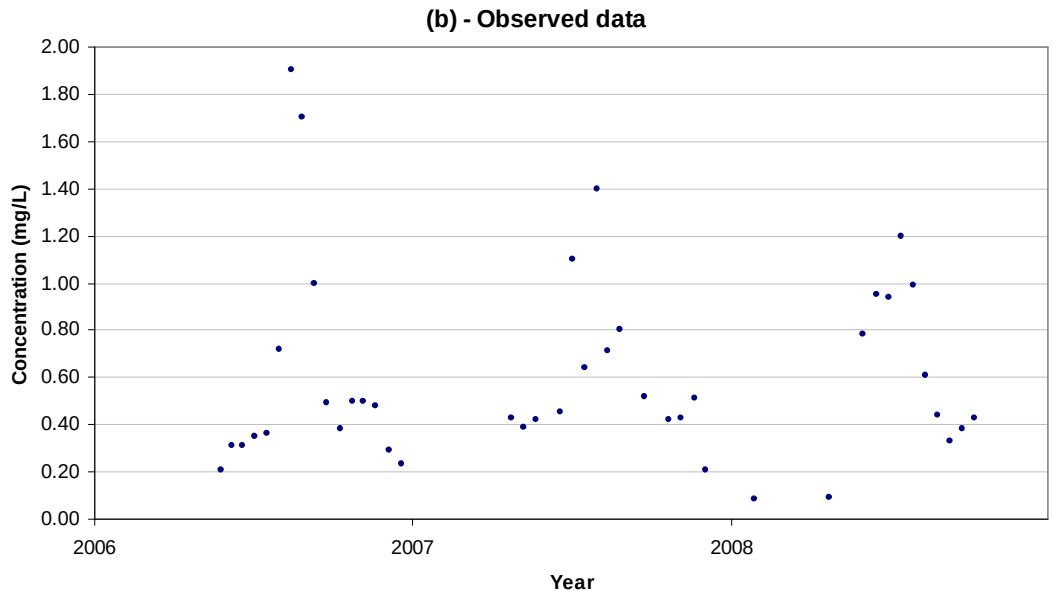
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	42	0	0	2006–2008
TP	42	0	1	2006–2008

Total nitrogen and total phosphorus statistics for 6111040

Statistic	Total nitrogen	Total phosphorus
Median	0.465	0.011
5th percentile	0.21	0.006
95th percentile	1.39	0.031
Lowest concentration	0.084	< 0.005
Highest concentration	1.9	0.05

Total nitrogen – Thomson Brook (Donnybrook-Boyup Road)

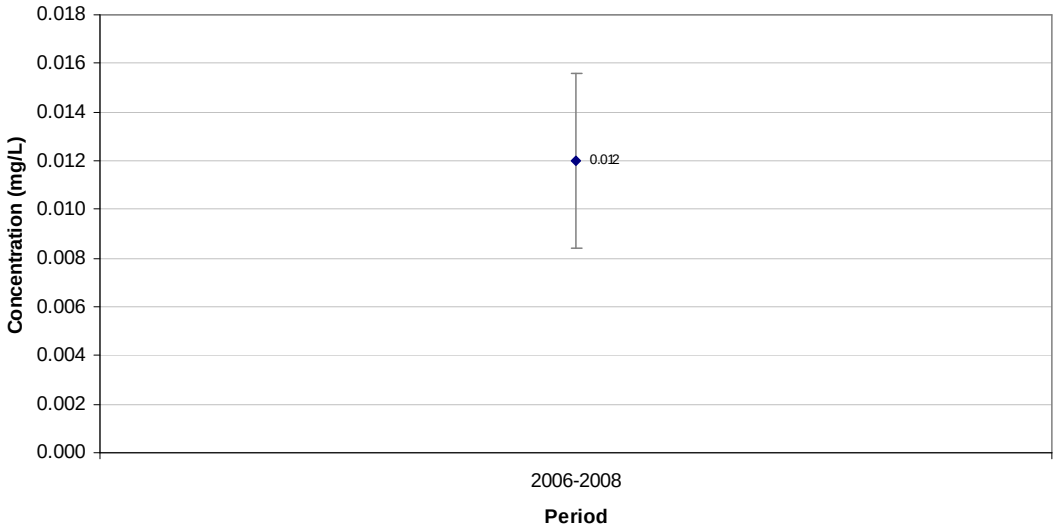




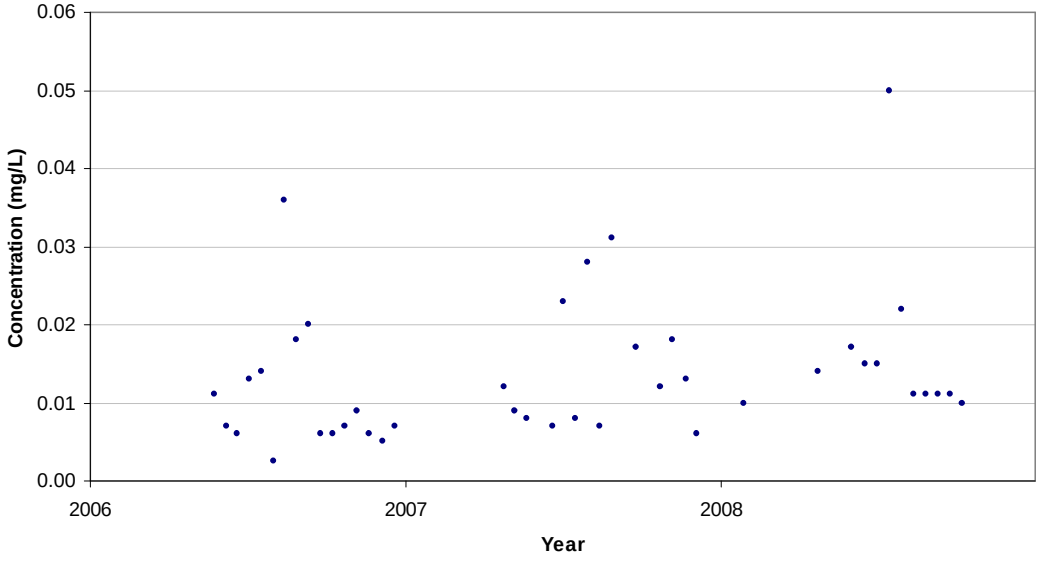
No trends

Total phosphorus – Thomson Brook (Donnybrook-Boyup Road)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6111043: Preston River (Preston 1)

	Period	Status	Trend
TN	2006–2008	0.42	E. Decreasing
TP	2006–2008	0.021	None

Data summary for 6111043

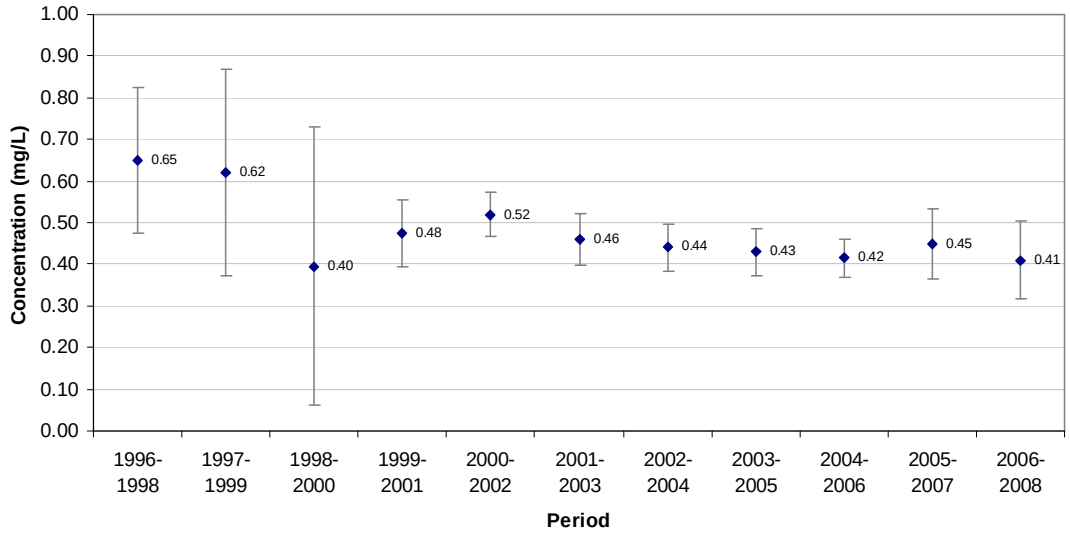
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	162	0	6	1996–2008
TP	162	12	3	1996–2008

Total nitrogen and total phosphorus statistics for 6111043

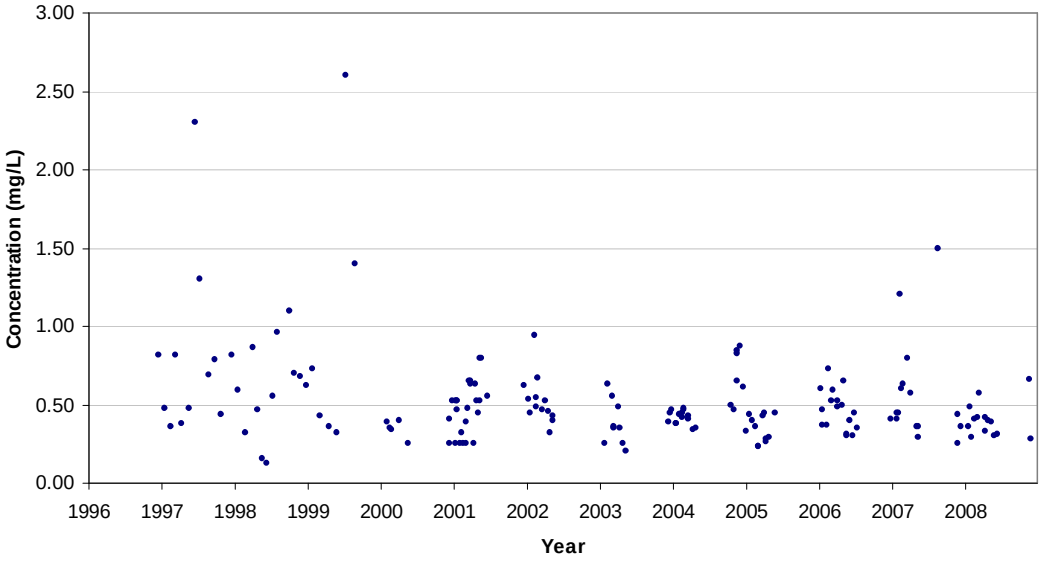
Statistic	Total nitrogen	Total phosphorus
Median	0.45	0.021
5th percentile	0.25	0.01
95th percentile	0.936	0.08
Lowest concentration	0.13	0.005
Highest concentration	2.6	0.13

Total nitrogen – Preston River (Preston 1)

(a) Median concentration and 90% confidence interval



(b) - Observed data

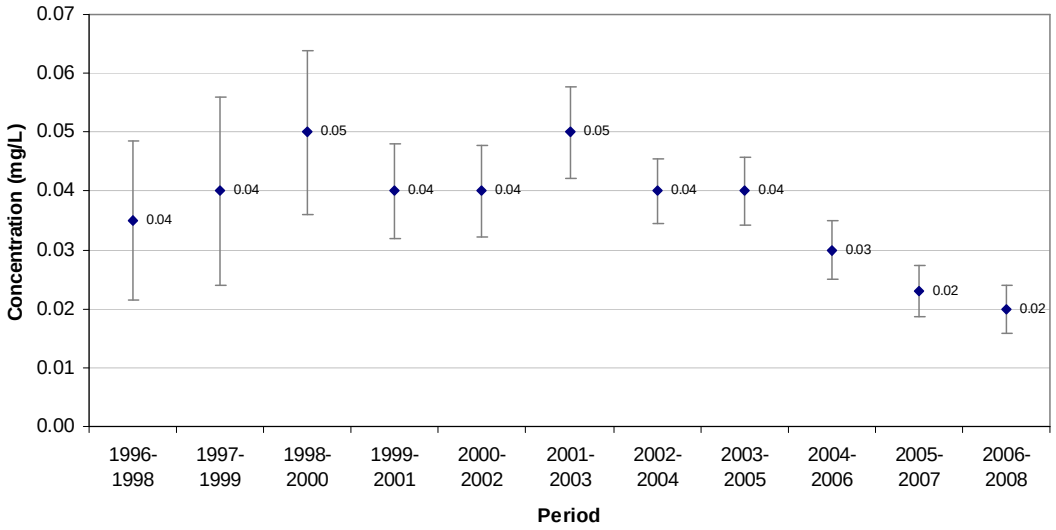


Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	2006–2008	Obs.	MK	-0.047	-2.04	0.041	47	32	240	E. Decreasing

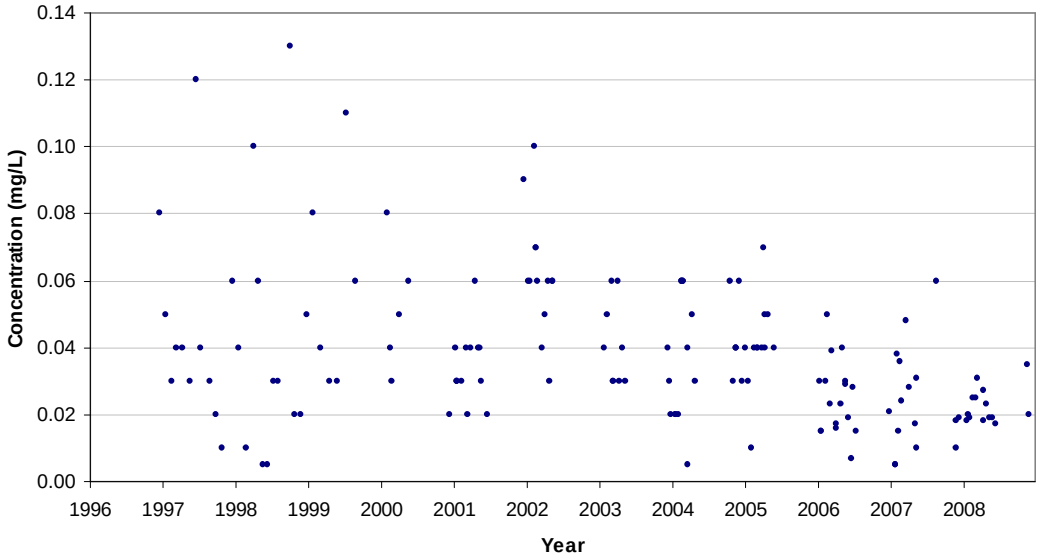
The table shows the trend statistics where Obs. = observed data, FAC = flow-corrected data, MK = Mann-Kendall test, SK = Seasonal-Kendall test, n = number of collected measurements, n* = number of independent measurements, n# = number of independent measurements required to detect a trend, and E. = emerging (trend).

Total phosphorus – Preston River (Preston 1)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6111058: Preston River (Dardanup Road)

	Period	Status	Trend
TN	2006–2008	0.335	None
TP	2006–2008	0.011	None

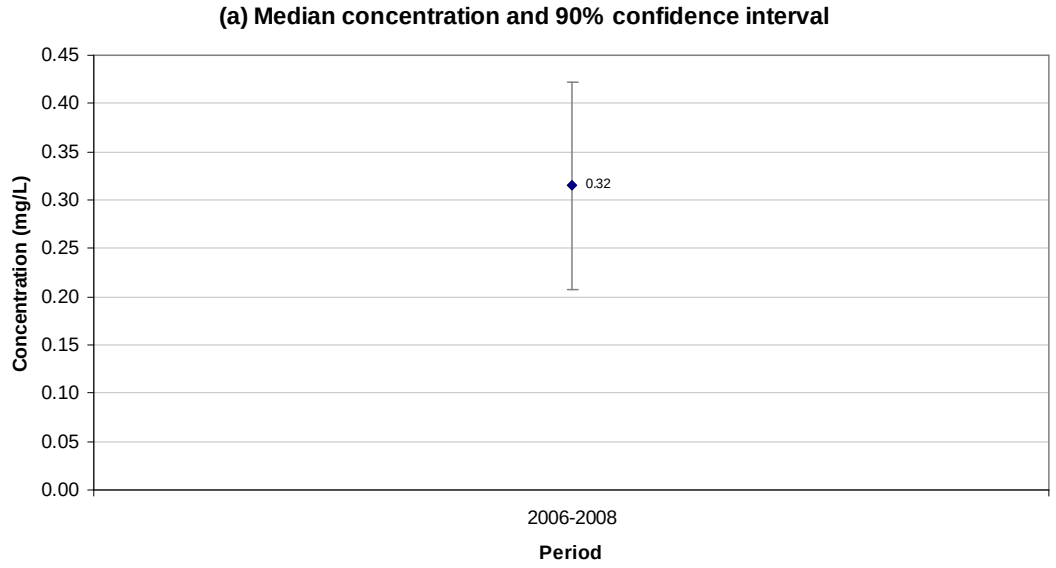
Data summary for 6111058

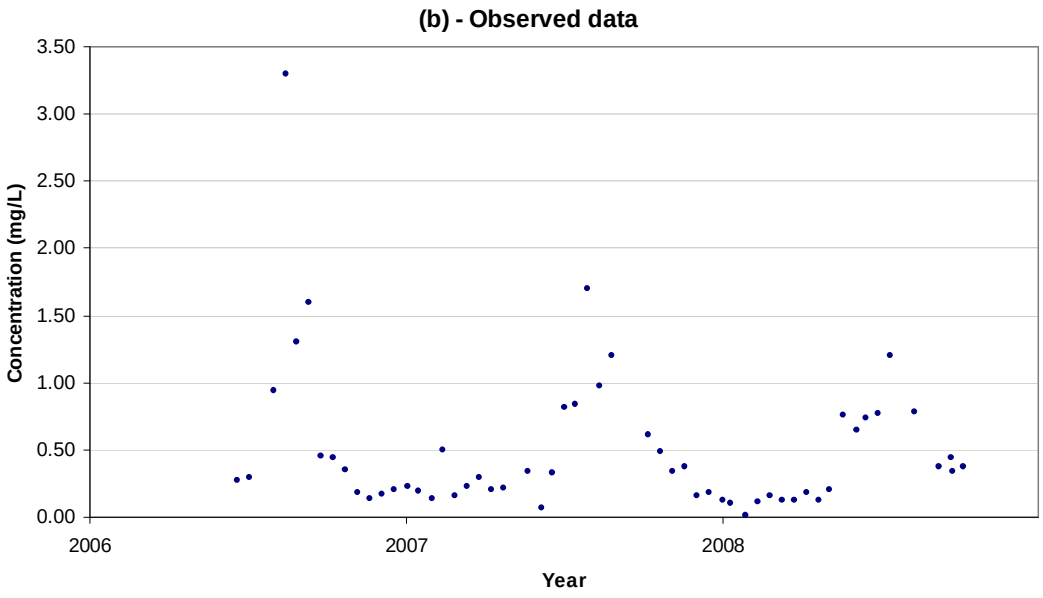
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	56	0	1	2006–2008
TP	57	0	2	2006–2008

Total nitrogen and total phosphorus statistics for 6111058

Statistic	Total nitrogen	Total phosphorus
Median	0.335	0.011
5th percentile	0.107	0.006
95th percentile	1.38	0.080
Lowest concentration	< 0.025	< 0.005
Highest concentration	3.3	0.12

Total nitrogen – Preston River (Dardanup Road)

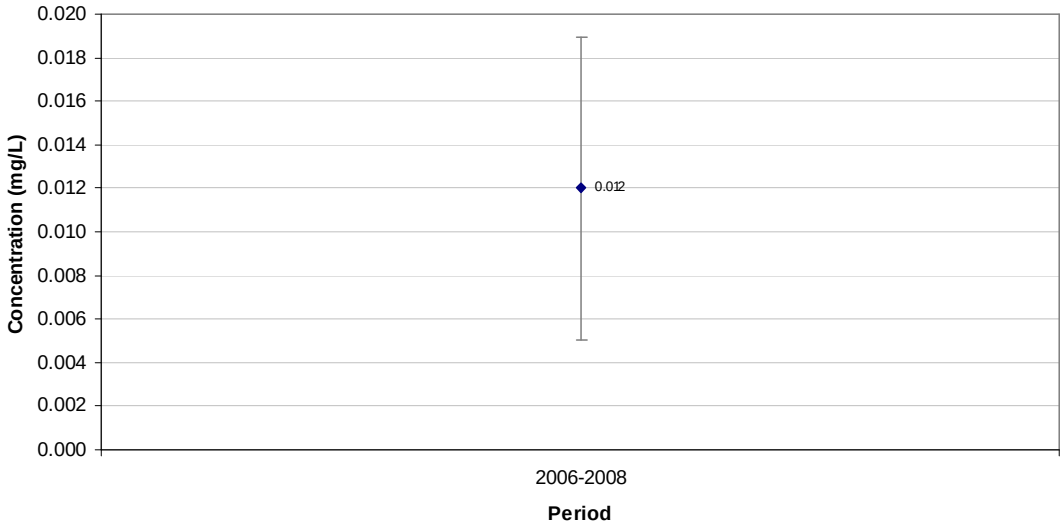




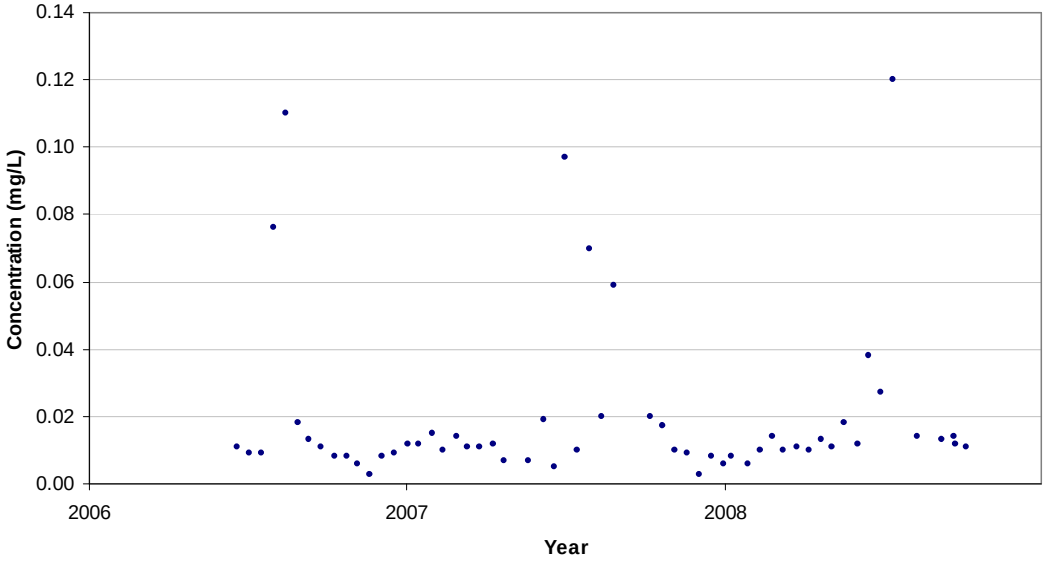
No trends

Total phosphorus – Preston River (Dardanup Road)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6111059: Canal (Meadow Road)

	Period	Status	Trend
TN	2006–2008	1.9	None
TP	2006–2008	0.12	None

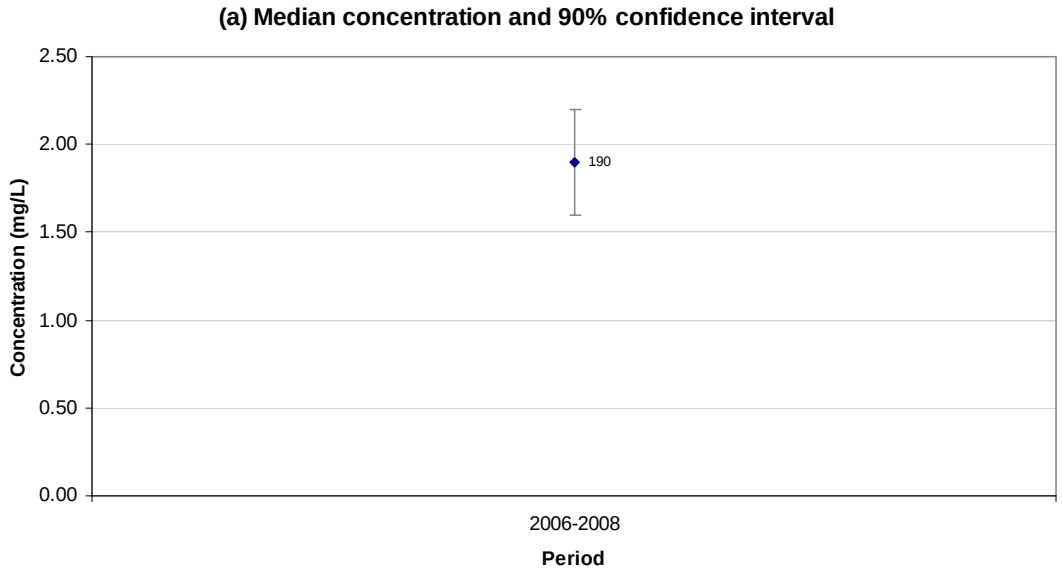
Data summary for 6111059

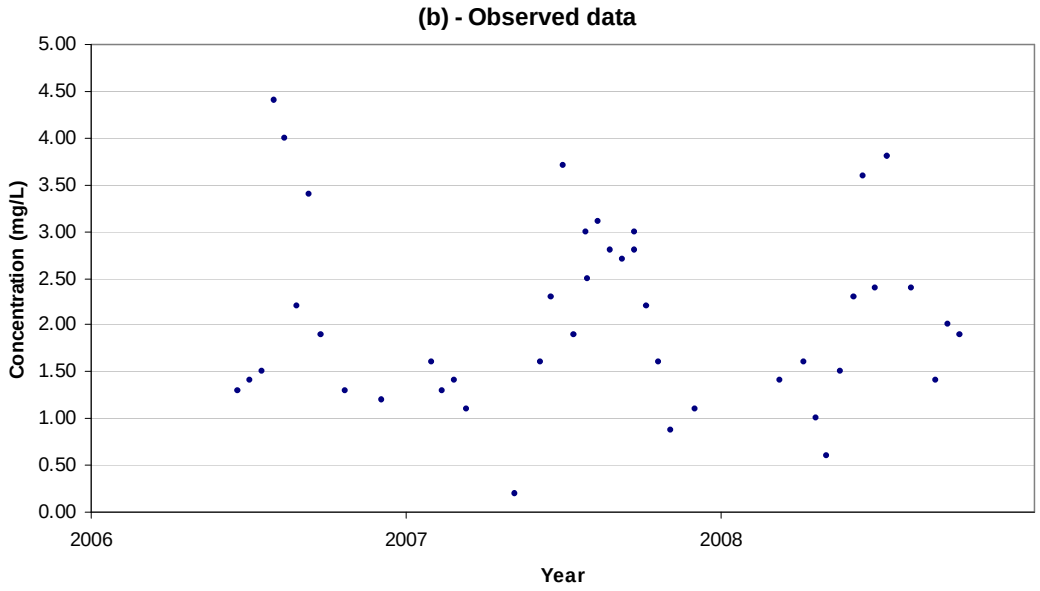
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	43	0	0	2006–2008
TP	43	0	0	2006–2008

Total nitrogen and total phosphorus statistics for 6111059

Statistic	Total nitrogen	Total phosphorus
Median	1.9	0.12
5th percentile	0.883	0.024
95th percentile	3.79	0.748
Lowest concentration	0.20	0.007
Highest concentration	4.4	1.2

Total nitrogen – Canal (Meadow Road)

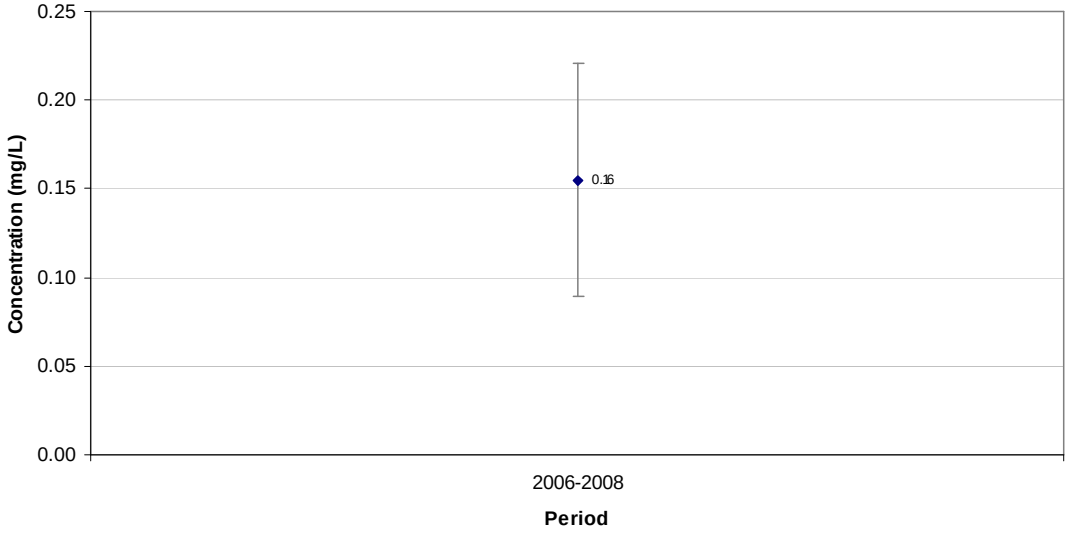




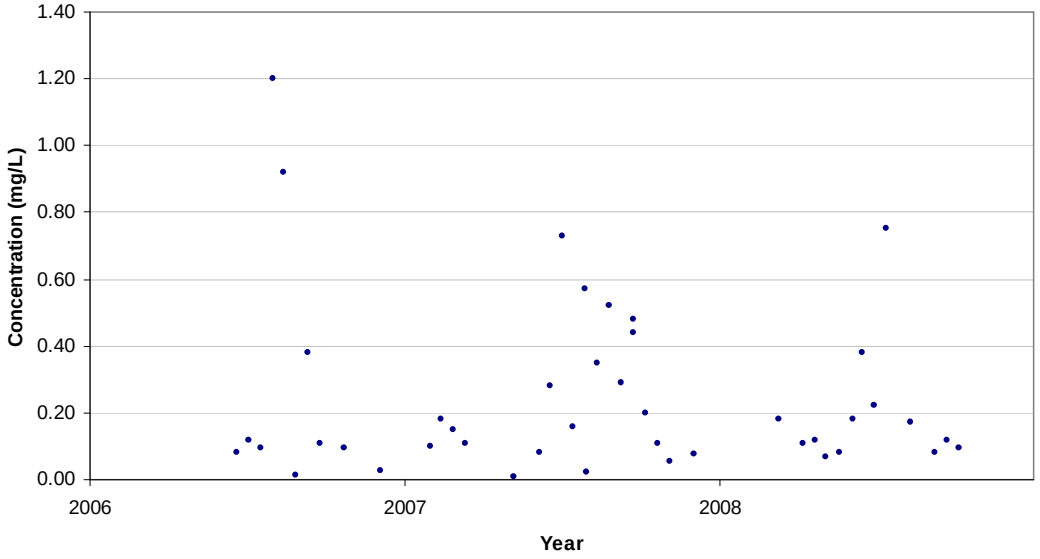
No trends

Total phosphorus – Canal (Meadow Road)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

612013: Collie River (Wellington flume)

	Period	Status	Trend
TN	2006–2008	0.47	None
TP	2006–2008	<0.005	None

Data summary for 612013

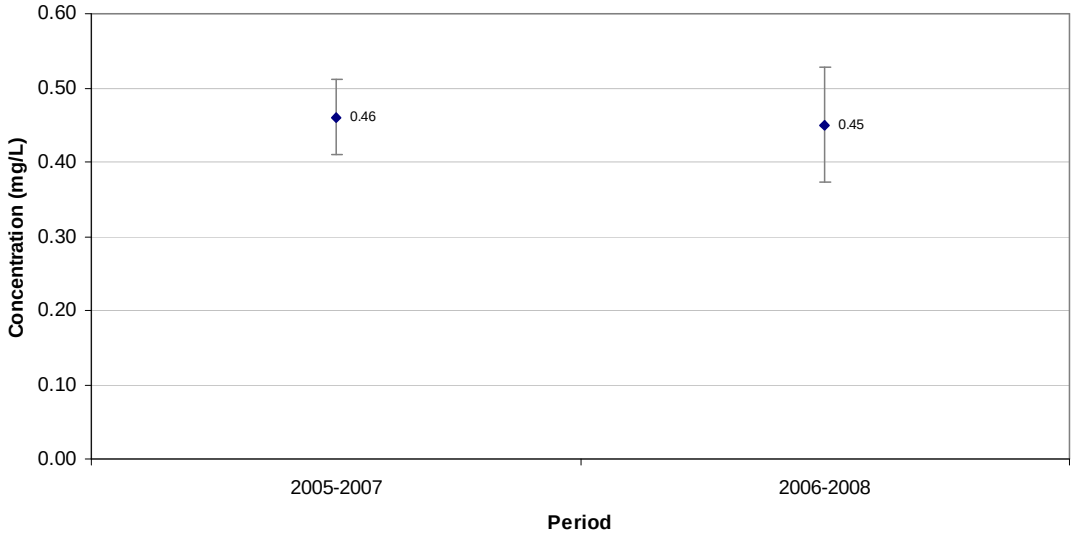
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	59	0	29	2005–2008
TP	59	0	0	2005–2008
Flow				1973–2008

Total nitrogen and total phosphorus statistics for 612013

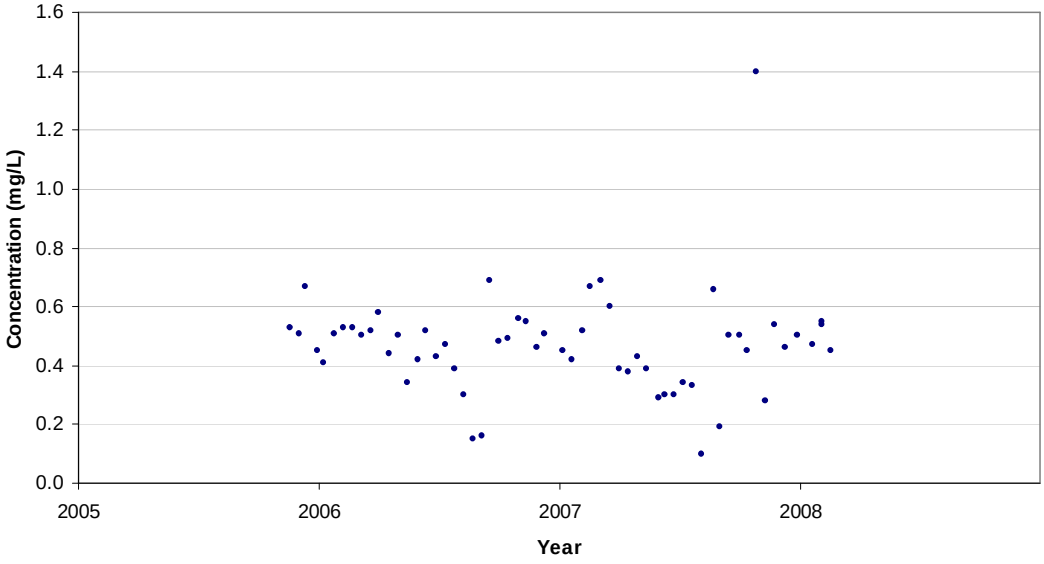
Statistic	Total nitrogen	Total phosphorus
Median	0.47	0.005
5th percentile	0.187	< 0.005
95th percentile	0.672	0.0112
Lowest concentration	0.1	< 0.005
Highest concentration	1.4	0.021

Total nitrogen – Collie River (Wellington flume)

(a) Median concentration and 90% confidence interval



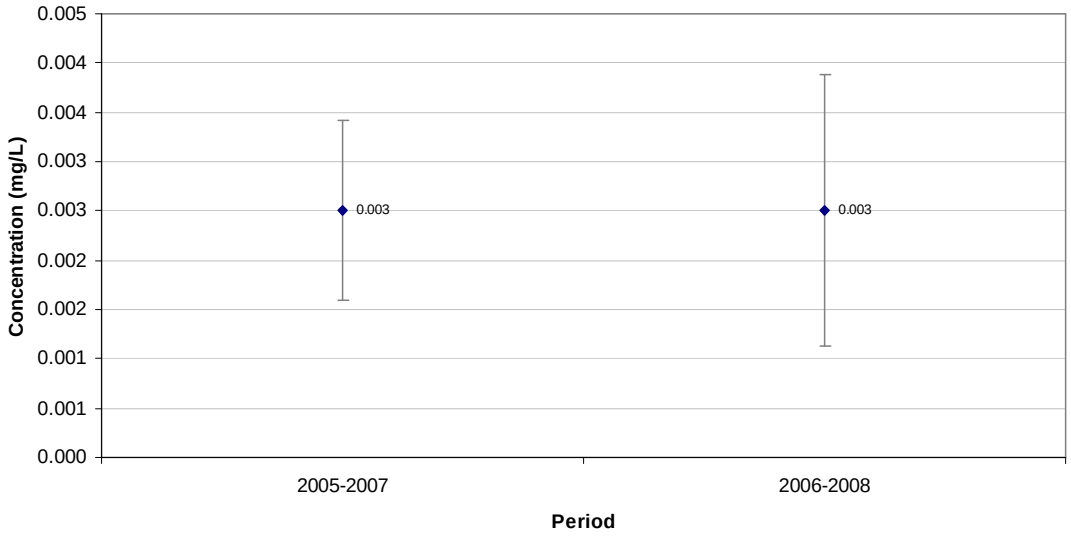
(b) - Observed data



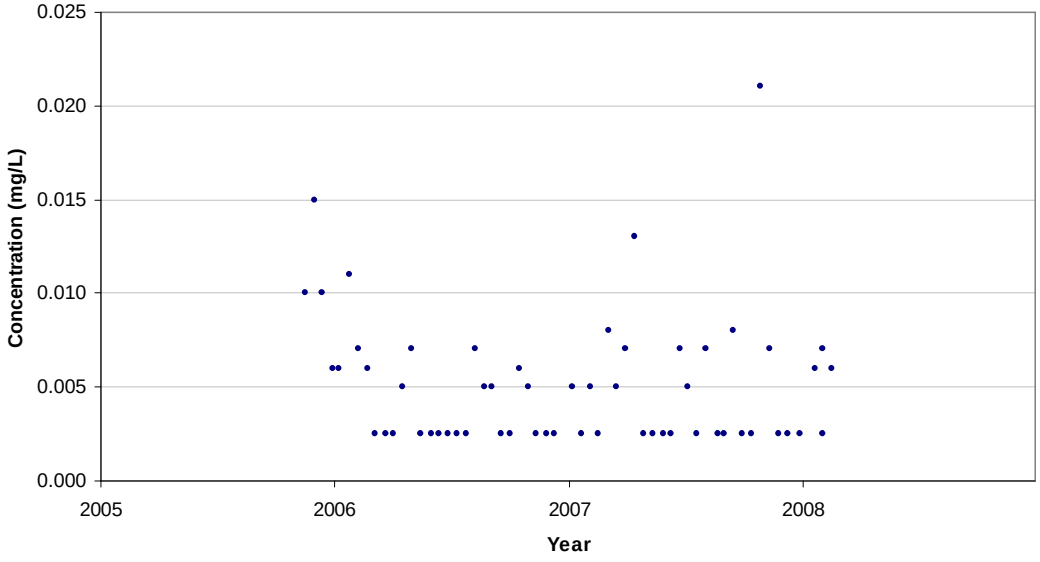
No trends

Total phosphorus – Collie River (Wellington flume)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

612015: Vindictive Drain (Harris Road)

	Period	Median	Trend
TN	2006–2008	2.25	None
TP	2006–2008	0.235	None

Data summary for 612015

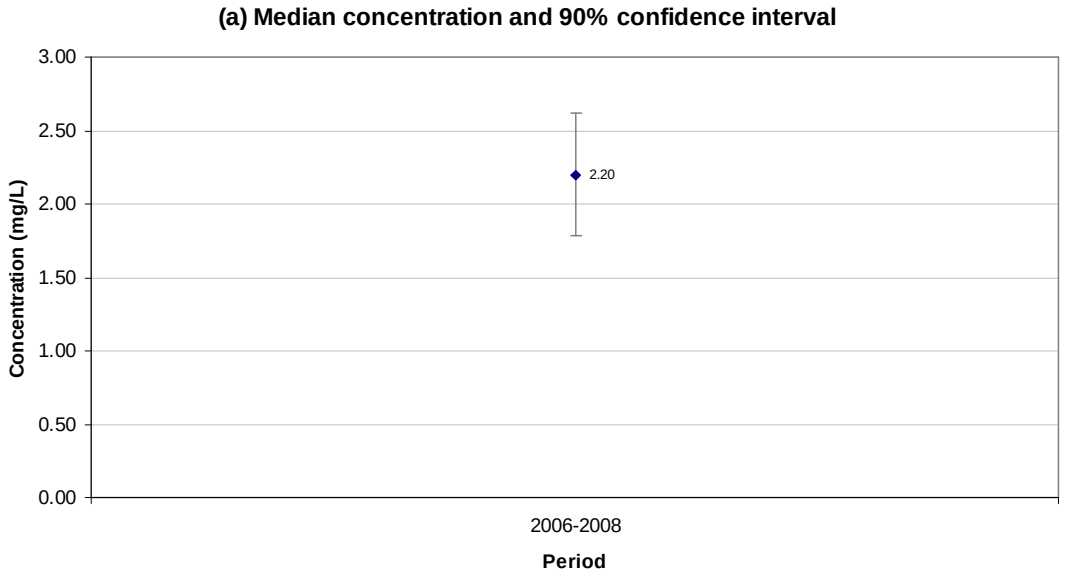
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	19	0	0	1992–2008
TP	19	0	0	1992–2008
Flow				1974–1995

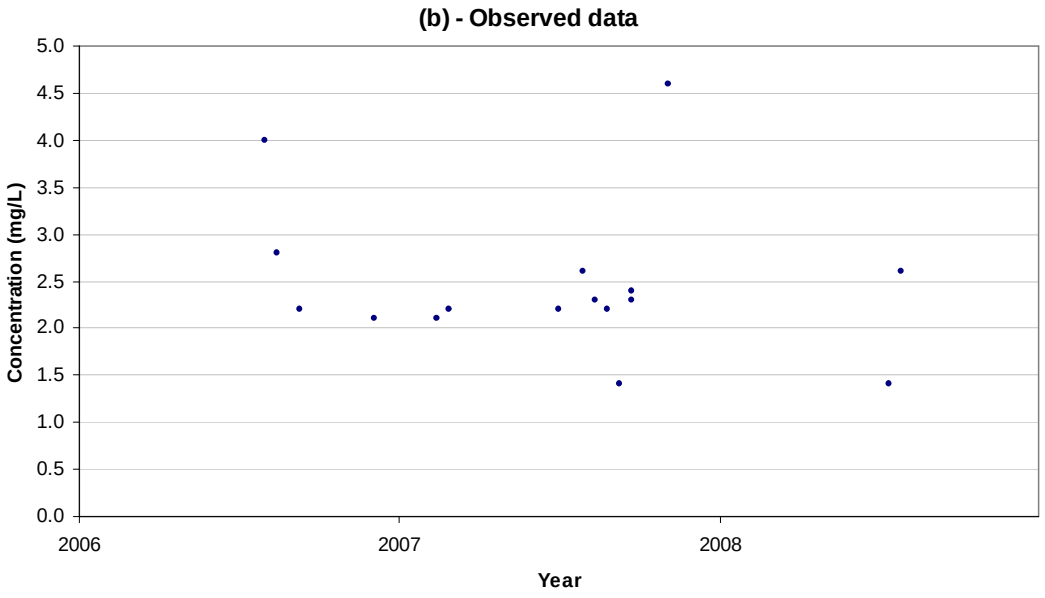
Total nitrogen and total phosphorus statistics for 612015

Statistic	Total nitrogen	Total phosphorus
Median	2.3	0.24
5th percentile	1.40	0.090
95th percentile	4.06	0.578
Lowest concentration	1.4	0.06
Highest concentration	4.6	1.01

Comments Only 3 TN and TP observations from 1992 during flow period

Total nitrogen – Vindictive Drain (Harris Road)

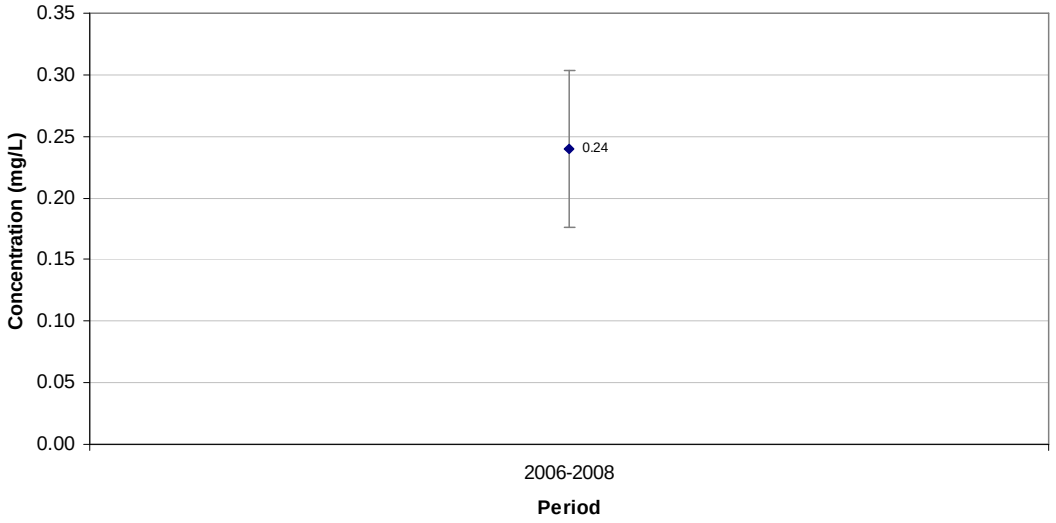




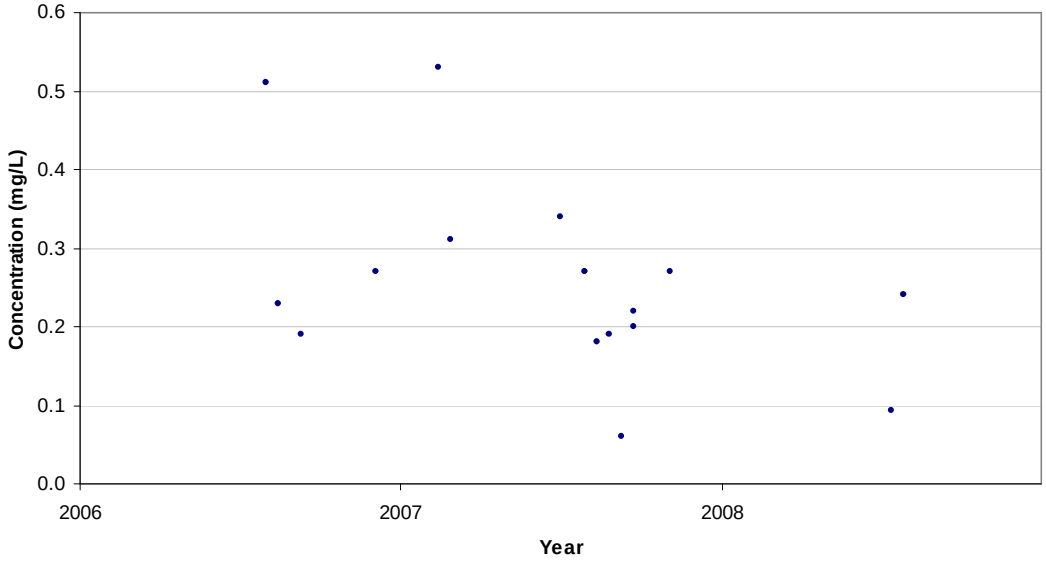
No trends

Total phosphorus – Vindictive Drain (Harris Road)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

612032: Brunswick River (Cross Farm)

	Period	Status	Trend
TN	2006–2008	1.2	None
TP	2006–2008	0.12	None

Data summary for 612032

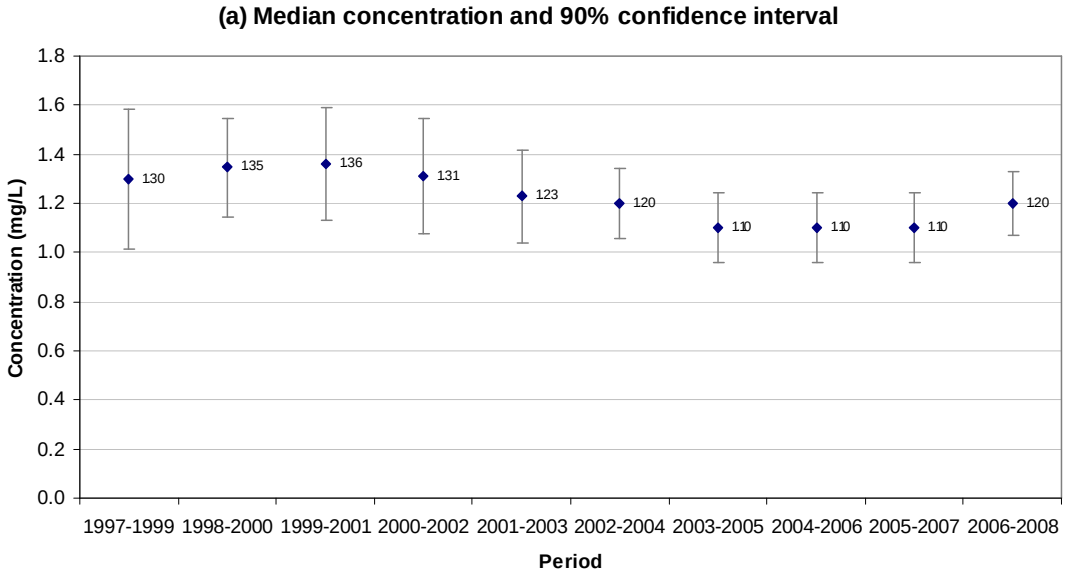
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	342	7	5	1992–2008
TP	368	155	0	1992–2008
Flow				1990–2008

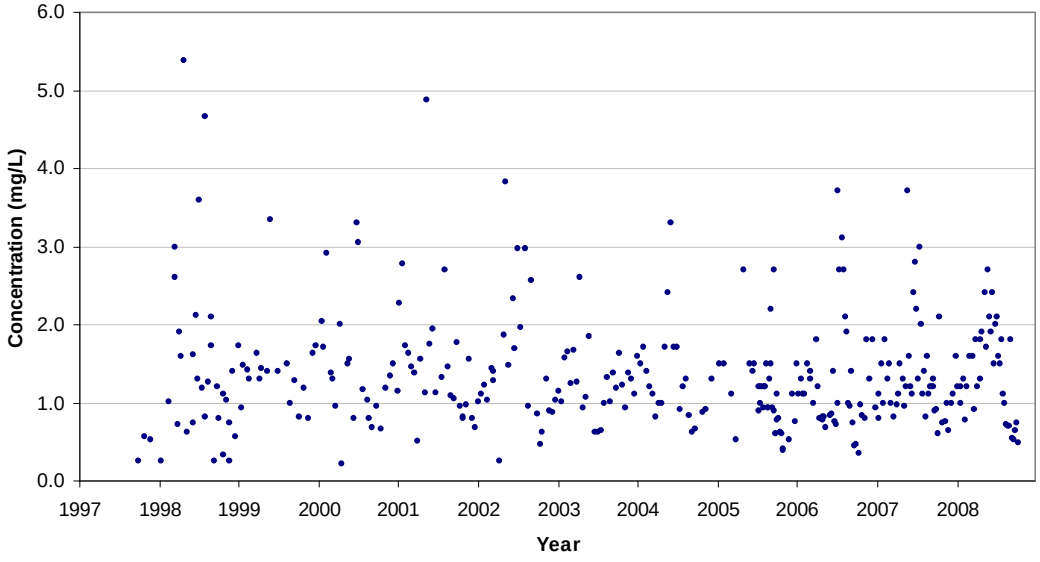
Total nitrogen and total phosphorus statistics for 612032

Statistic	Total nitrogen	Total phosphorus
Median	1.2	0.12
5th percentile	0.52	0.043
95th percentile	2.83	0.36
Lowest concentration	0.22	0.006
Highest concentration	5.38	0.58

Comment: 155 TP data deleted with detection limit = 0.4 mg/L

Total nitrogen – Brunswick River (Cross Farm)

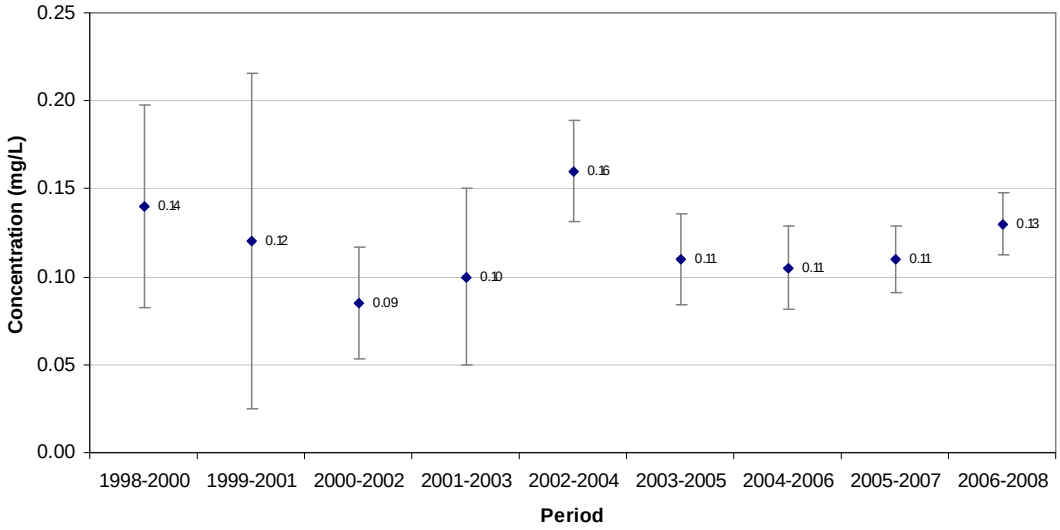




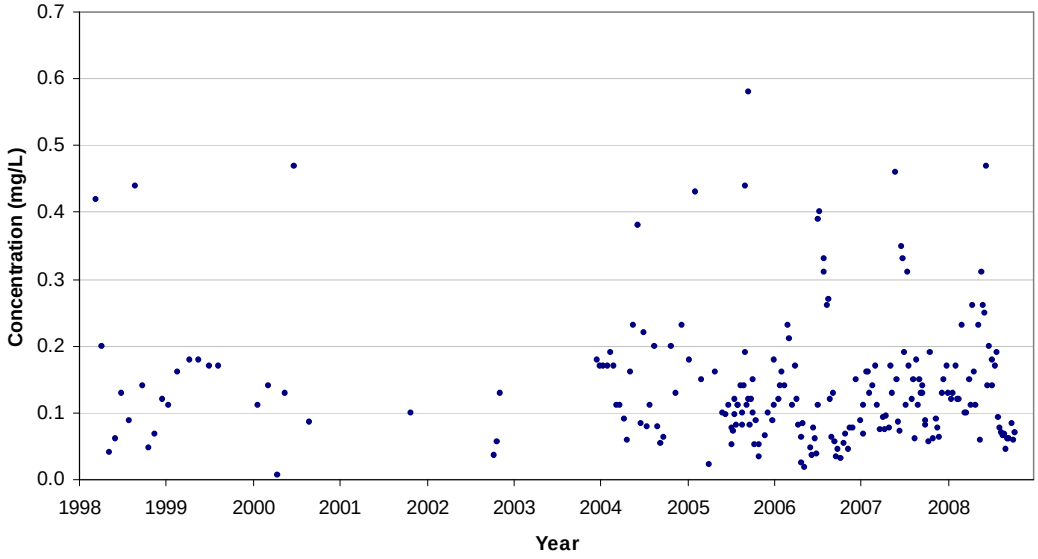
No trends

Total phosphorus – Brunswick River (Cross Farm)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

612039: Wellesley River (Juegenup Wellesley)

	Period	Status	Trend
TN	2006–2008	1.45	E. Increasing
TP	2006–2008	0.17	Increasing

*612039 concentration data were flow correlated. Flow-corrected TP data had a statistically significantly increasing trend for whole record and also for the period 2006 to 2008.

Data summary for 612039

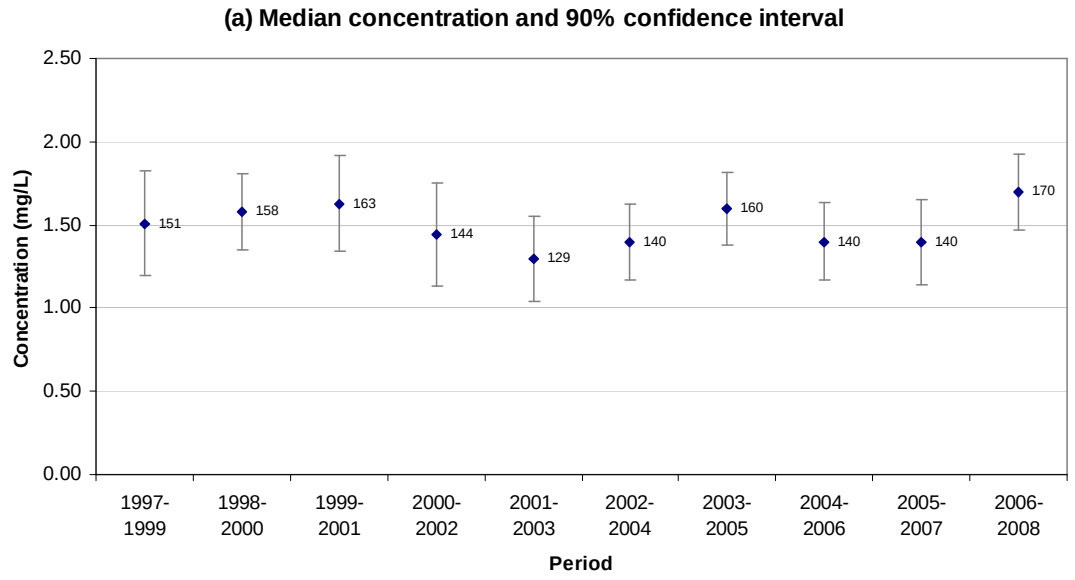
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	333	7	15	1992–2008
TP	342	133	0	1992–2008
Flow				1990–2008

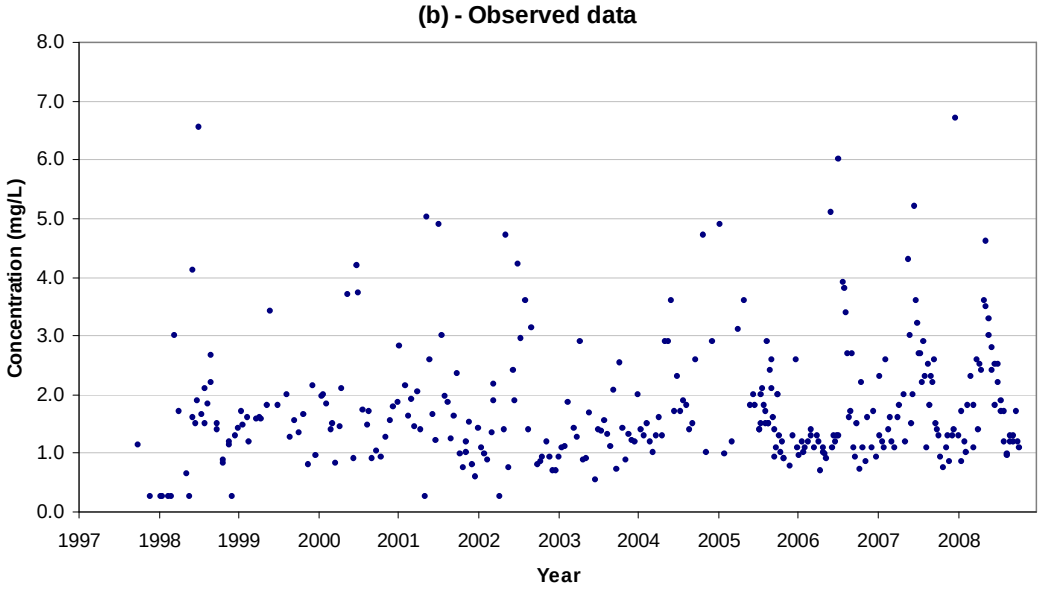
Total nitrogen and total phosphorus statistics for 612039

Statistic	Total nitrogen	Total phosphorus
Median	1.5	0.17
5th percentile	0.72	0.071
95th percentile	3.78	0.45
Lowest concentration	< 0.5	0.014
Highest concentration	6.7	0.72

Comment: TP 133 data deleted with detection limit = 0.4 mg/L

Total nitrogen – Wellesley River (Juegenup Wellesley)

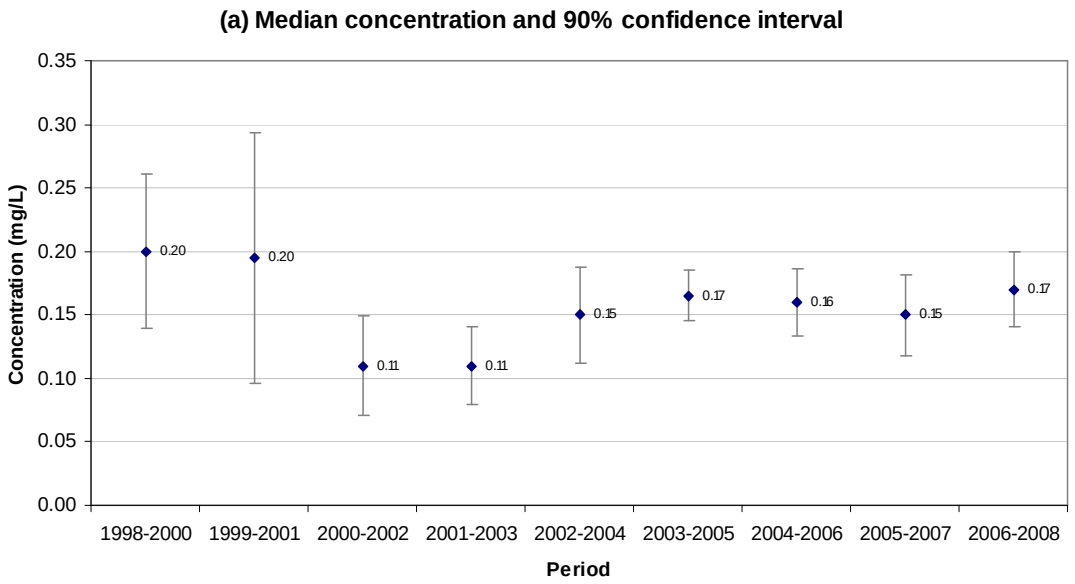


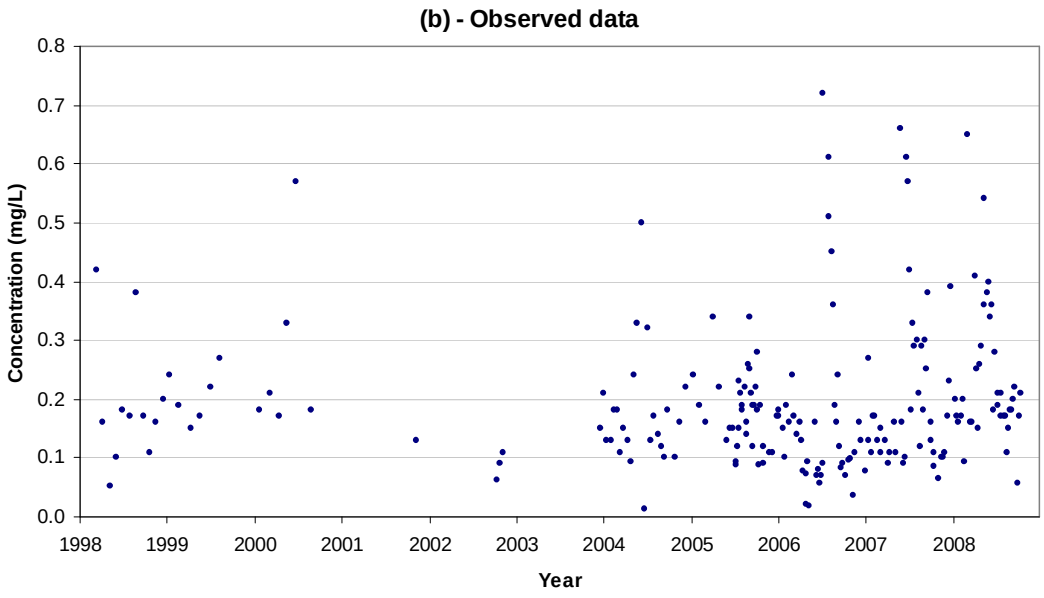


Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	2006–2008	Obs.	MK	0.13	2.127	0.033	119	31	342	E. Increasing
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	1998–2008	FAC	MK	0.028	2.324	0.02	321	136	763	E. Increasing
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	1998–2008	FAC	SK	0.025	2.328	0.02	321	203	792	E. Increasing

The table shows the trend statistics where Obs. = observed data, FAC = flow-corrected data, MK = Mann-Kendall test, SK = Seasonal-Kendall test, n = number of collected measurements, n* = number of independent measurements, n# = number of independent measurements required to detect a trend, and E. = emerging (trend).

Total phosphorus – Wellesley River (Juegenup Wellesley)





Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TP	1998–2008	FAC	MK	0.009	3.523	0	206	110	99	Increasing
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TP	1998–2008	FAC	SK	0.01	3.451	0.001	206	119	65	Increasing
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TP	2006–2008	Obs.	MK	0.031	3.351	0.001	119	71	120	E. Increasing
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TP	2006–2008	FAC	MK	0.042	4.468	0	119	57	52	Increasing
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TP	2006–2008	FAC	SK	0.041	3.741	0	119	71	34	Increasing

Clearly the long-term trend test should have been from 2003 to 2008

The table shows the trend statistics where Obs. = observed data, FAC = flow-corrected data, MK = Mann-Kendall test, SK = Seasonal-Kendall test, n = number of collected measurements, n* = number of independent measurements, n# = number of independent measurements required to detect a trend,

and E. = emerging (trend).

612043: Collie River (Rose Road)

	Period	Status	Trend
TN	2006–2008	0.40	None
TP	2006–2008	0.01	None

Data summary for 612043

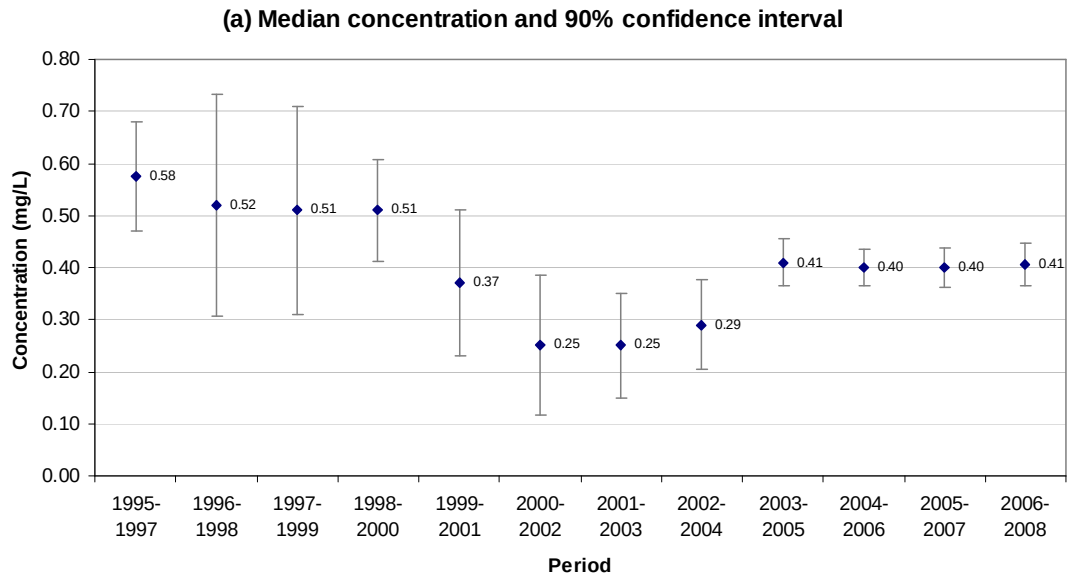
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	413	6	67	1995–2008
TP	446	155	25	1995–2008
Flow				1996–2008

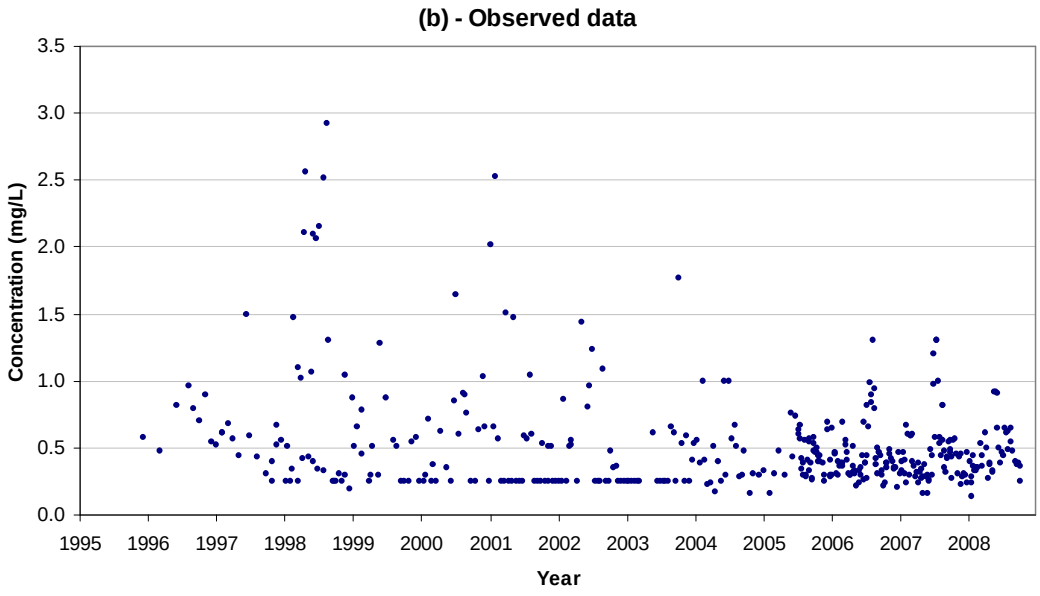
Total nitrogen and total phosphorus statistics for 612043

Statistic	Total nitrogen	Total phosphorus
Median	0.41	0.011
5th percentile	< 0.5	< 0.005
95th percentile	1.27	0.037
Lowest concentration	0.14	< 0.005
Highest concentration	2.93	0.11

Comment: TP 155 data deleted with detection limit = 0.4 mg/L

Total nitrogen – Collie River (Rose Road)

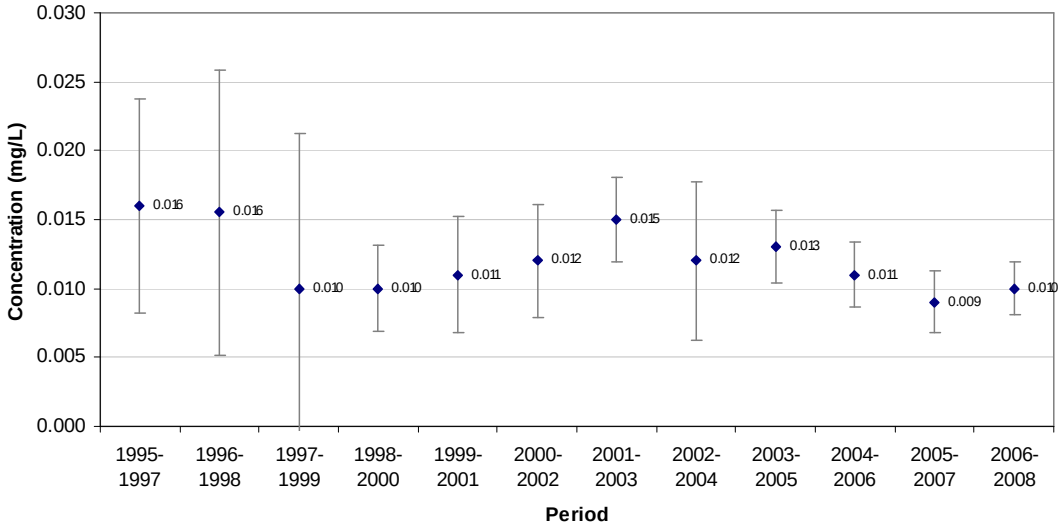




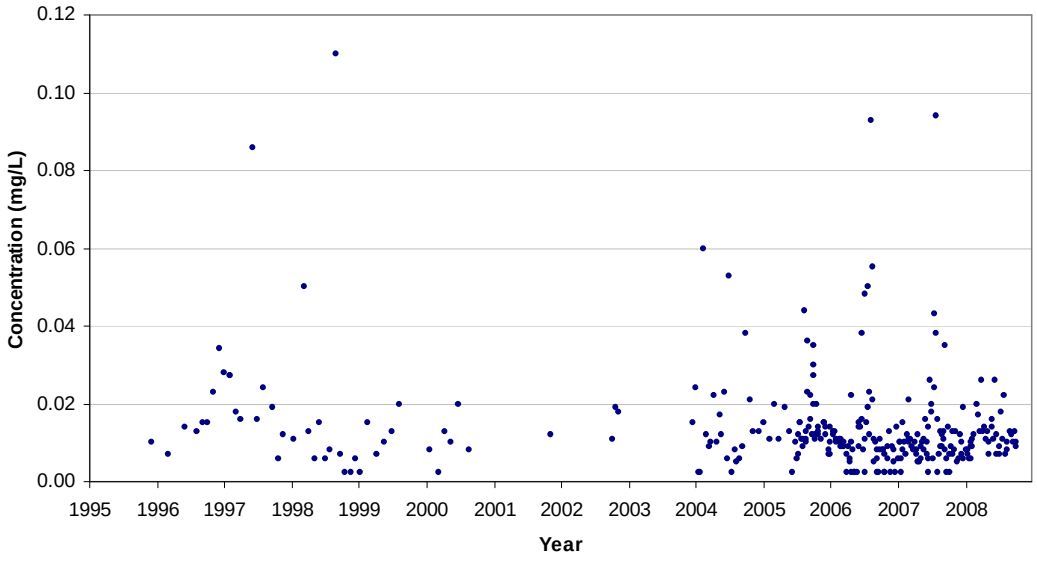
No trends

Total phosphorus – Collie River (Rose Road)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

612047: Brunswick River (Beela)

	Period	Status	Trend
TN	2006–2008	0.315	None
TP	2006–2008	0.011	E. Decreasing*

*Emerging decreasing trend in flow corrected data

Data summary for 612047

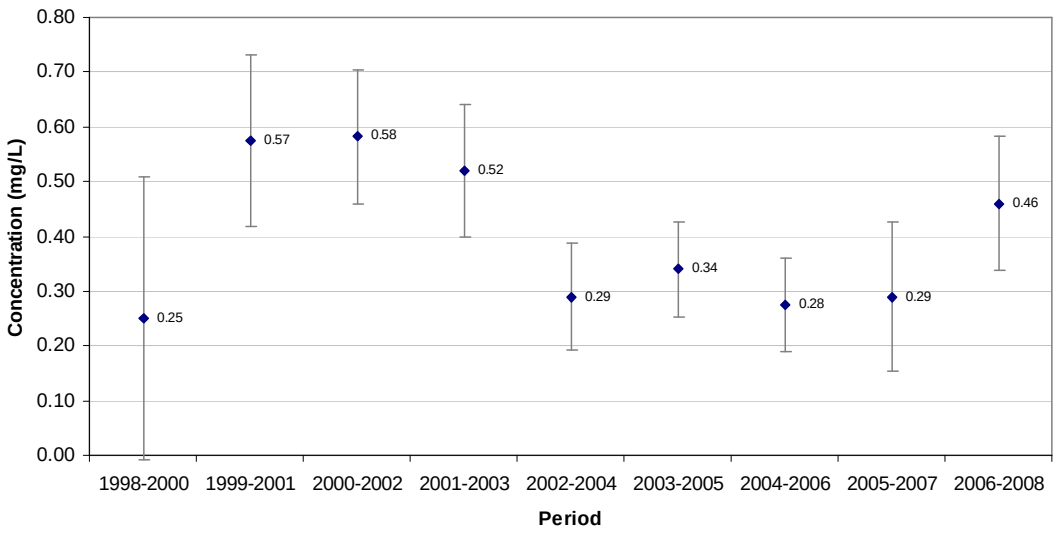
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	158	0	26	1998–2008
TP	160	66	8	1998–2008
Flow				2000–2008

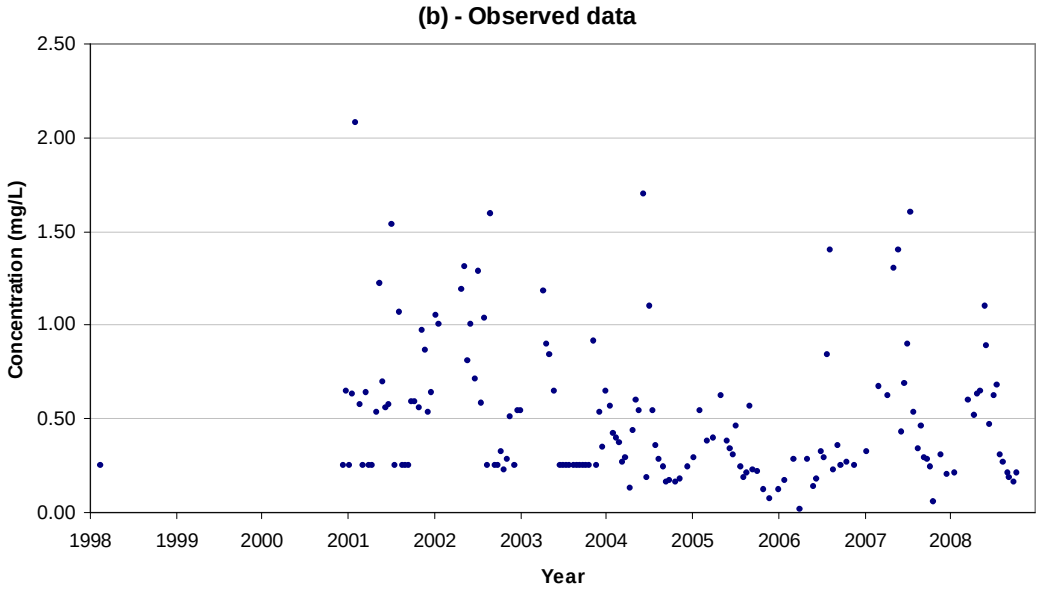
Total nitrogen and total phosphorus statistics for 612047

Statistic	Total nitrogen	Total phosphorus
Median	0.36	0.0125
5th percentile	0.16	< 0.005
95th percentile	1.30	0.053
Lowest concentration	<0.025	< 0.005
Highest concentration	2.08	0.073

Comment: TP 66 data deleted with detection limit = 0.4 mg/L

Total nitrogen – Brunswick River (Beela)

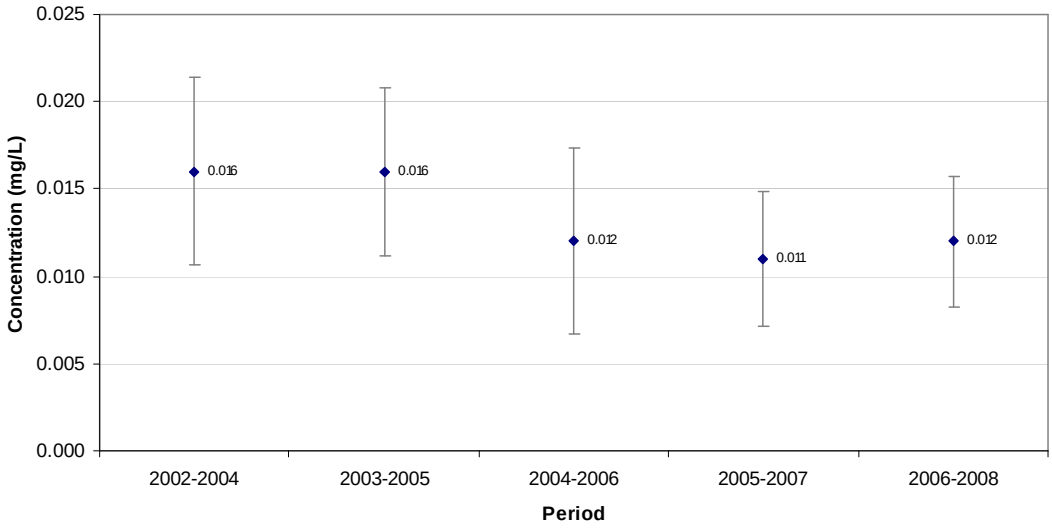




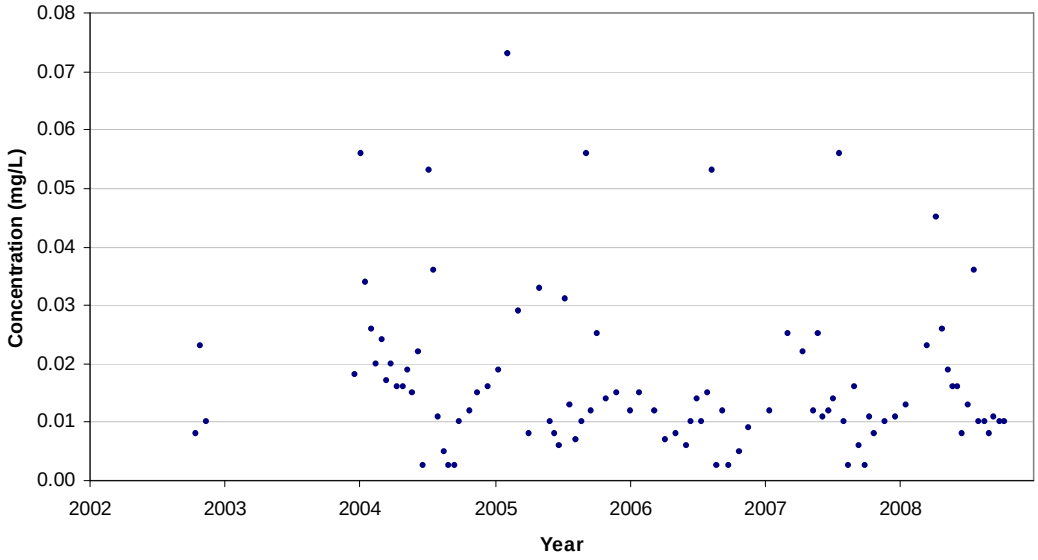
No trends

Total phosphorus – Brunswick River (Beela)

(a) Median concentration and 90% confidence interval



(b) - Observed data



Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TP	2002–2008	FAC	MK	-0.002	-3.583	0	94	94	88	Decreasing
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TP	2002–2008	FAC	SK	-0.001	-2.227	0.026	94	94	119	E. Decreasing
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TP	2006–2008	FAC	MK	-0.002	-2.218	0.027	50	50	300	E. Decreasing

The table shows the trend statistics where Obs. = observed data, FAC = flow-corrected data, MK = Mann-Kendall test, SK = Seasonal-Kendall test, n = number of collected measurements, n* = number of independent measurements, n# = number of independent measurements required to detect a trend, and E. = emerging (trend).

6121130: Brunswick River (Wellesley Road Crossing)

	Period	Status	Trend
TN	2006–2008	0.38	None
TP	2006–2008	0.014	None

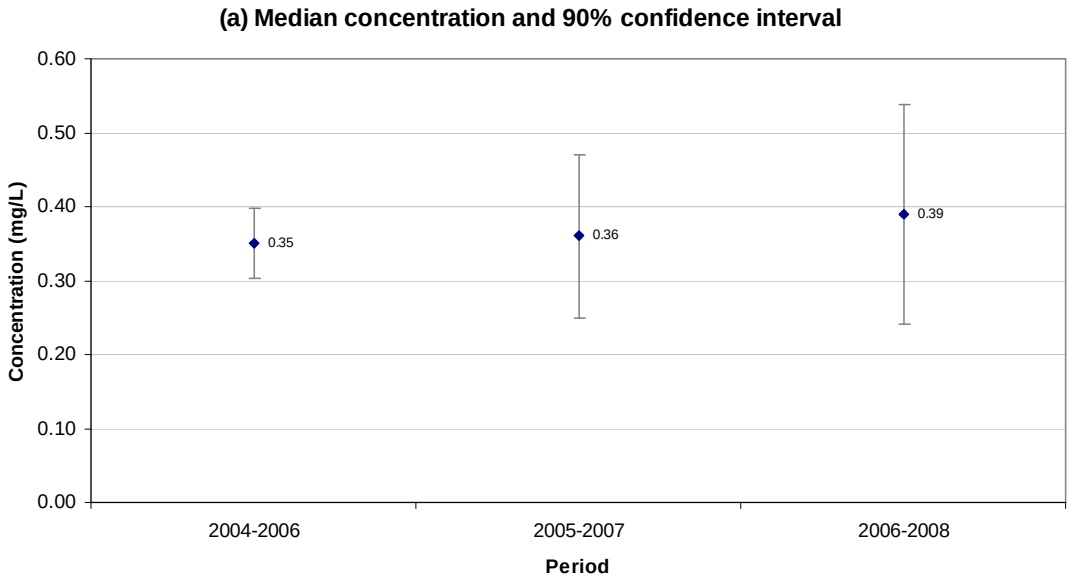
Data summary for 6121130

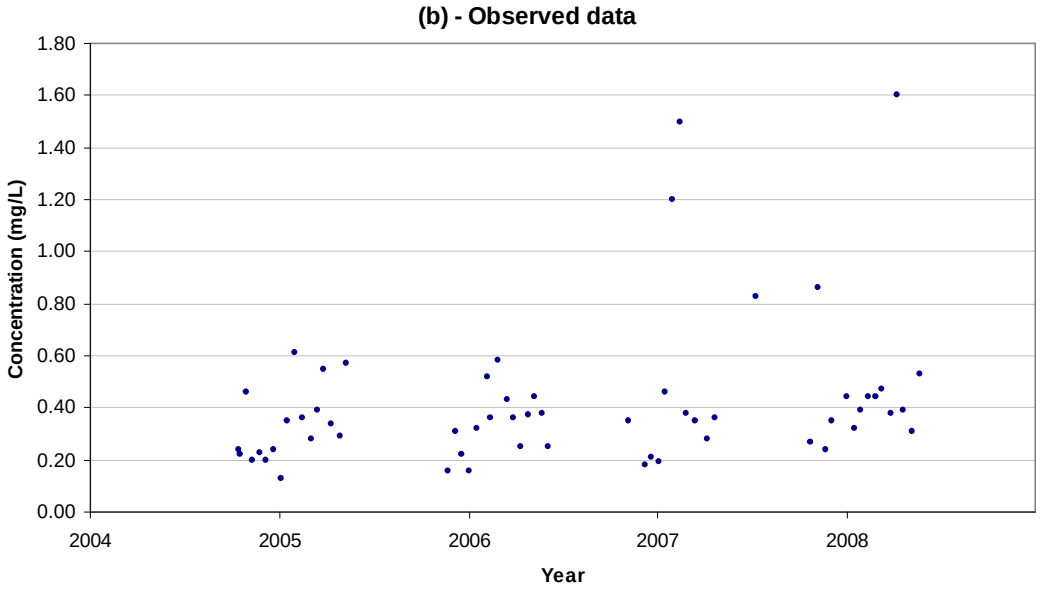
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	59	0	0	2004–2008
TP	59	0	4	2004–2008

Total nitrogen and total phosphorus statistics for 6121130

Statistic	Total nitrogen	Total phosphorus
Median	0.36	0.014
5th percentile	0.178	< 0.005
95th percentile	0.894	0.057
Lowest concentration	0.13	< 0.005
Highest concentration	1.6	0.097

Total nitrogen – Brunswick River (Wellesley Road Crossing)



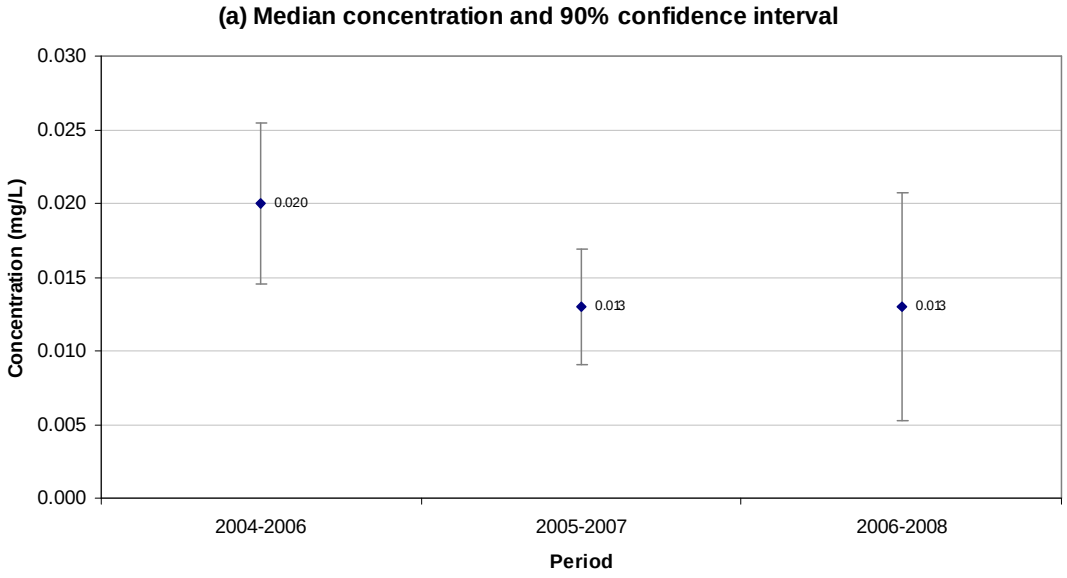


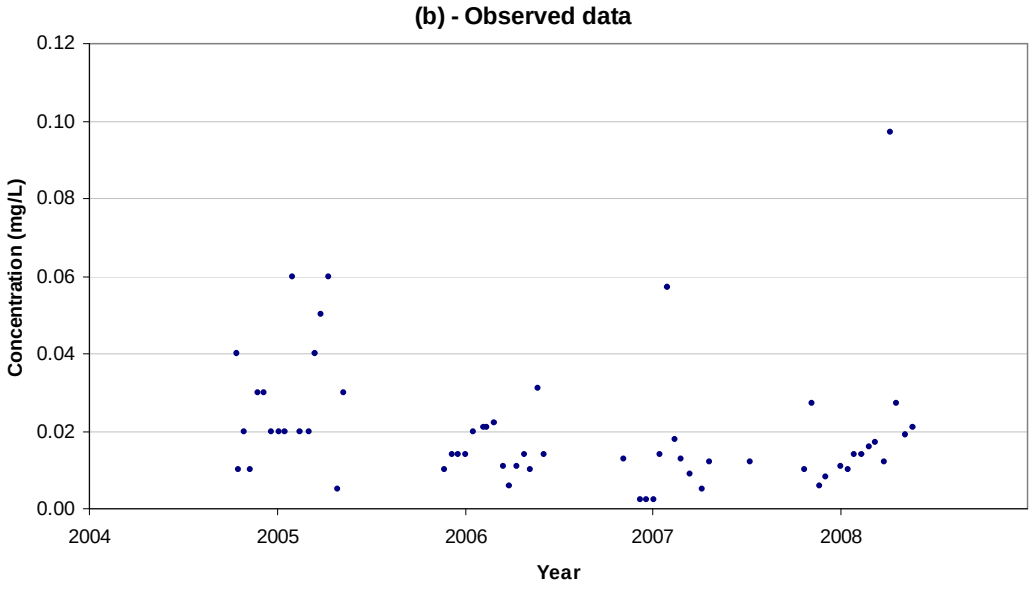
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	2004–2008	Obs.	MK	0.042	2.854	0.004	59	58	168	E. Increasing

No trend in 2006 to 2008 data

The table shows the trend statistics where Obs. = observed data, FAC = flow-corrected data, MK = Mann-Kendall test, SK = Seasonal-Kendall test, n = number of collected measurements, n* = number of independent measurements, n# = number of independent measurements required to detect a trend, and E. = emerging (trend).

Total phosphorus – Brunswick River (Wellesley Road Crossing)





No trends

6121162: Brunswick River (Brunswick 2)

	Period	Status	Trend
TN	2006–2008	1.2	None
TP	2006–2008	0.11	None

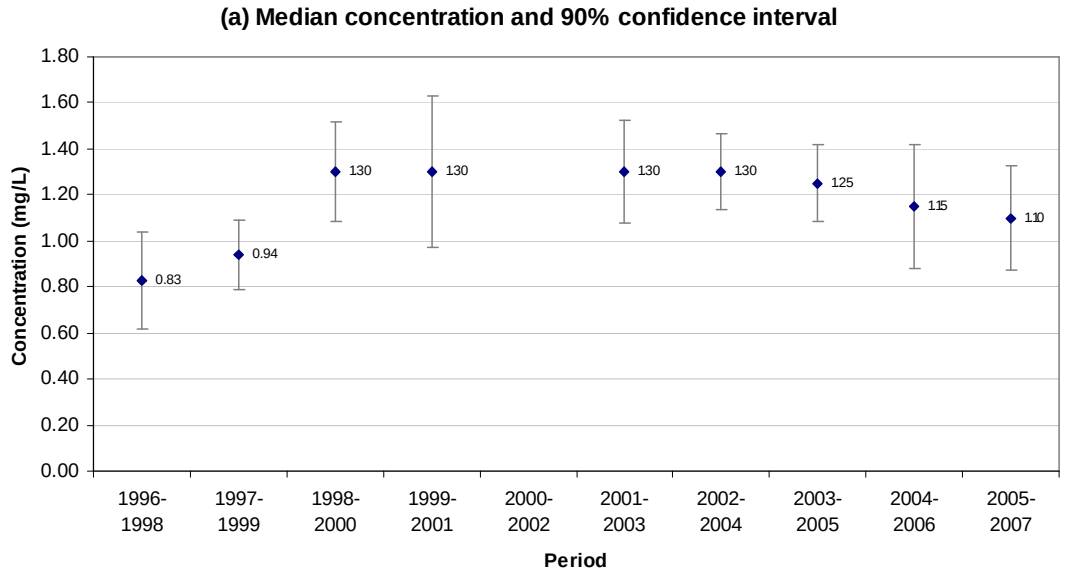
Data summary for 6121162

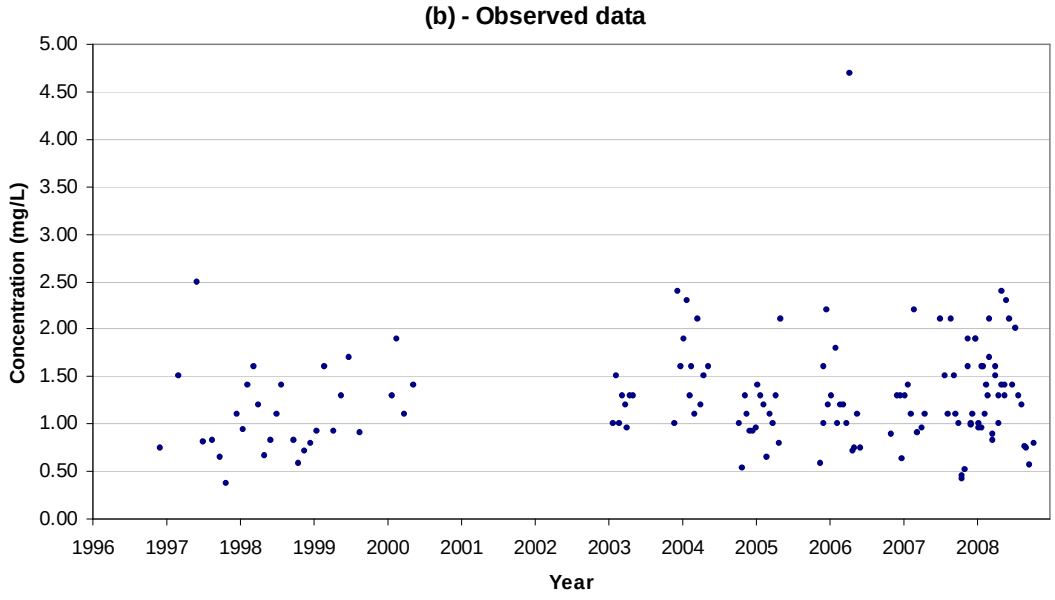
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	156	0	0	1996–2008
TP	157	0	0	1996–2008

Total nitrogen and total phosphorus statistics for 6121162

Statistic	Total nitrogen	Total phosphorus
Median	1.2	0.11
5th percentile	0.59	0.04
95th percentile	2.225	0.312
Lowest concentration	0.37	0.029
Highest concentration	4.7	0.60

Total nitrogen – Brunswick River (Brunswick 2)

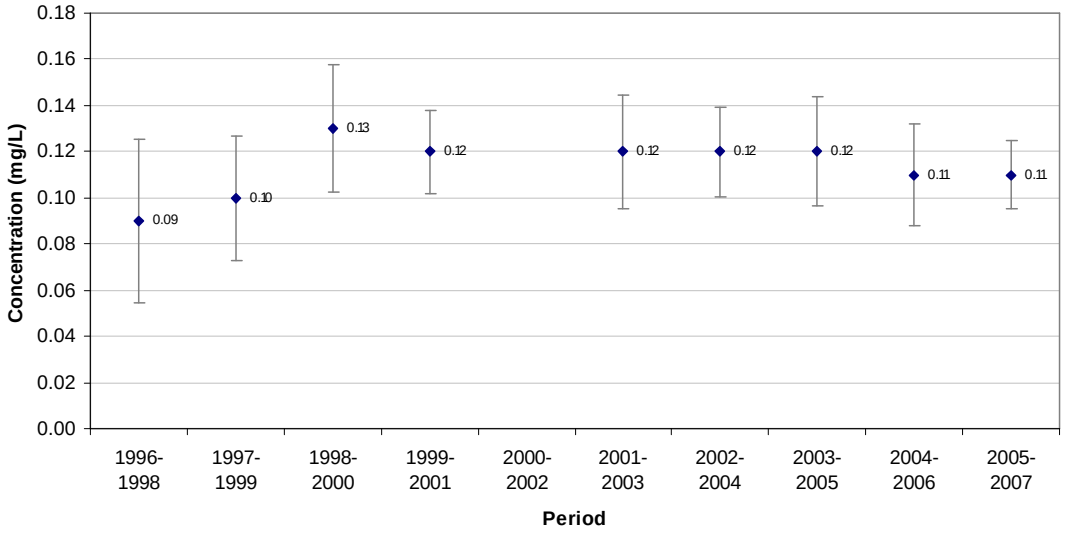




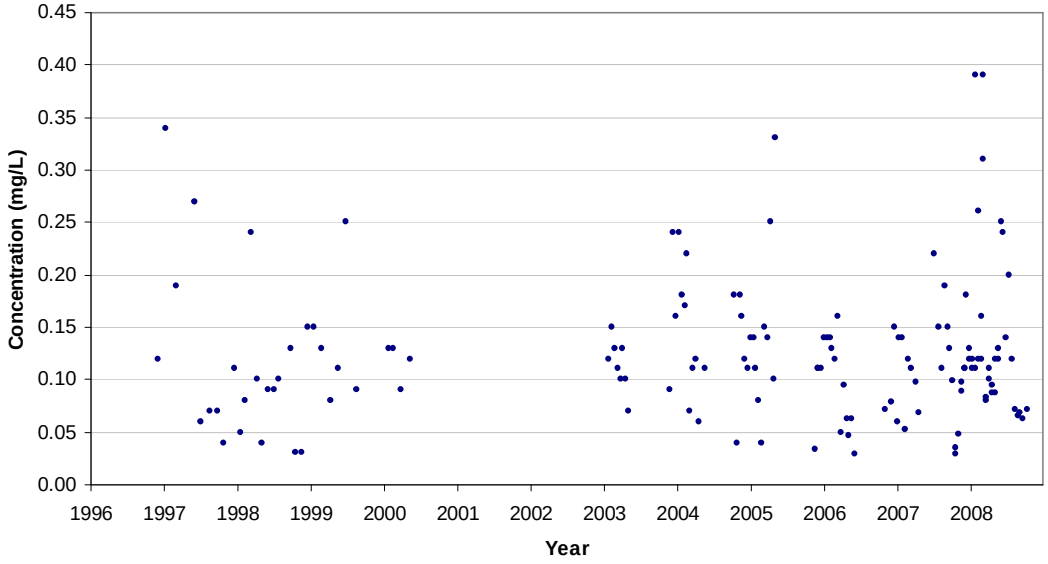
No trends

Total phosphorus – Brunswick River (Brunswick 2)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6121168: Collie River (Collie 4)

	Period	Status	Trend
TN	2006–2008	0.49	None
TP	2006–2008	0.018	None

Data summary for 6121168

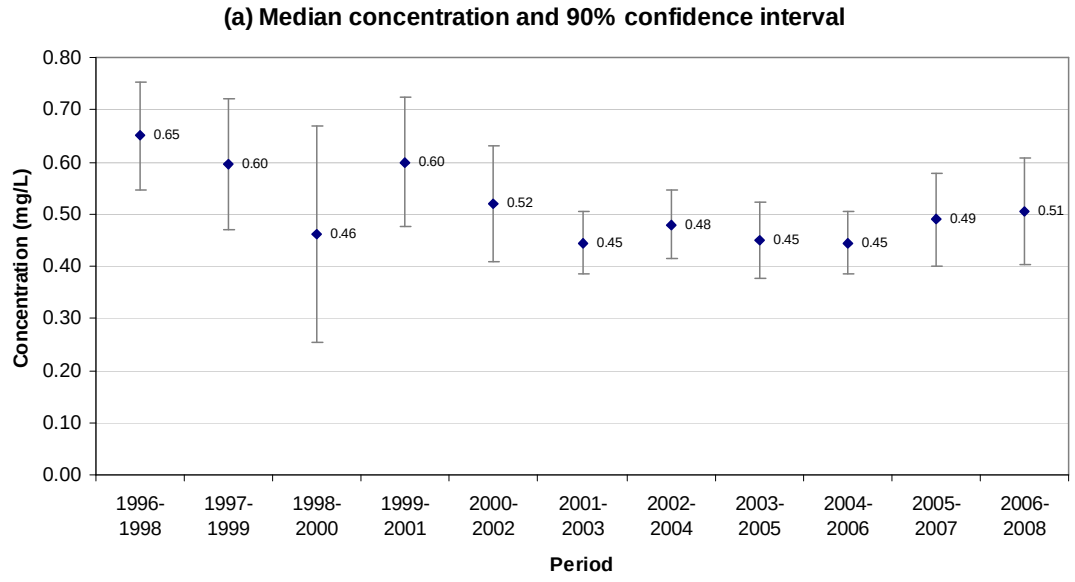
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	158	0	2	1996–2008
TP	158	12	7	1996–2008

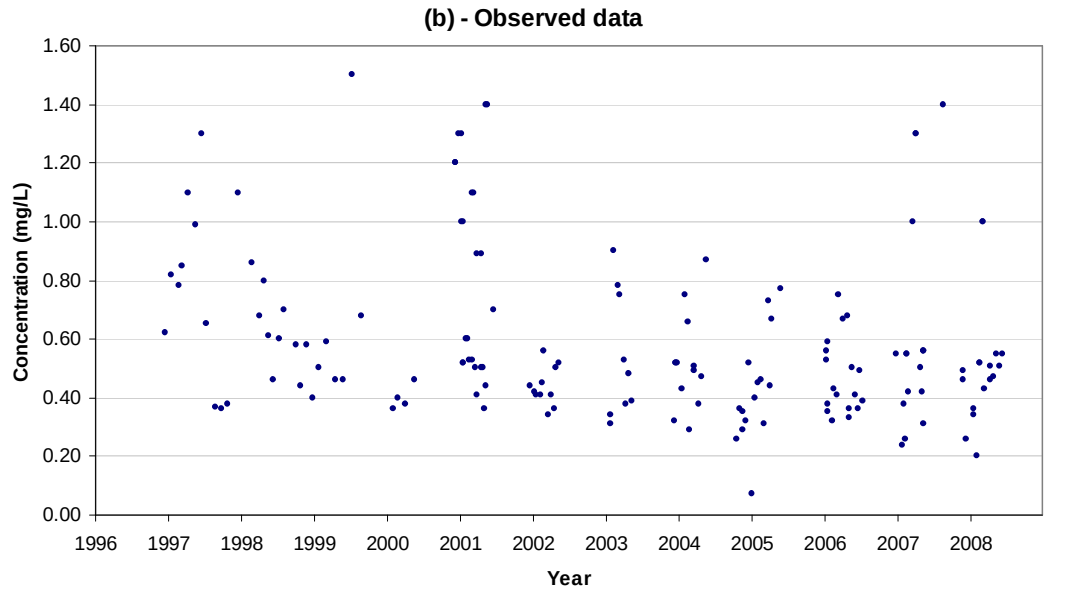
Total nitrogen and total phosphorus statistics for 6121168

Statistic	Total nitrogen	Total phosphorus
Median	0.51	0.03
5th percentile	0.307	0.01
95th percentile	1.3	0.218
Lowest concentration	0.07	< 0.005
Highest concentration	22.0	0.36

12 TP data with LOR = 0.4 mg/L were removed

Total nitrogen – Collie River (Collie 4)





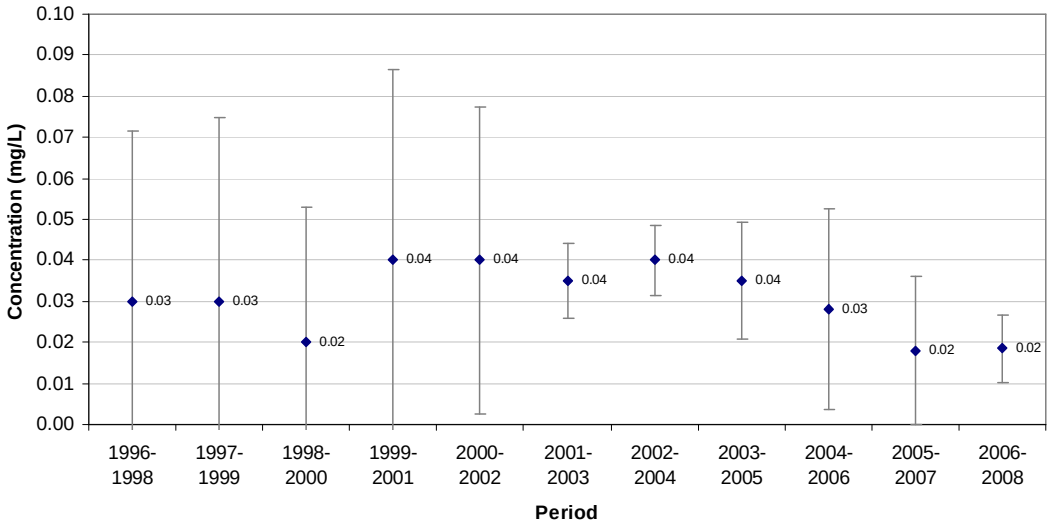
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	1996–2008	Obs.	MK	-0.016	-3.312	0.001	157	129	6931	E. Decreasing
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	1996–2008	Obs.	SK	-0.017	-2.763	0.006	157	129	6212	E. Decreasing

No trends in 2006 to 2008 data

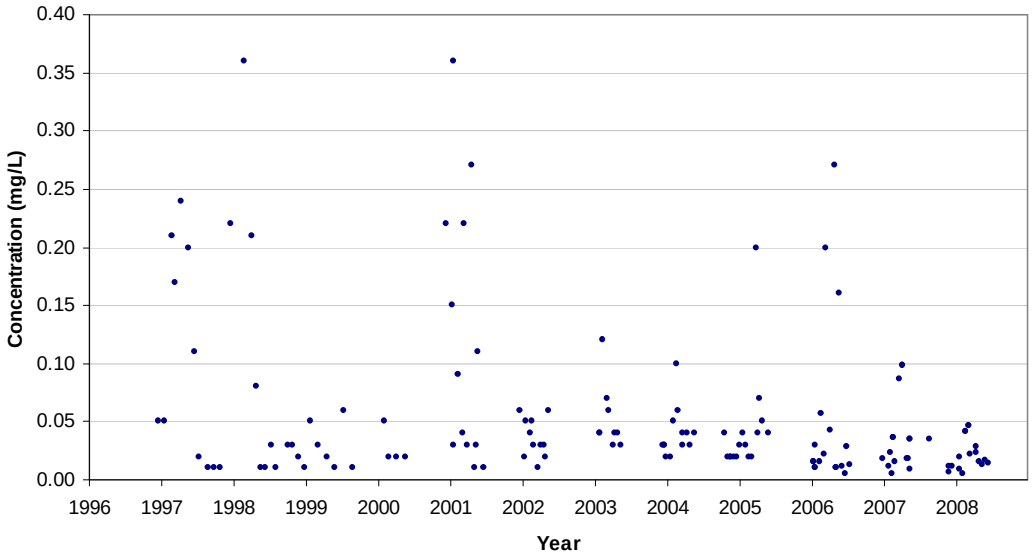
The table shows the trend statistics where Obs. = observed data, FAC = flow-corrected data, MK = Mann-Kendall test, SK = Seasonal-Kendall test, n = number of collected measurements, n* = number of independent measurements, n# = number of independent measurements required to detect a trend, and E. = emerging (trend).

Total phosphorus – Collie River (Collie 4)

(a) Median concentration and 90% confidence interval



(b) - Observed data



Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TP	1996–2008	Obs.	MK	-0.002	-3.231	0.001	145	119	769	E. Decreasing
Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TP	1996–2008	Obs.	SK	-0.003	-4.111	0	145	119	206	E. Decreasing

No trends in 2006 to 2008 data

The table shows the trend statistics where Obs. = observed data, FAC = flow-corrected data, MK = Mann-Kendall test, SK = Seasonal-Kendall test, n = number of collected measurements, n* = number of independent measurements, n# = number of independent measurements required to detect a trend, and E. = emerging (trend).

6121173: Leschenault Estuary (Parkfield Drain)

	Period	Status	Trend
TN	2006–2008	1.2	None
TP	2006–2008	0.052	None

Data summary for 6121173

	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	216	0	5	1996–2008
TP	217	19	1	1996–2008

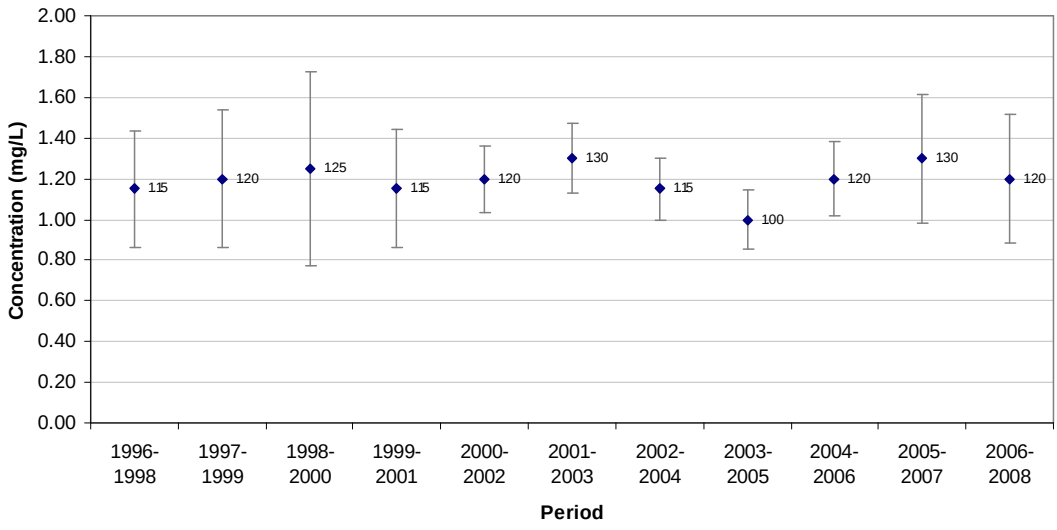
Total nitrogen and total phosphorus statistics for 6121173

Statistic	Total nitrogen	Total phosphorus
Median	1.2	0.07
5th percentile	0.538	0.02
95th percentile	2.4	0.273
Lowest concentration	< 0.025	0.005
Highest concentration	12.0	1.0

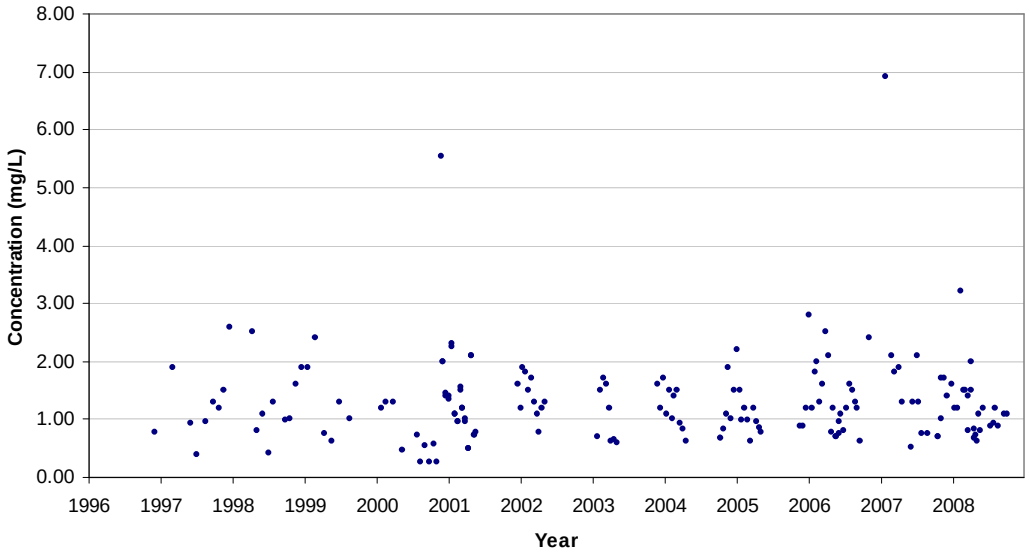
19 TP data with LOR = 0.4 mg/L were removed

Total nitrogen – Leschenault Estuary (Parkfield Drain)

(a) Median concentration and 90% confidence interval



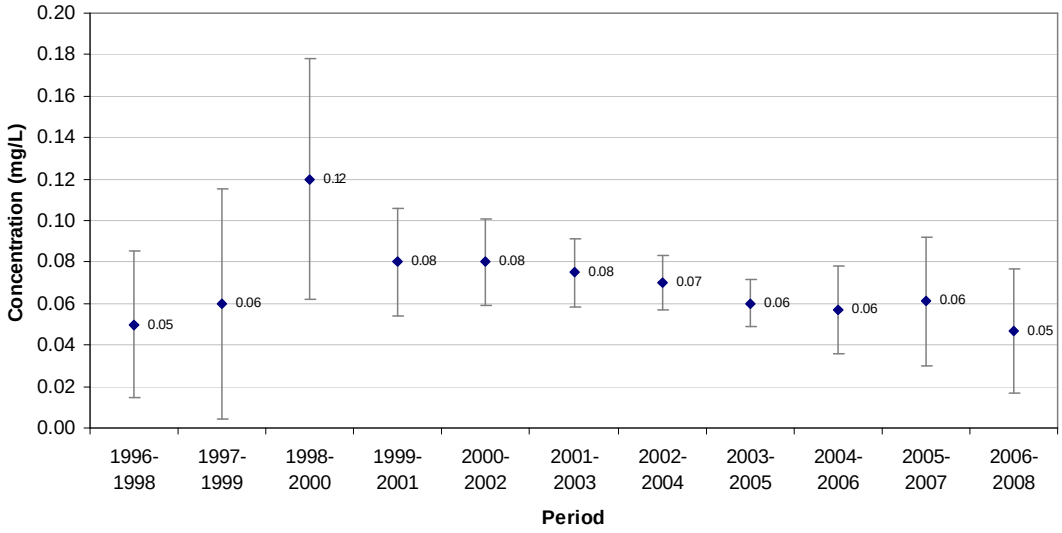
(b) - Observed data



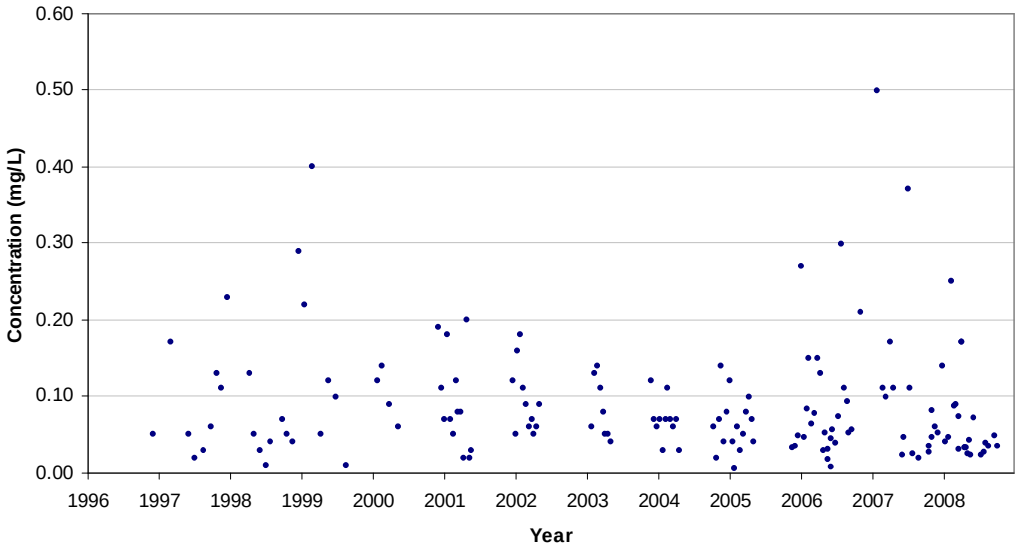
No trends

Total phosphorus – Leschenault Estuary (Parkfield Drain)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6121184: Mangosteen Drain (Leitch Road)

	Period	Status	Trend
TN	2006–2008	2.6	Increasing
TP	2006–2008	0.365	E. Increasing

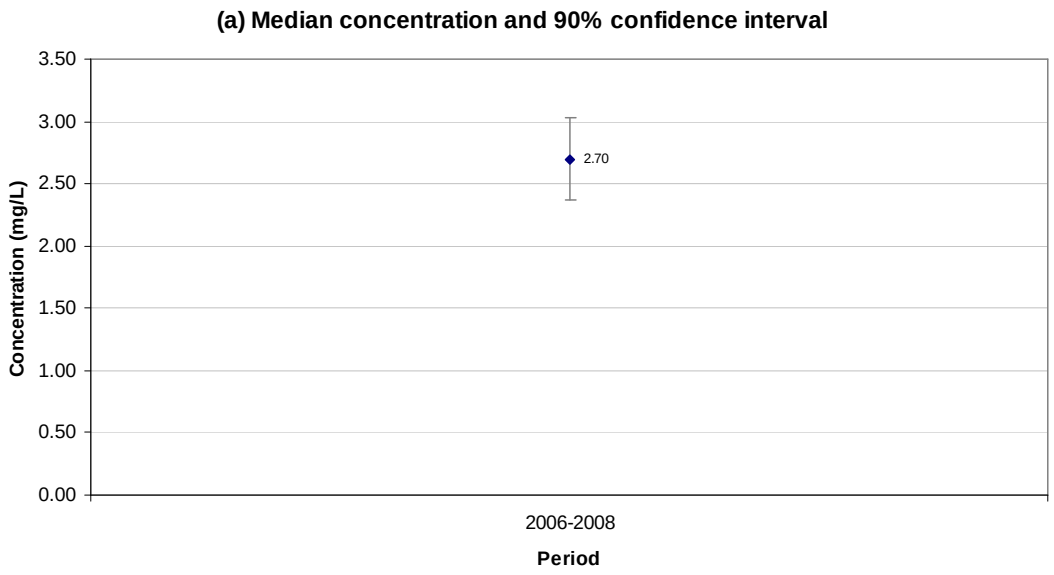
Data summary for 6121184

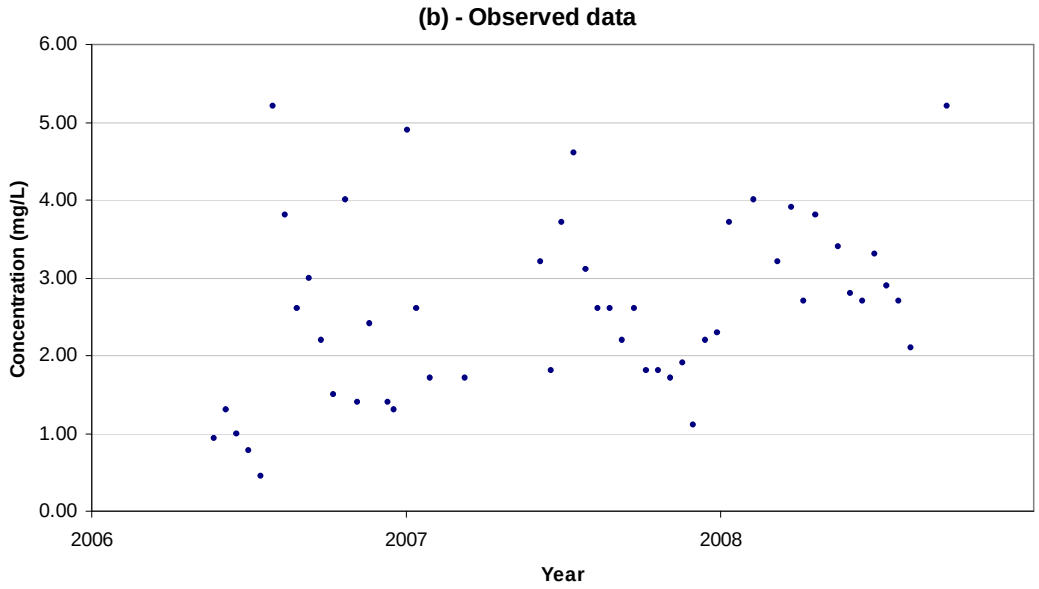
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	50	0	0	2006–2008
TP	50	0	0	2006–2008

Total nitrogen and total phosphorus statistics for 6121184

Statistic	Total nitrogen	Total phosphorus
Median	2.6	0.365
5th percentile	0.96	0.11
95th percentile	4.76	1.06
Lowest concentration	0.44	0.079
Highest concentration	5.2	1.7

Total nitrogen – Mangosteen Drain (Leitch Road)

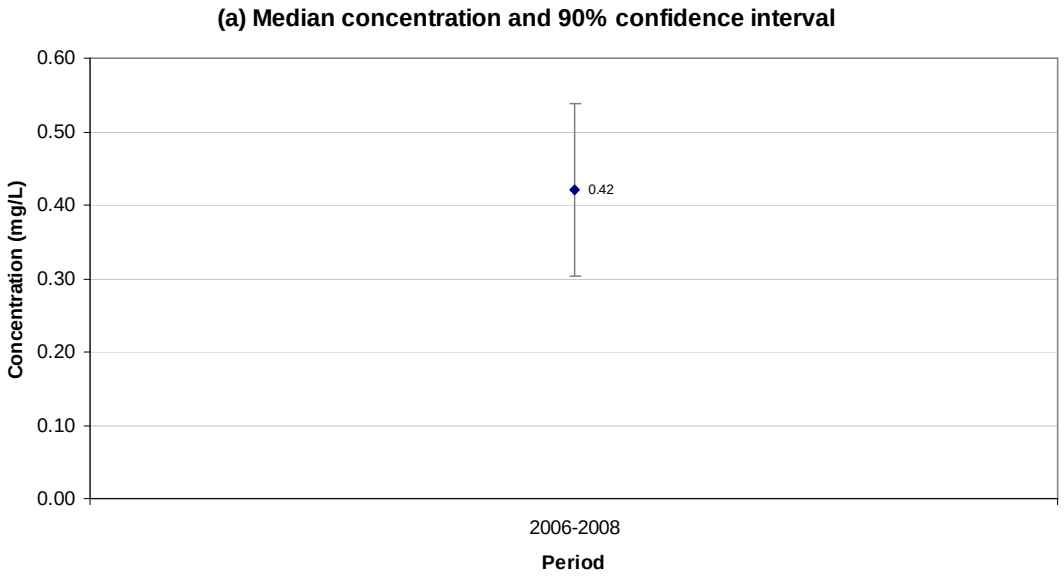


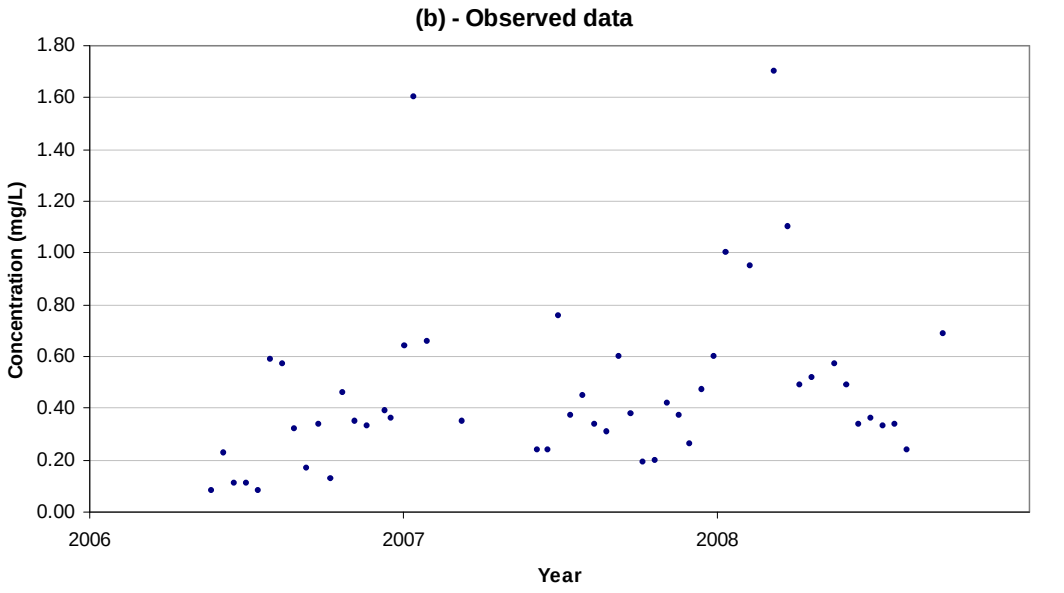


Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	2006–2008	Obs.	MK	0.647	2.71	0.007	49	49	34	Increasing

The table shows the trend statistics where Obs. = observed data, FAC = flow-corrected data, MK = Mann-Kendall test, SK = Seasonal-Kendall test, n = number of collected measurements, n* = number of independent measurements, n# = number of independent measurements required to detect a trend, and E. = emerging (trend).

Total phosphorus – Mangosteen Drain (Leitch Road)





Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TP	2006–2008	Obs.	MK	0.115	2.631	0.009	49	21	92	E. Increasing

The table shows the trend statistics where Obs. = observed data, FAC = flow-corrected data, MK = Mann-Kendall test, SK = Seasonal-Kendall test, n = number of collected measurements, n* = number of independent measurements, n# = number of independent measurements required to detect a trend, and E. = emerging (trend).

6121187: Mornington Creek (Campbell Road)

	Period	Status	Trend
TN	2006–2008	1.6	None
TP	2006–2008	0.15	None

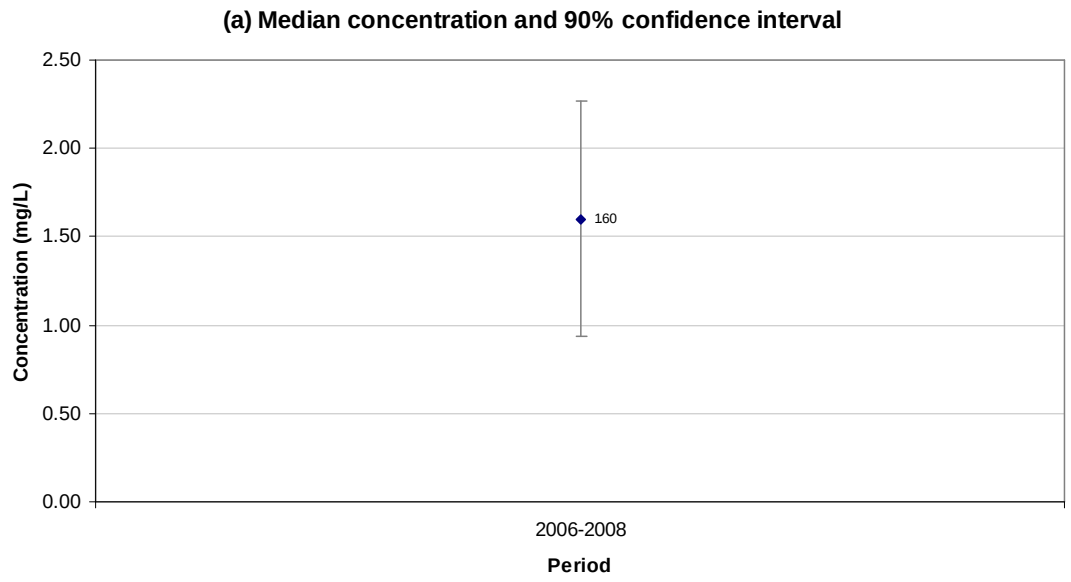
Data summary for 6121187

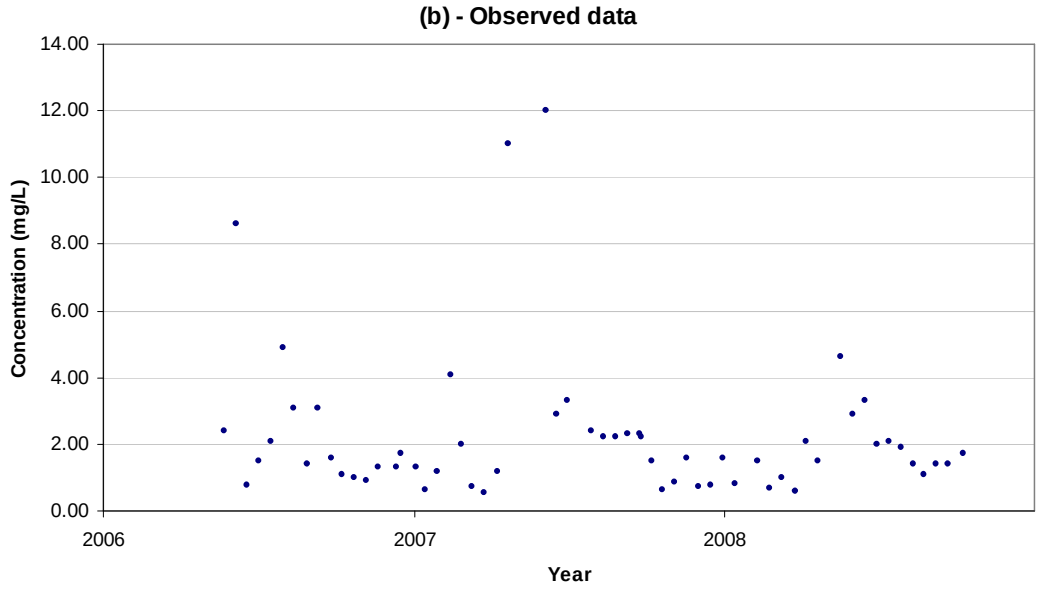
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	59	0	0	2006–2008
TP	59	0	0	2006–2008

Total nitrogen and total phosphorus statistics for 6121187

Statistic	Total nitrogen	Total phosphorus
Median	1.6	0.15
5th percentile	0.647	0.043
95th percentile	5.27	0.472
Lowest concentration	0.56	0.027
Highest concentration	12.0	0.61

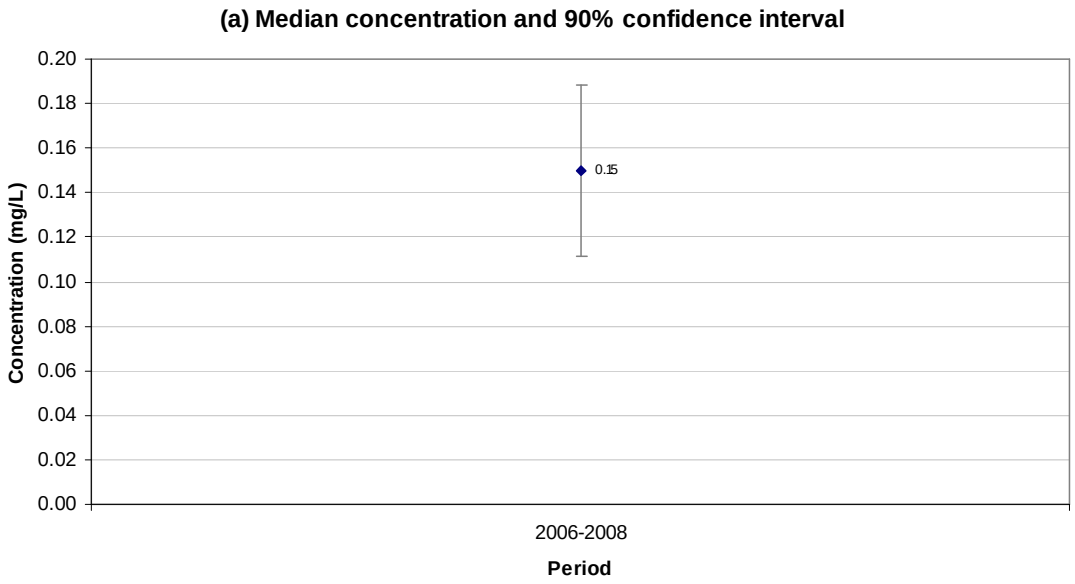
Total nitrogen – Mornington Creek (Campbell Road)

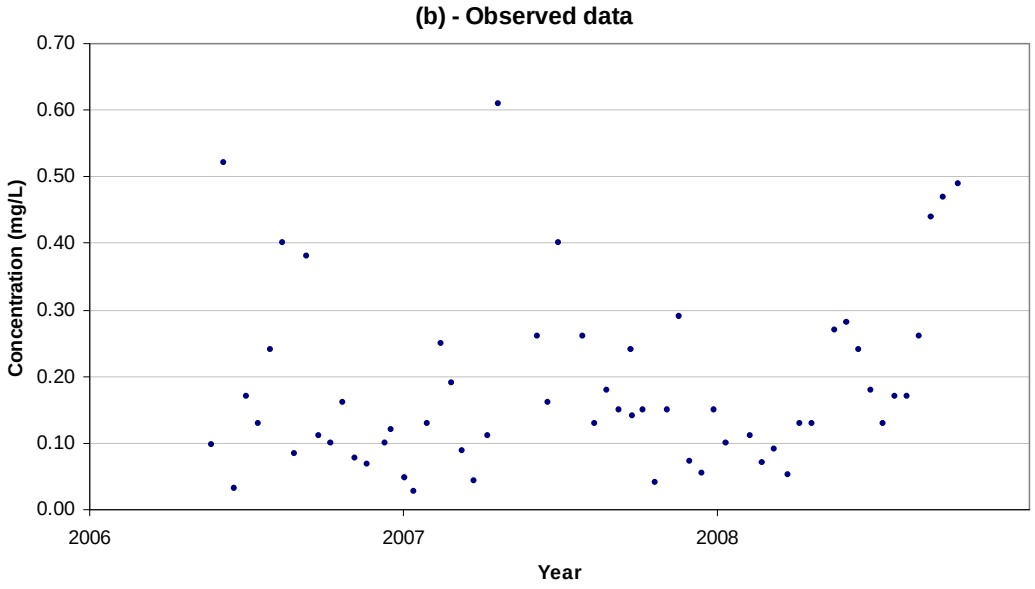




No trends

Total phosphorus – Mornington Creek (Campbell Road)





No trends

6121195: Brunswick River (Caravan Park Brunswick)

	Period	Status	Trend
TN	2006–2008	0.39	None
TP	2006–2008	0.012	None

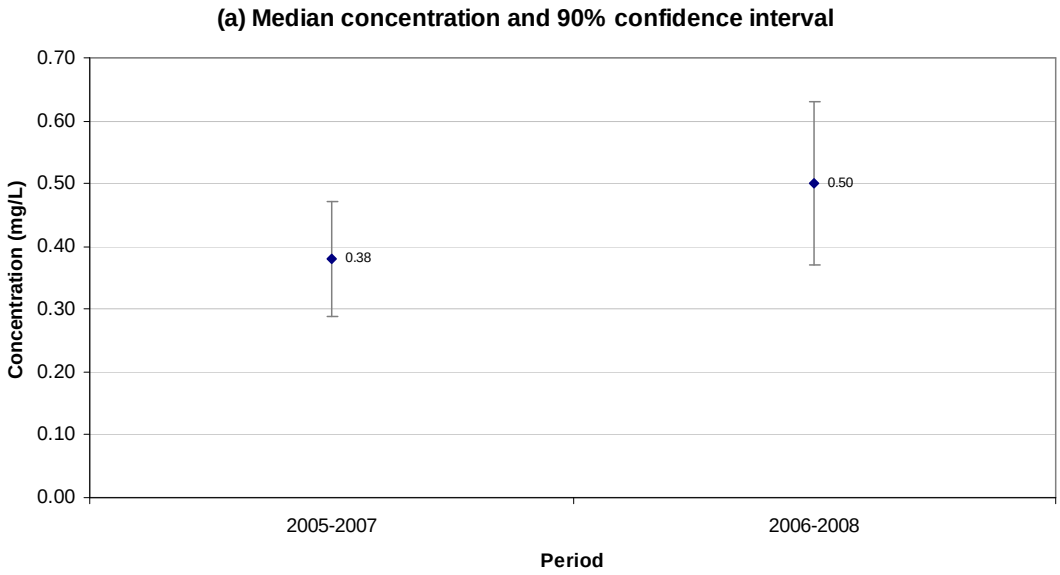
Data summary for 6121195

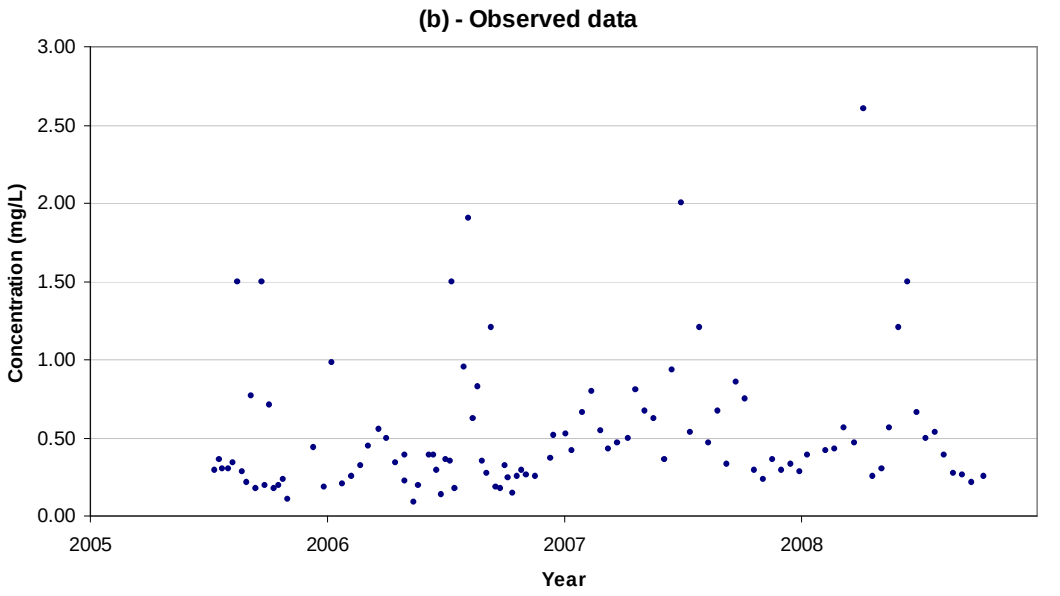
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	103	0	0	2005–2008
TP	104	0	6	2005–2008

Total nitrogen and total phosphorus statistics for 6121195

Statistic	Total nitrogen	Total phosphorus
Median	0.37	0.013
5th percentile	0.17	0.003
95th percentile	1.5	0.086
Lowest concentration	0.091	< 0.005
Highest concentration	2.6	0.27

Total nitrogen – Brunswick River (Caravan Park Brunswick)



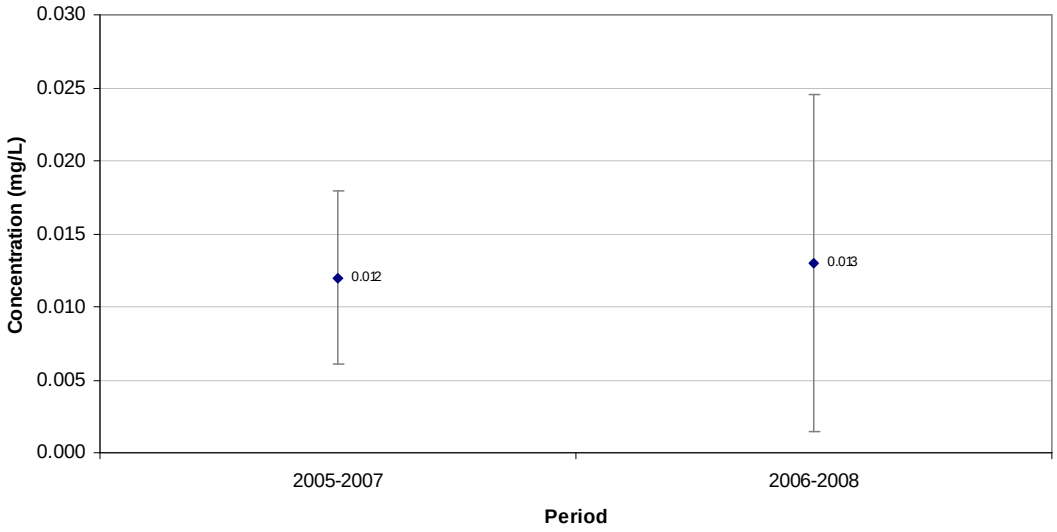


Nutrient	Period	Series	Test	Trend	Z-stat	p-value	n	n*	n#	Trend Result
TN	2005–2008	Obs.	MK	0.055	2.436	0.015	102	81	282	E. Increasing

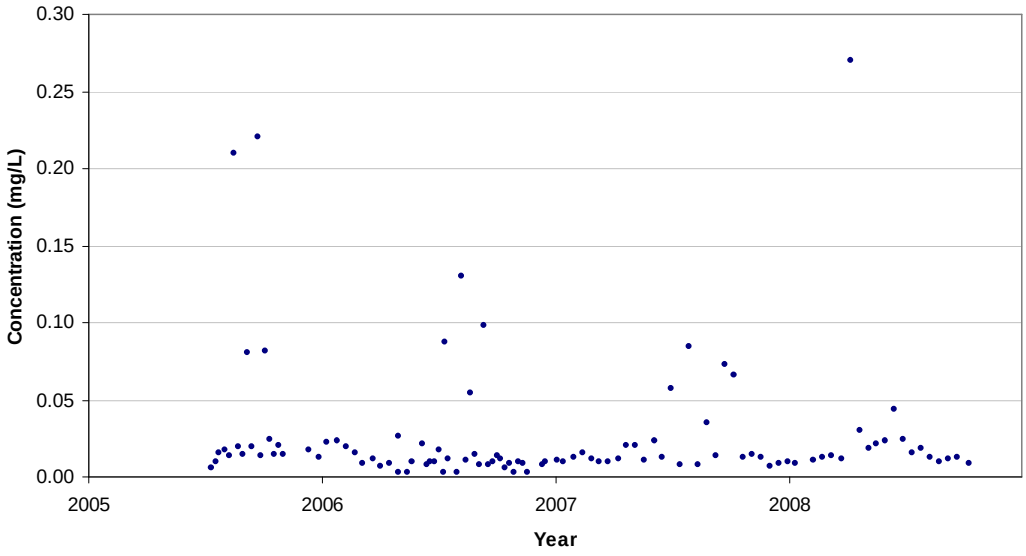
The table shows the trend statistics where Obs. = observed data, FAC = flow-corrected data, MK = Mann-Kendall test, SK = Seasonal-Kendall test, n = number of collected measurements, n* = number of independent measurements, n# = number of independent measurements required to detect a trend, and E. = emerging (trend).

Total phosphorus – Brunswick River (Caravan Park Brunswick)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6121203: Elvira Gully (Elvira Gully)

	Period	Status	Trend
TN	2006–2008	2.8	None
TP	2006–2008	0.42	None

Data summary for 6121203

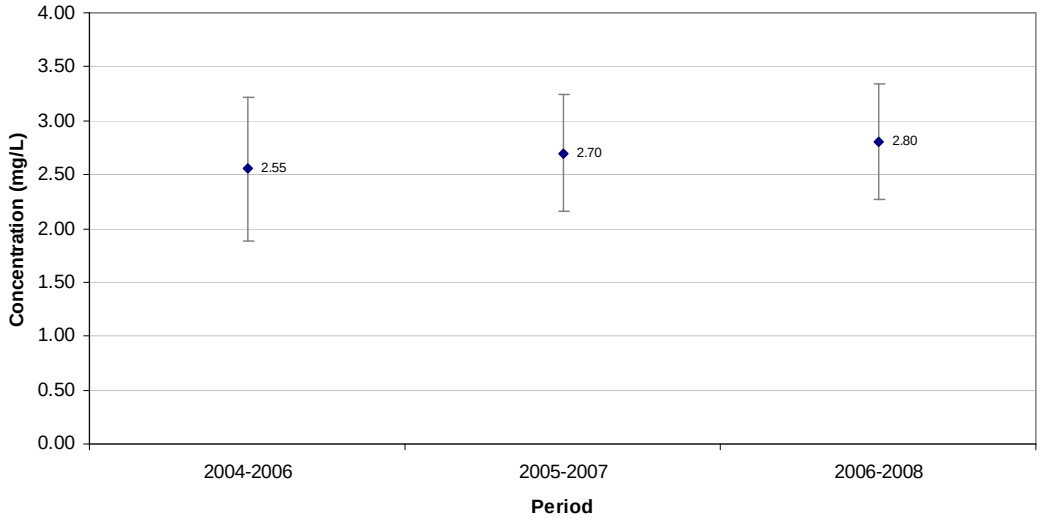
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	94	0	0	2004–2008
TP	94	0	0	2004–2008

Total nitrogen and total phosphorus statistics for 6121203

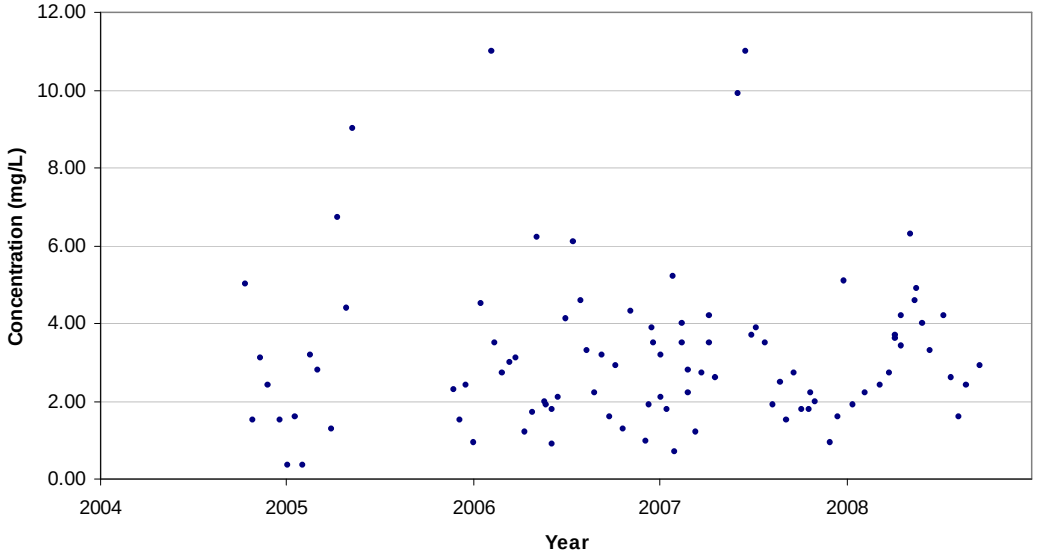
Statistic	Total nitrogen	Total phosphorus
Median	2.7	0.41
5th percentile	0.92	0.093
95th percentile	6.44	1.5
Lowest concentration	0.34	0.01
Highest concentration	11.0	3.3

Total nitrogen – Elvira Gully (Elvira Gully)

(a) Median concentration and 90% confidence interval



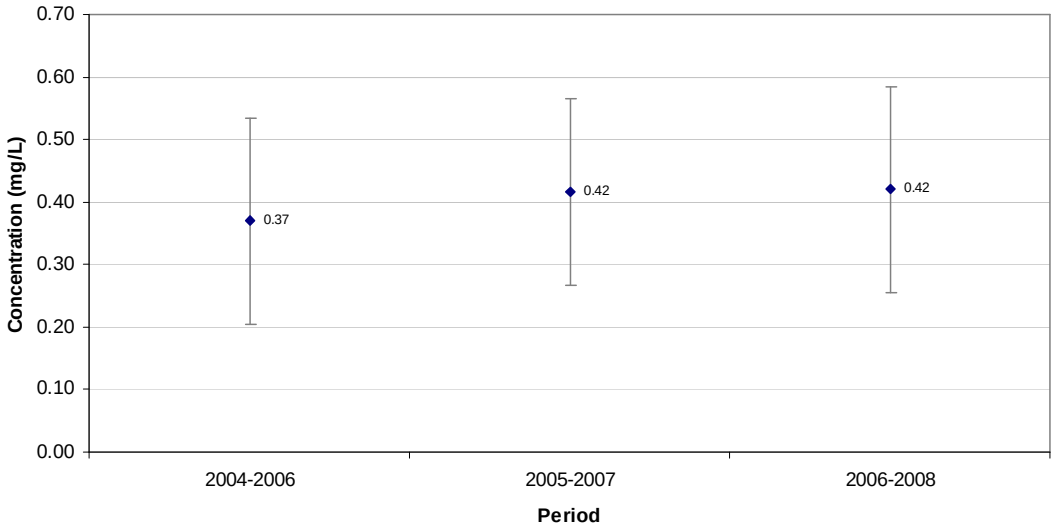
(b) - Observed data



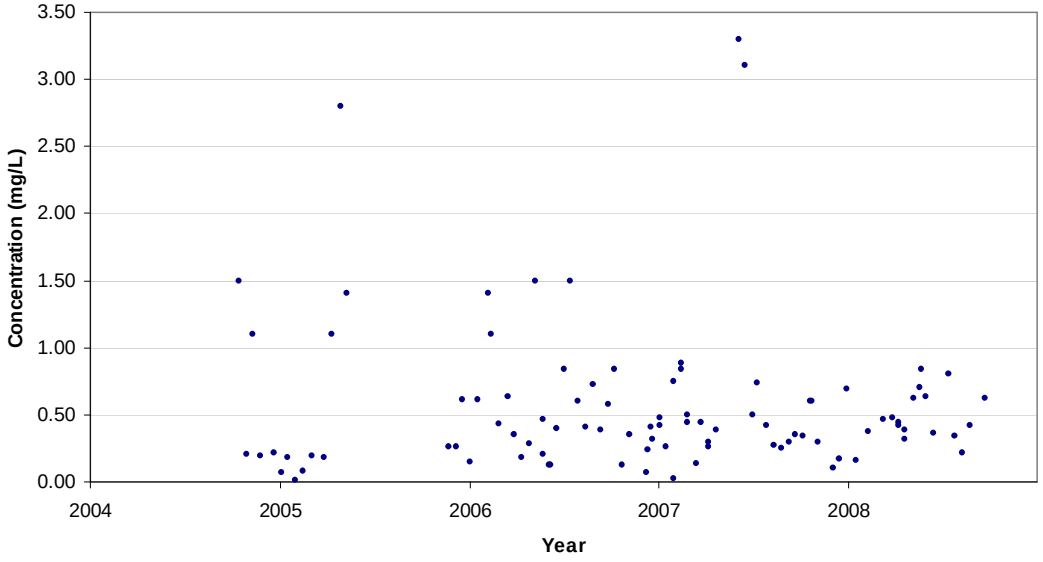
No trends

Total phosphorus – Elvira Gully (Elvira Gully)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6121220: Wellesley River (Hope Ave)

	Period	Status	Trend
TN	2006–2008	3.1	None
TP	2006–2008	0.305	None

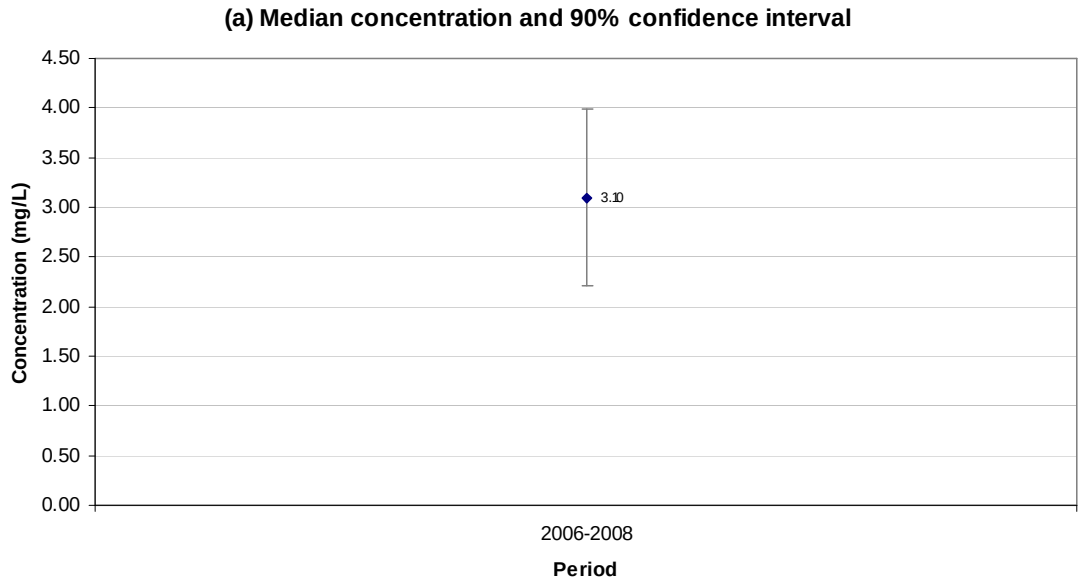
Data summary for 6121220

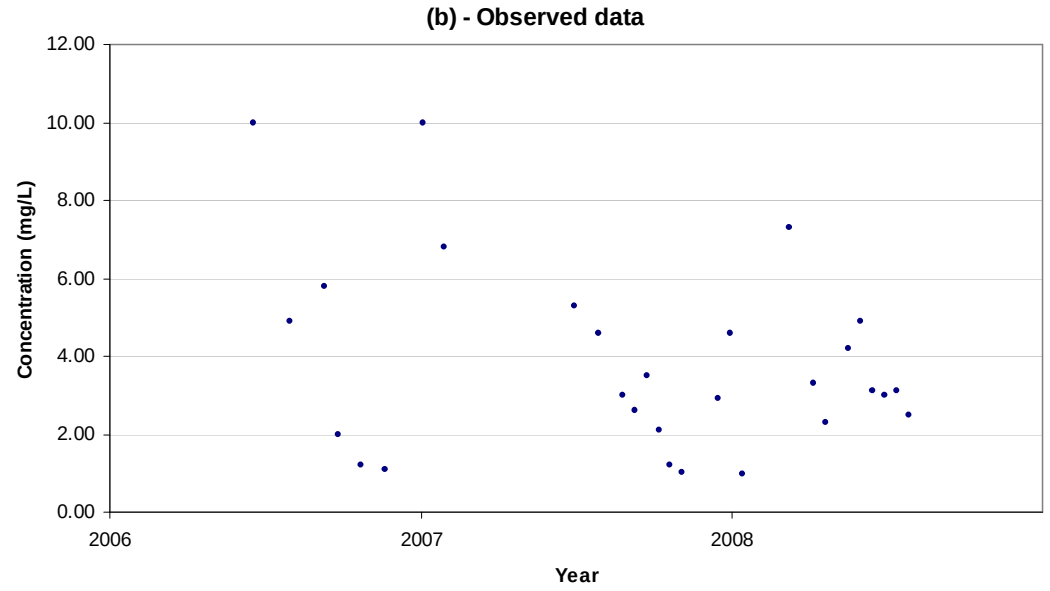
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	28	0	0	2006–2008
TP	28	0	0	2006–2008

Total nitrogen and total phosphorus statistics for 6121220

Statistic	Total nitrogen	Total phosphorus
Median	3.1	0.305
5th percentile	1.035	0.050
95th percentile	9.055	1.344
Lowest concentration	0.97	0.038
Highest concentration	10.0	1.6

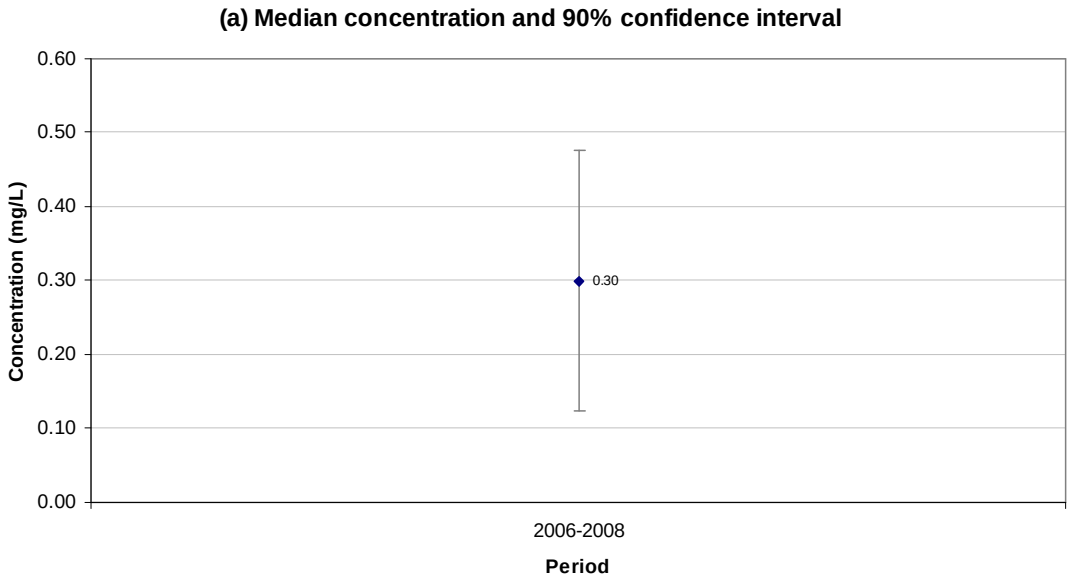
Total nitrogen – Wellesley River (Hope Ave)

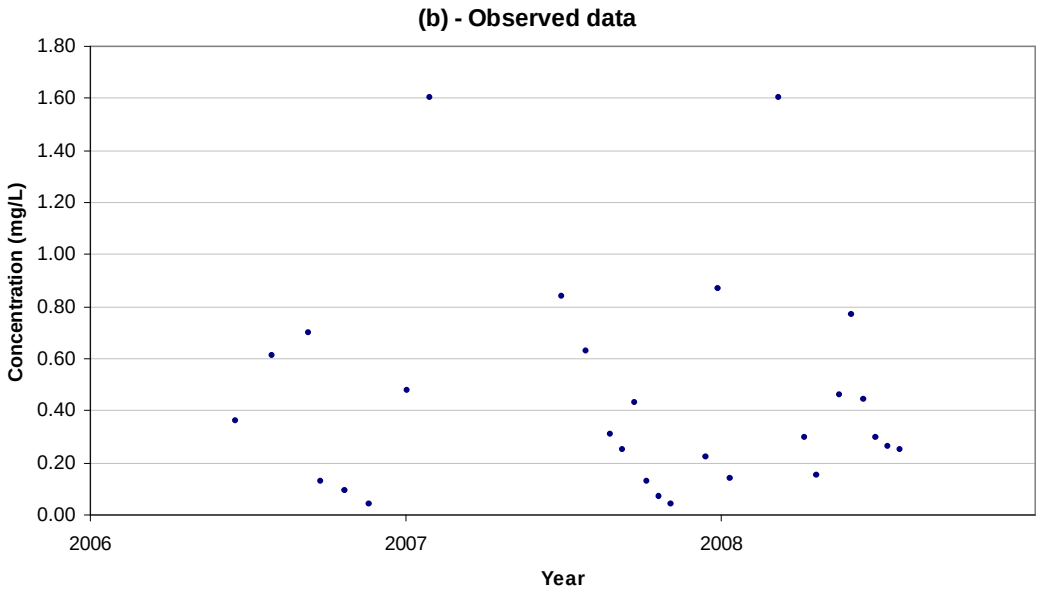




No trends

Total phosphorus – Wellesley River (Hope Ave)





No trends

6121221: Bindiup Creek (Bernies)

	Period	Status	Trend
TN	2006–2008	1.8	None
TP	2006–2008	0.135	None

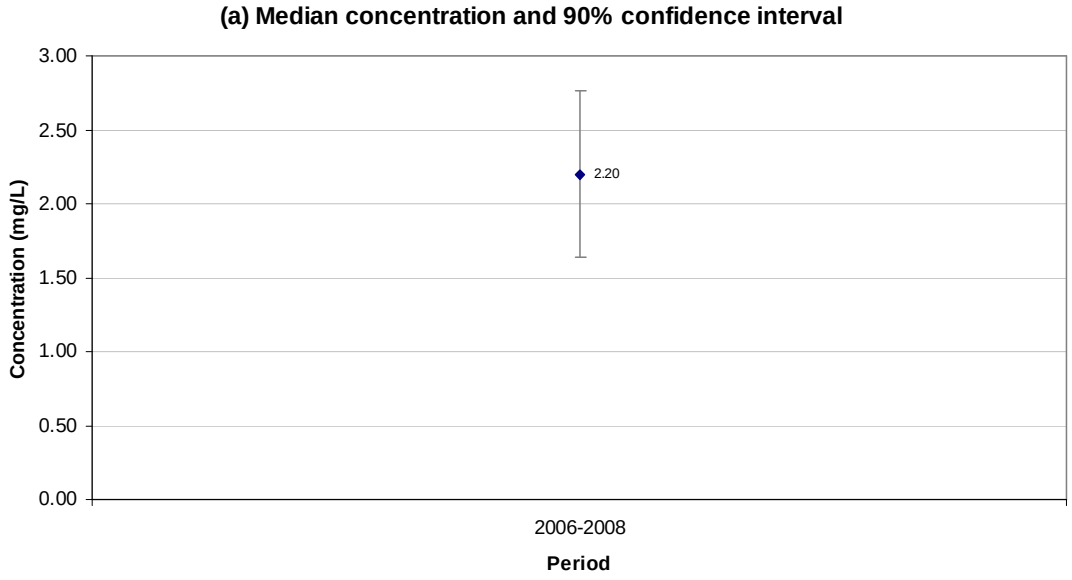
Data summary for 6121221

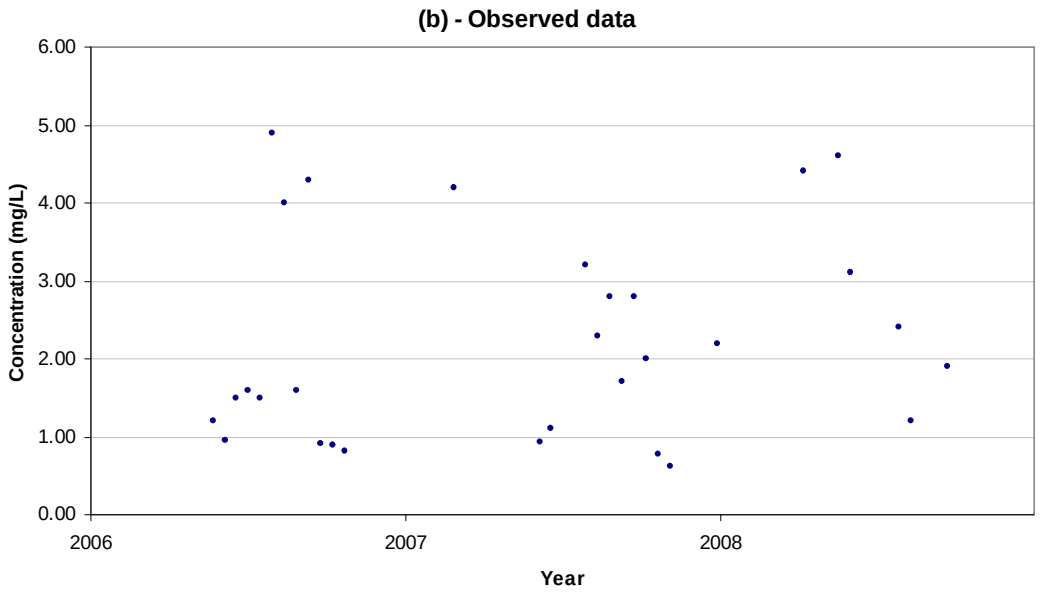
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	30	0	0	2006–2008
TP	30	0	0	2006–2008

Total nitrogen and total phosphorus statistics for 6121221

Statistic	Total nitrogen	Total phosphorus
Median	1.8	0.135
5th percentile	0.794	0.050
95th percentile	4.51	0.608
Lowest concentration	0.62	0.037
Highest concentration	4.9	1.10

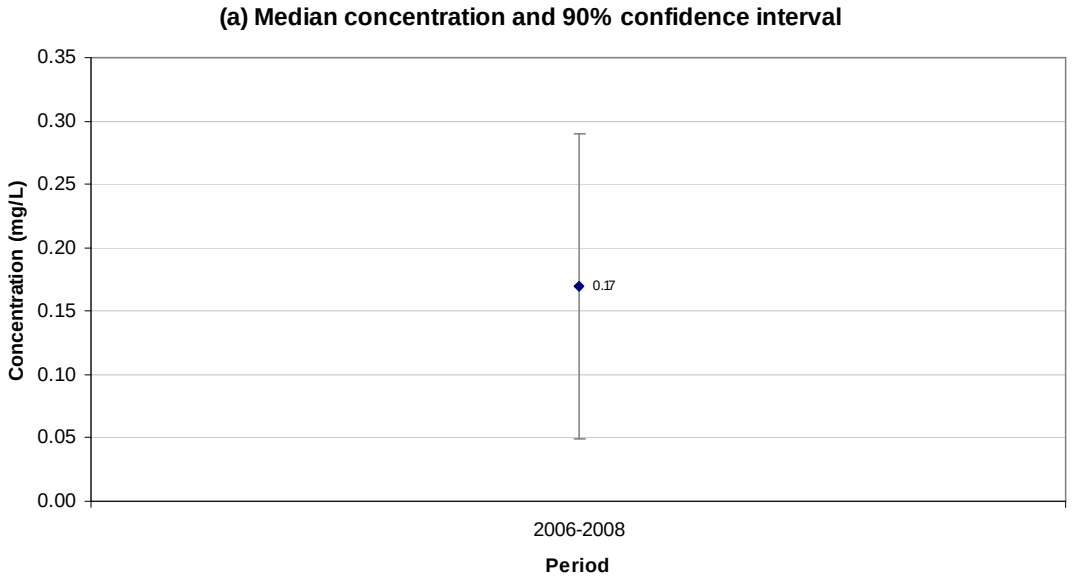
Total nitrogen – Bindiup Creek (Bernies)

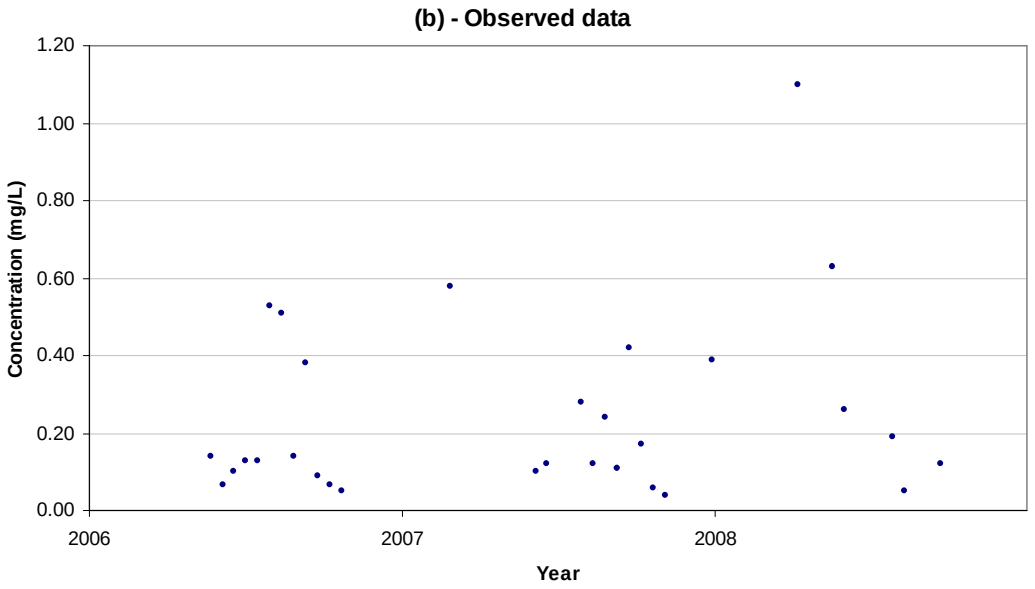




No trends

Total phosphorus – Bindiup Creek (Bernies)





No trends

6121222: Henty Brook (Henty)

	Period	Status	Trend
TN	2006–2008	0.67	None
TP	2006–2008	0.017	None

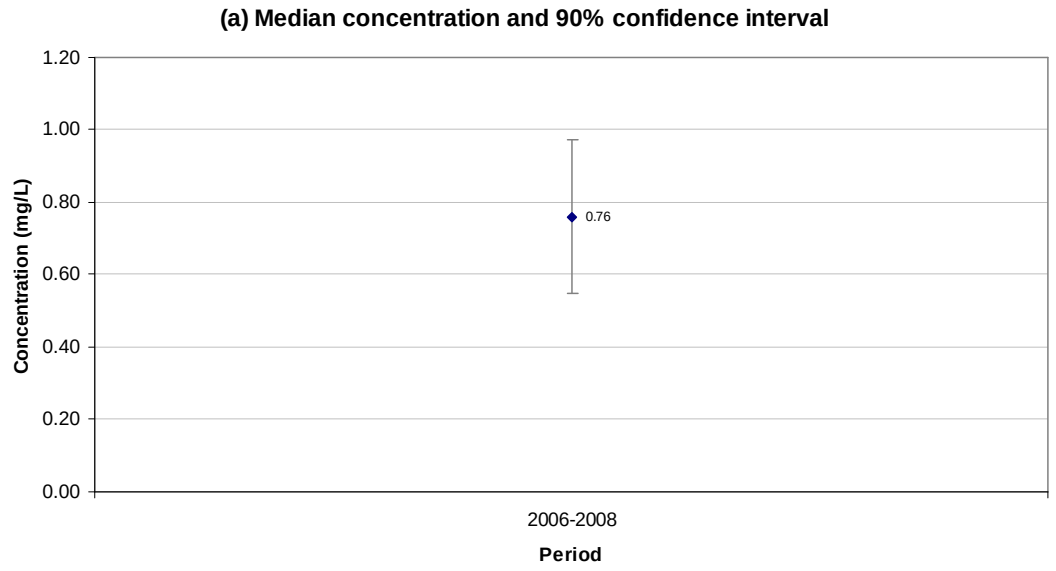
Data summary for 6121222

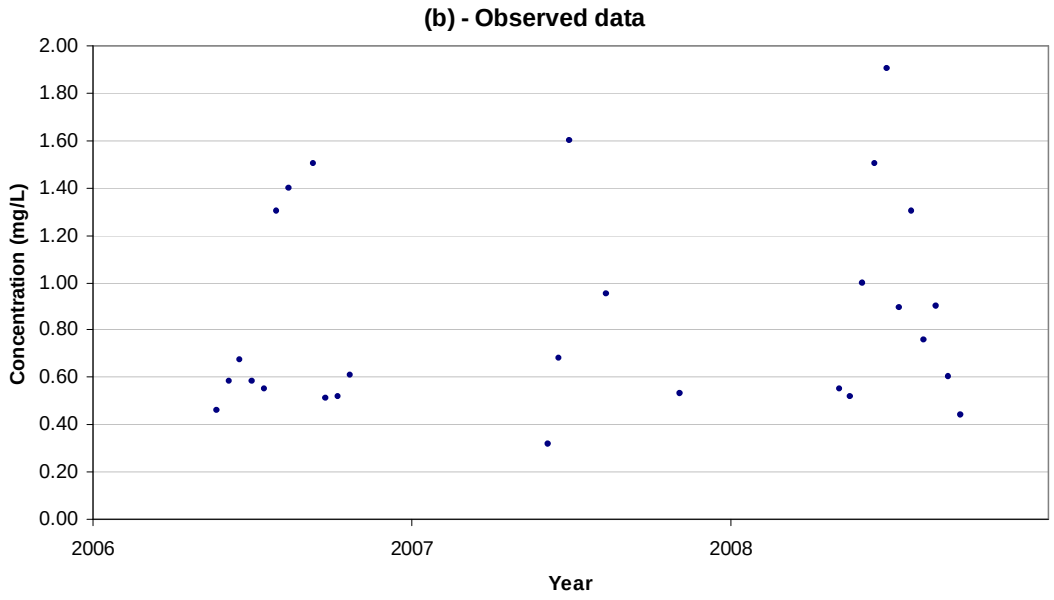
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	27	0	0	2006–2008
TP	27	0	0	2006–2008

Total nitrogen and total phosphorus statistics for 6121222

Statistic	Total nitrogen	Total phosphorus
Median	0.67	0.017
5th percentile	0.446	0.012
95th percentile	1.57	0.068
Lowest concentration	0.32	0.01
Highest concentration	1.9	0.093

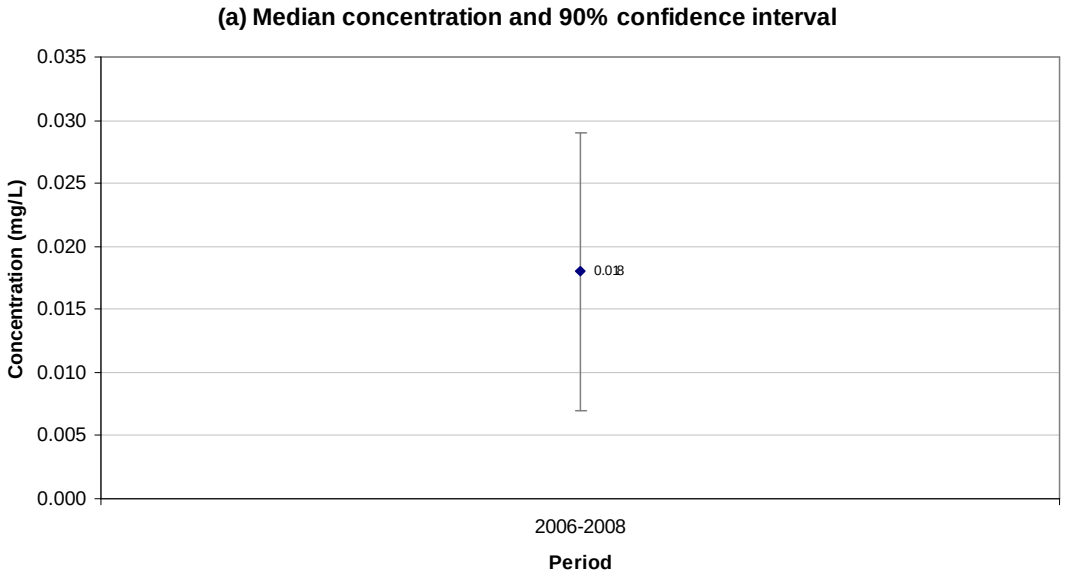
Total nitrogen – Henty Brook (Henty)

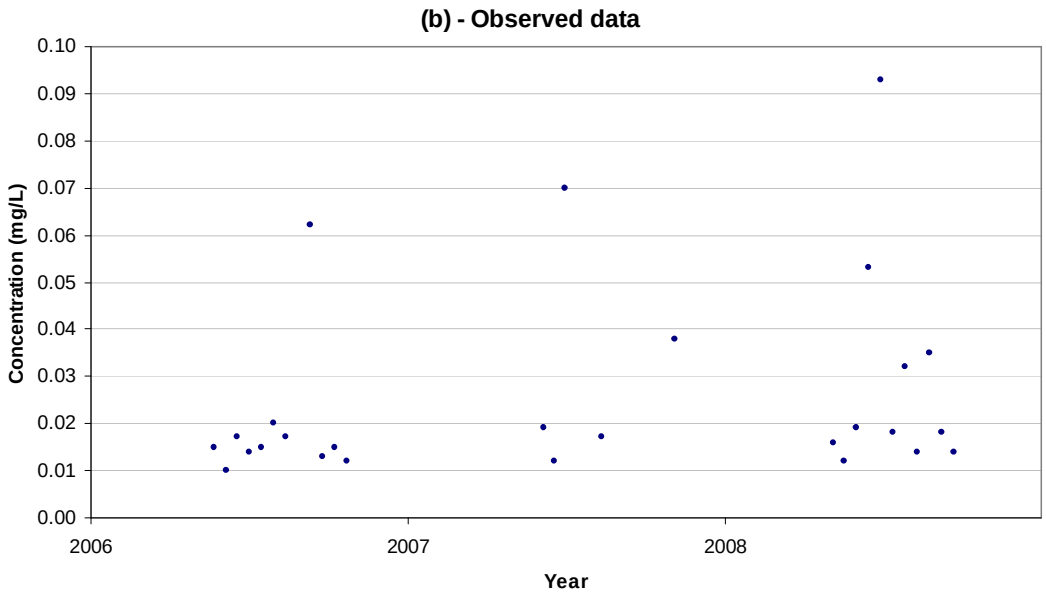




No trends

Total phosphorus – Henty Brook (Henty)





No trends

6121223: Canal to Henty (Near Henty)

	Period	Status	Trend
TN	2006–2008	1.1	None
TP	2006–2008	0.039	None

Data summary for 6121223

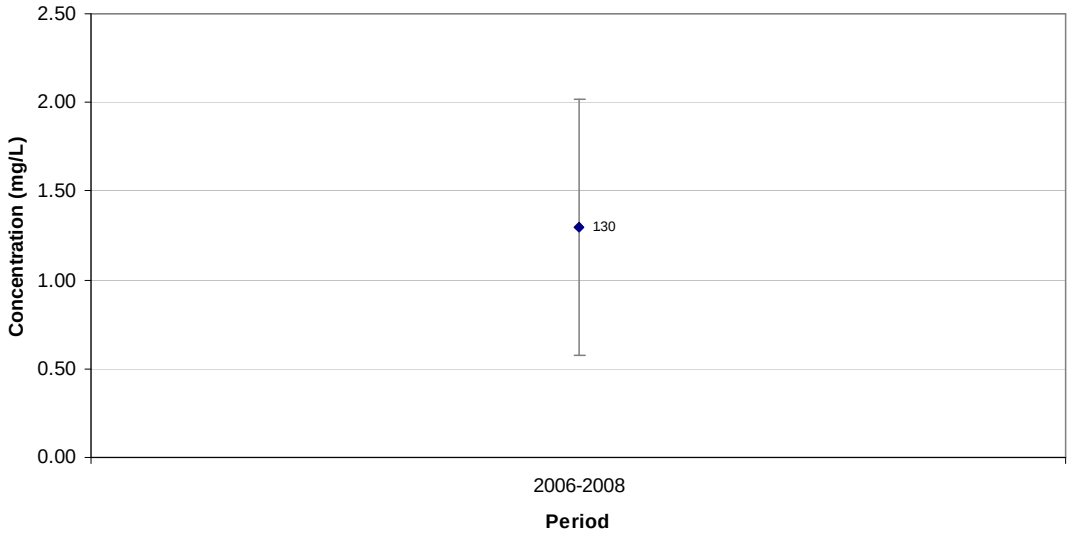
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	23	0	0	2006–2008
TP	23	0	0	2006–2008

Total nitrogen and total phosphorus statistics for 6121223

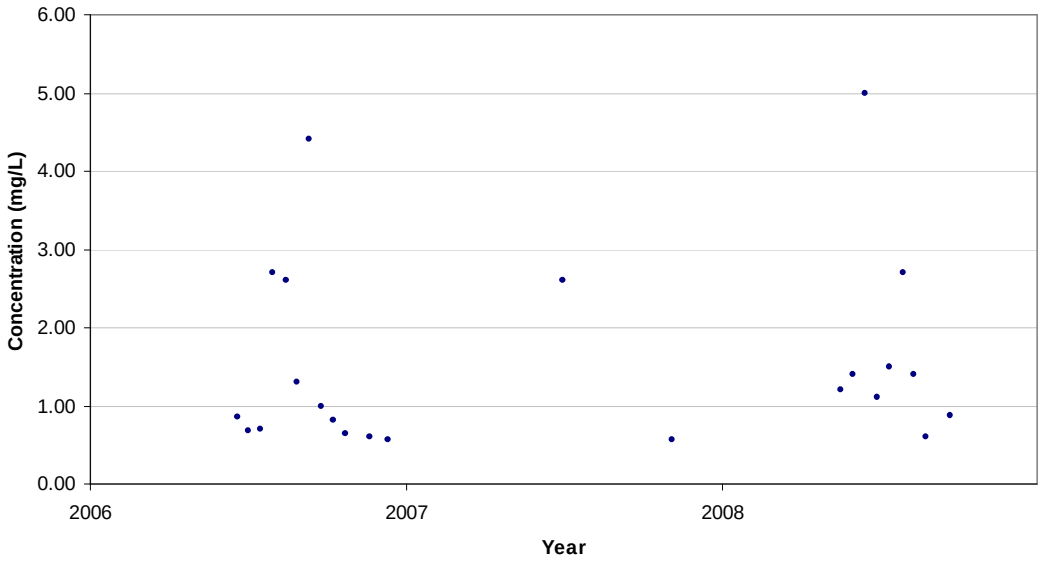
Statistic	Total nitrogen	Total phosphorus
Median	1.1	0.039
5th percentile	0.573	0.016
95th percentile	4.23	0.254
Lowest concentration	0.57	0.015
Highest concentration	5.0	0.30

Total nitrogen – Canal to Henty (Near Henty)

(a) Median concentration and 90% confidence interval



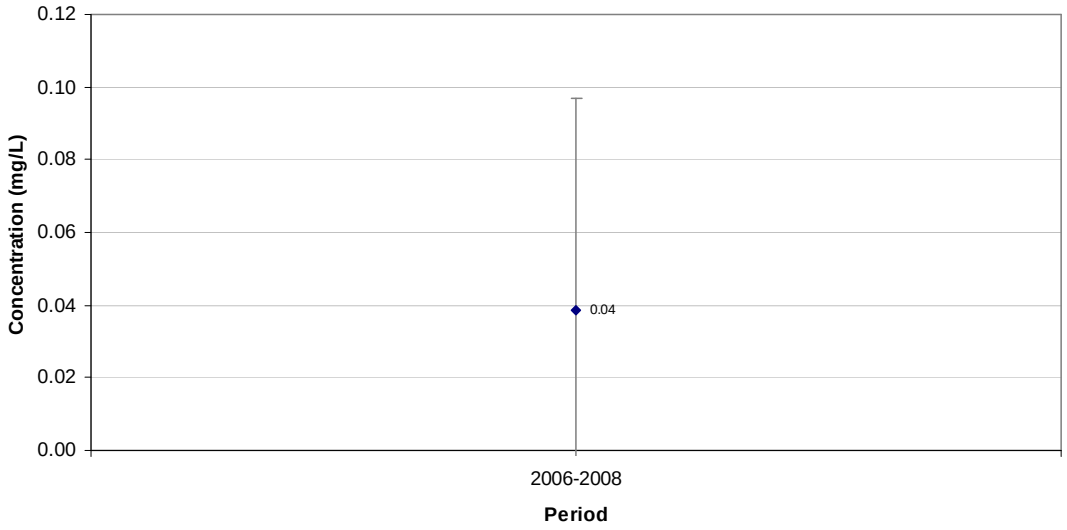
(b) - Observed data



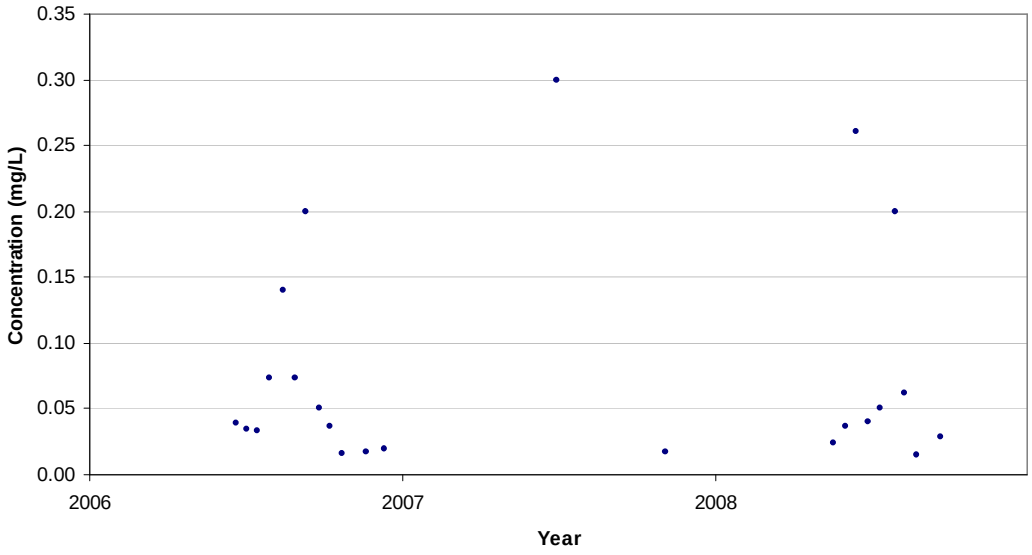
No trends

Total phosphorus – Canal to Henty (Near Henty)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6121225: Millars Creek (Millars)

	Period	Status	Trend
TN	2006–2008	1.55	None
TP	2006–2008	0.09	None

Data summary for 6121225

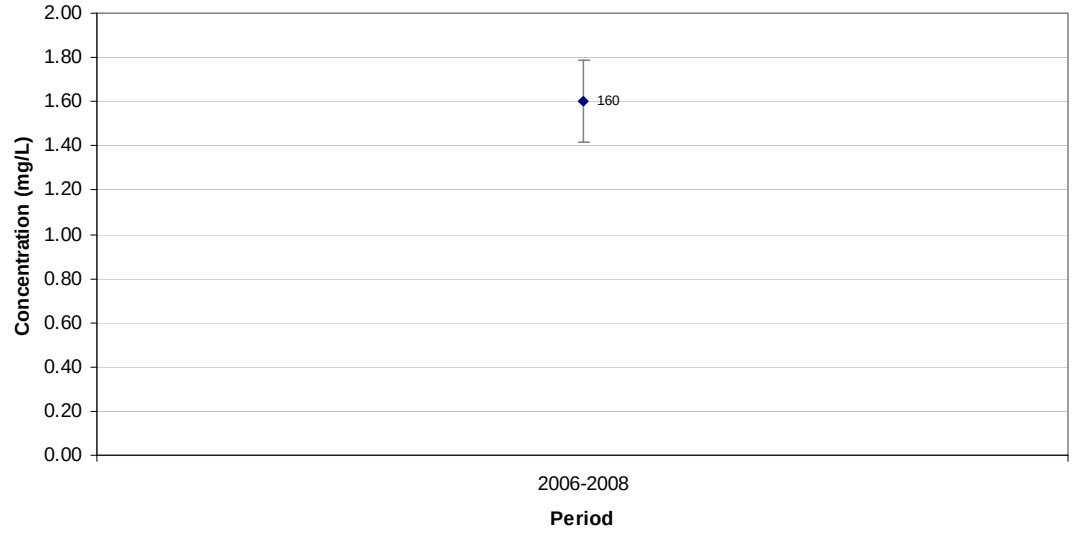
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	56	0	0	2006–2008
TP	56	0	0	2006–2008

Total nitrogen and total phosphorus statistics for 6121225

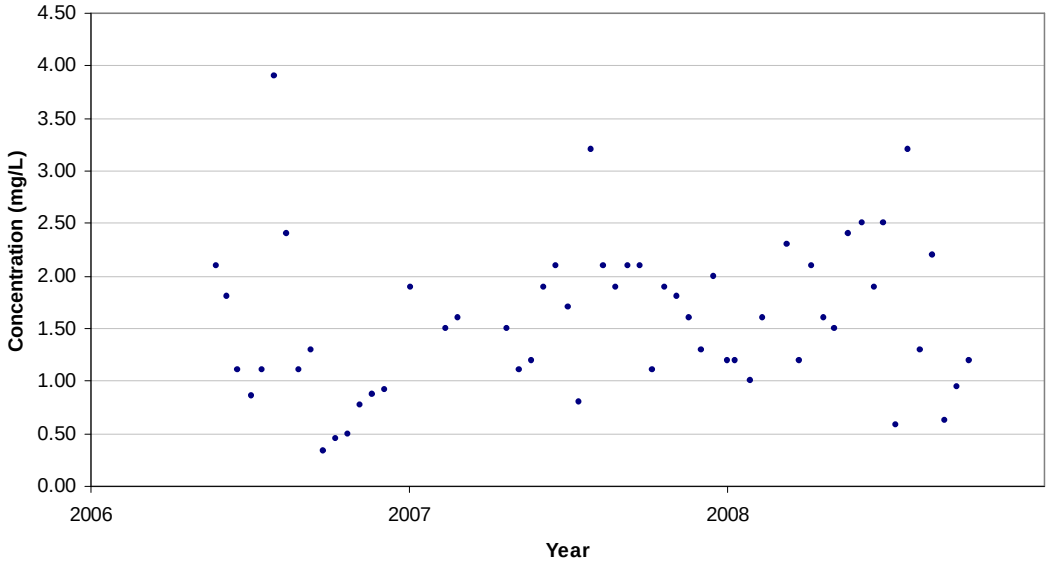
Statistic	Total nitrogen	Total phosphorus
Median	1.55	0.091
5th percentile	0.56	0.019
95th percentile	2.675	0.415
Lowest concentration	0.34	0.018
Highest concentration	3.9	0.46

Total nitrogen – Millars Creek (Millars)

(a) Median concentration and 90% confidence interval

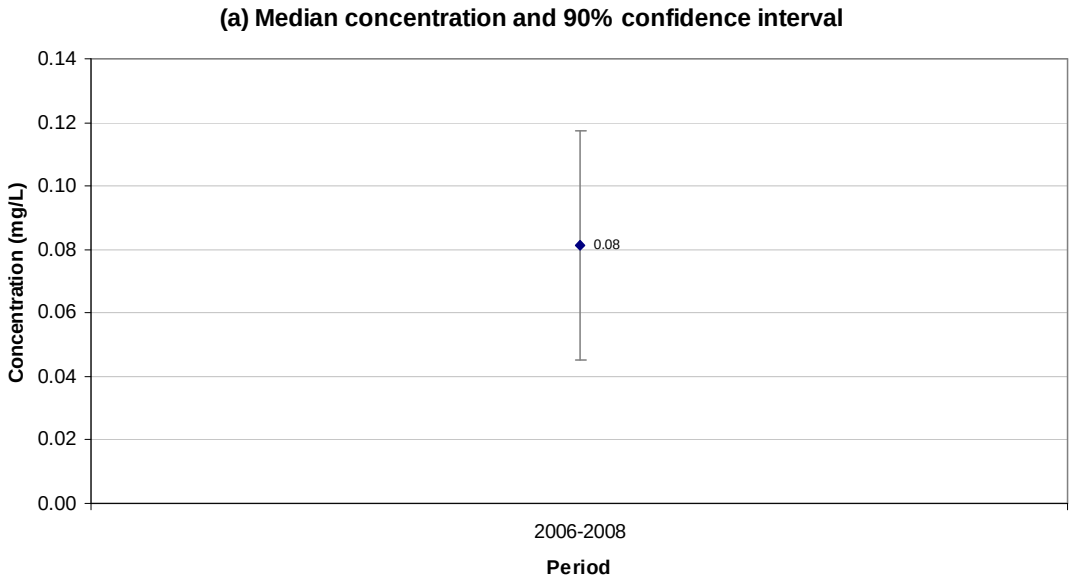


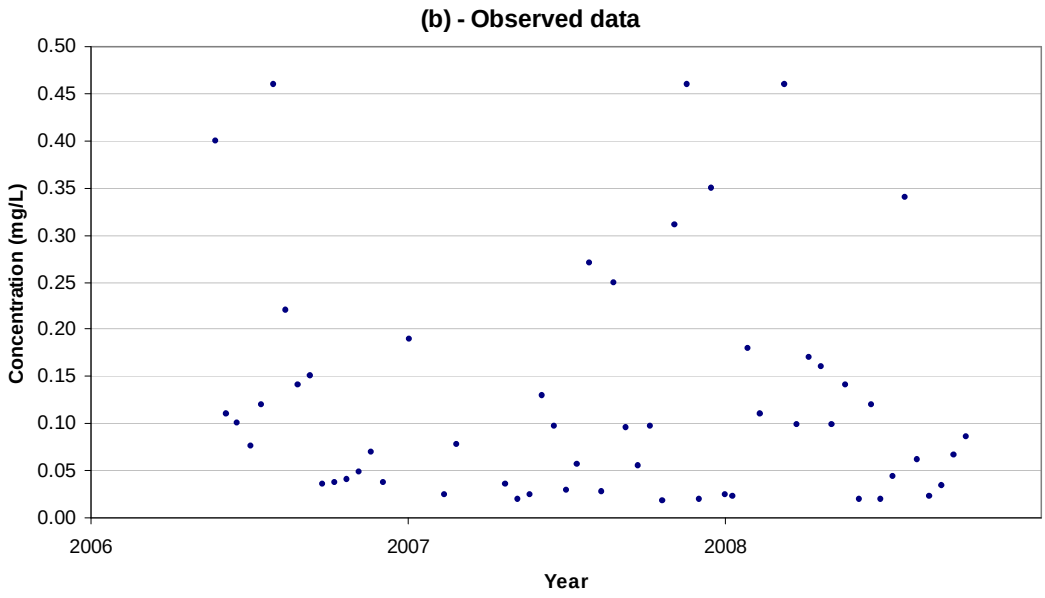
(b) - Observed data



No trends

Total phosphorus – Millars Creek (Millars)





No trends

6121226: Collie River (Hands Street)

	Period	Status	Trend
TN	2006–2008	1.3	None
TP	2006–2008	0.026	None

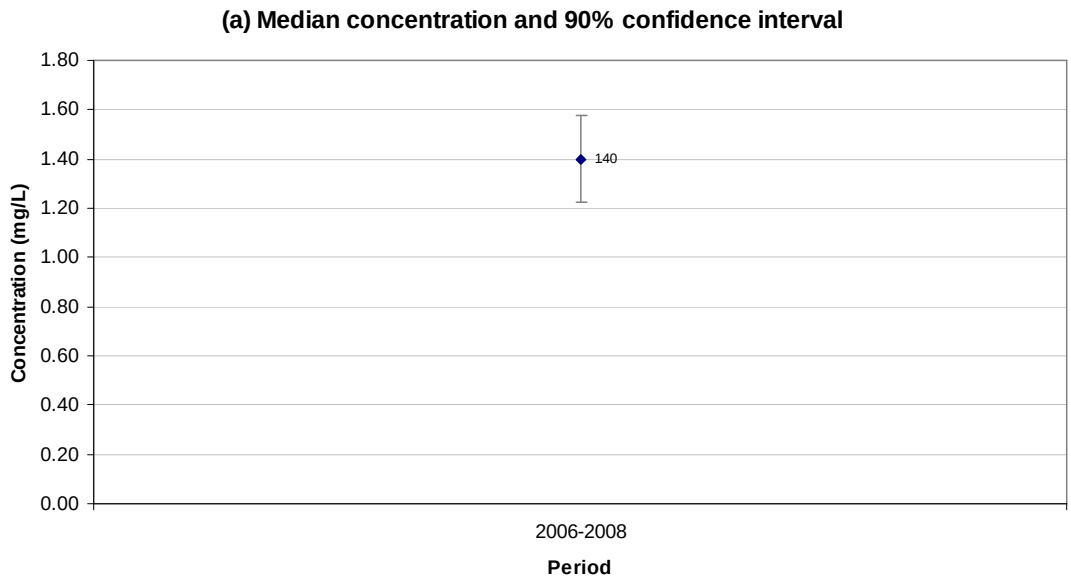
Data summary for 6121226

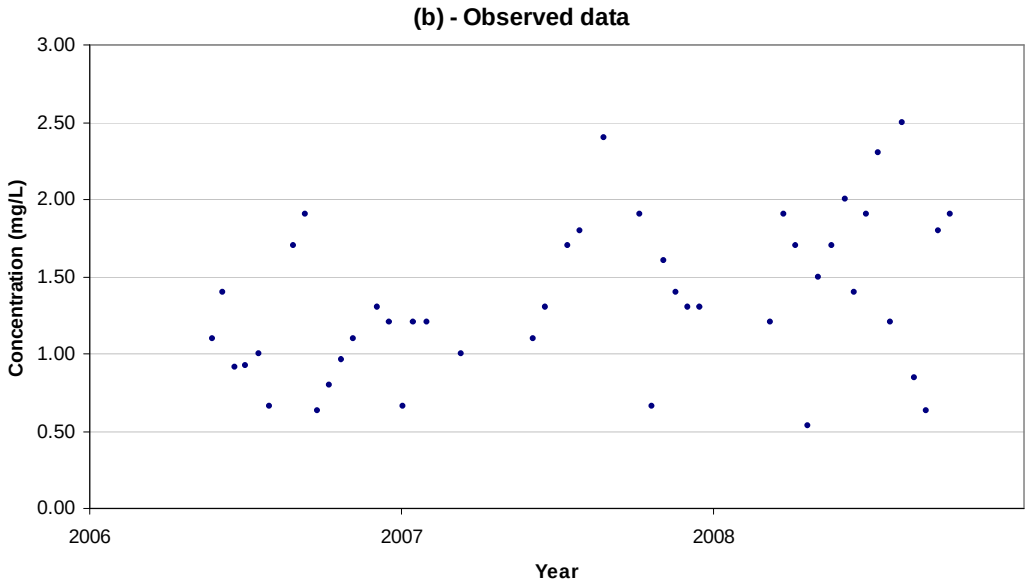
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	45	0	0	2006–2008
TP	45	0	0	2006–2008

Total nitrogen and total phosphorus statistics for 6121226

Statistic	Total nitrogen	Total phosphorus
Median	1.3	0.026
5th percentile	0.636	0.014
95th percentile	2.24	0.162
Lowest concentration	0.53	0.24
Highest concentration	2.5	0.026

Total nitrogen – Collie River (Hands Street)

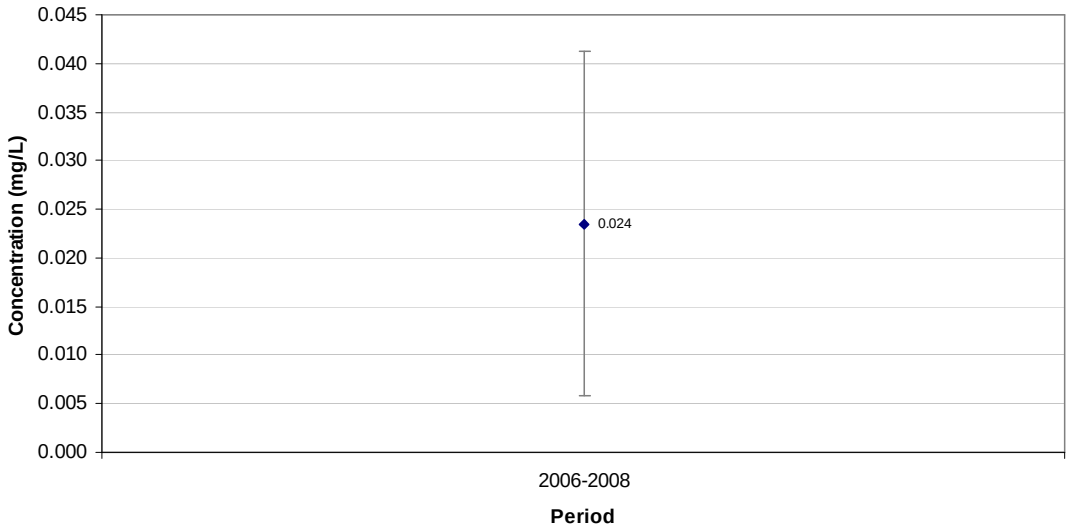




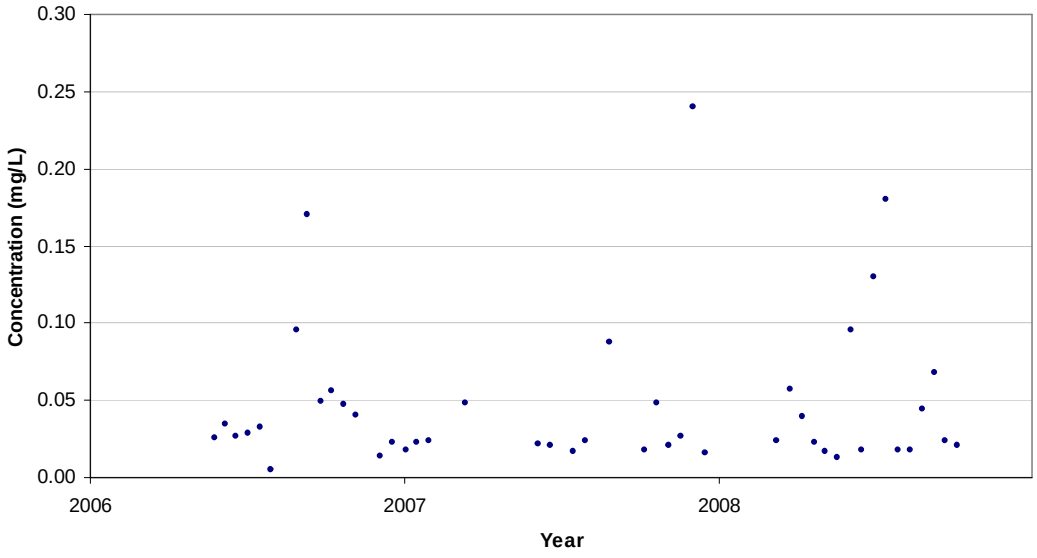
No trends

Total phosphorus – Collie River (Hands Street)

(a) Median concentration and 90% confidence interval



(b) - Observed data



No trends

6121229: Wellesley River (Kemerton Bridge)

	Period	Status	Trend
TN	2007–2008	1.85	None
TP	2007–2008	0.205	None

Data summary for 6121229

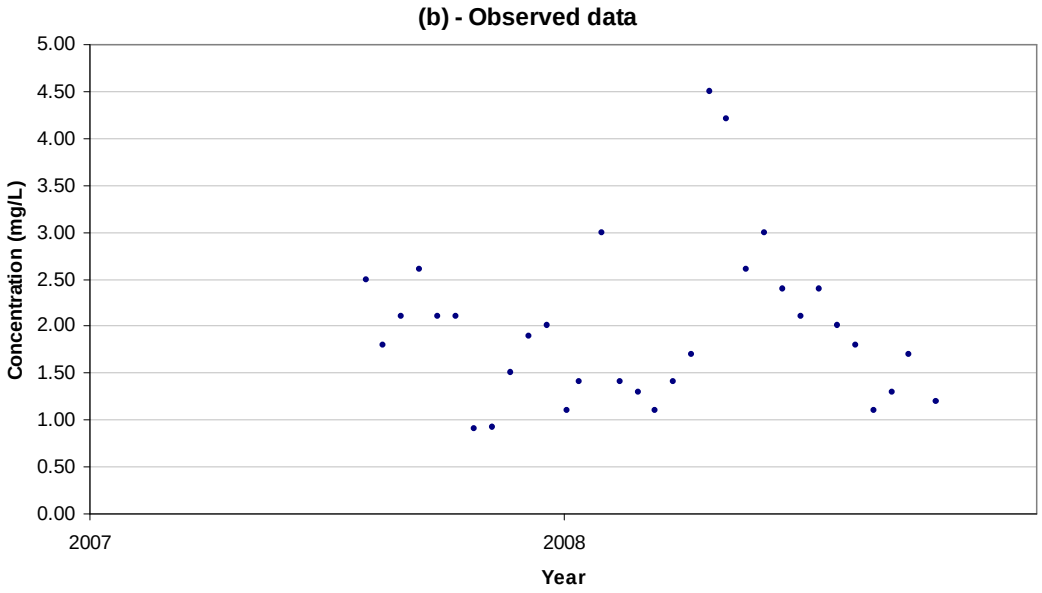
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	32	0	0	2007–2008
TP	32	0	0	2007–2008

Total nitrogen and total phosphorus statistics for 6121229

Statistic	Total nitrogen	Total phosphorus
Median	1.85	0.205
5th percentile	1.024	0.093
95th percentile	3.54	0.334
Lowest concentration	0.91	0.08
Highest concentration	4.5	0.39

Total nitrogen – Wellesley River (Kemerton Bridge)

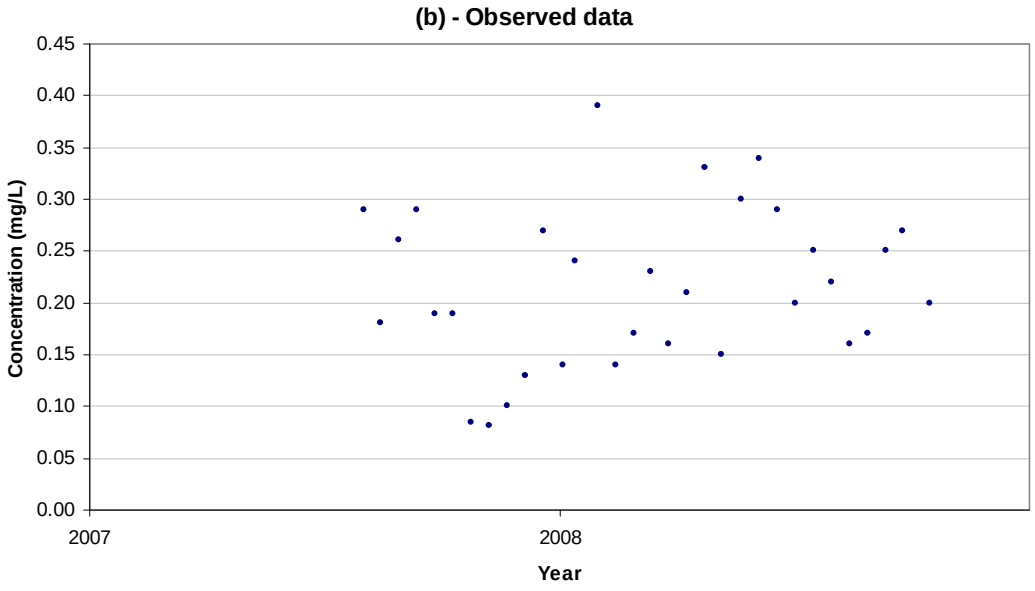
Only two years of data



No trends

Total phosphorus – Wellesley River (Kemerton Bridge)

Only two years of data



No trends

6121230: Taverner Road Canal (Hynes Road)

	Period	Status	Trend
TN	2007–2008	2.05	None
TP	2007–2008	0.18	None

Data summary for 6121230

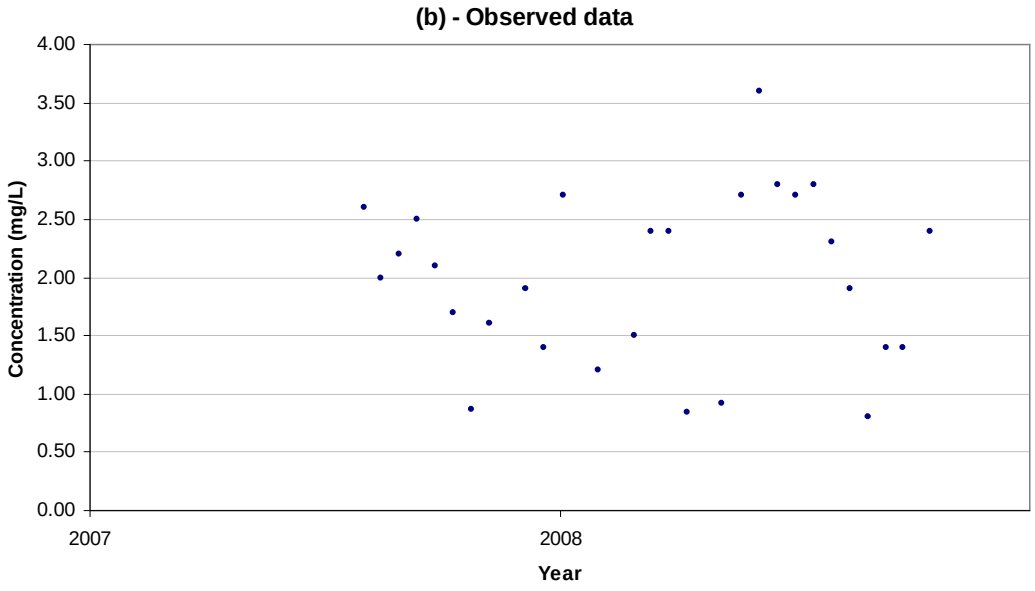
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	28	0	0	2007–2008
TP	28	0	0	2007–2008

Total nitrogen and total phosphorus statistics for 6121230

Statistic	Total nitrogen	Total phosphorus
Median	2.05	0.18
5th percentile	0.850	0.050
95th percentile	2.8	0.343
Lowest concentration	0.80	0.029
Highest concentration	3.6	0.35

Total nitrogen – Taverner Road Canal (Hynes Road)

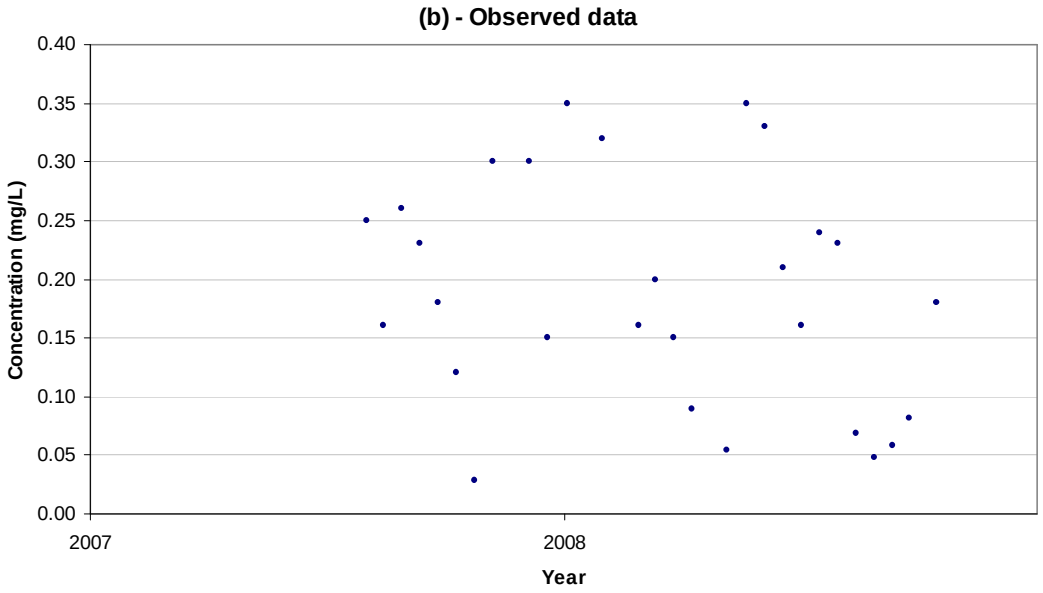
Only two years of data



No trends

Total phosphorus – Taverner Road Canal (Hynes Road)

Only two years of data



No trends

6121231: Punchbowl Canal (Hayward Road)

	Period	Status	Trend
TN	2007–2008	2.1	None
TP	2007–2008	0.066	None

Data summary for 6121231

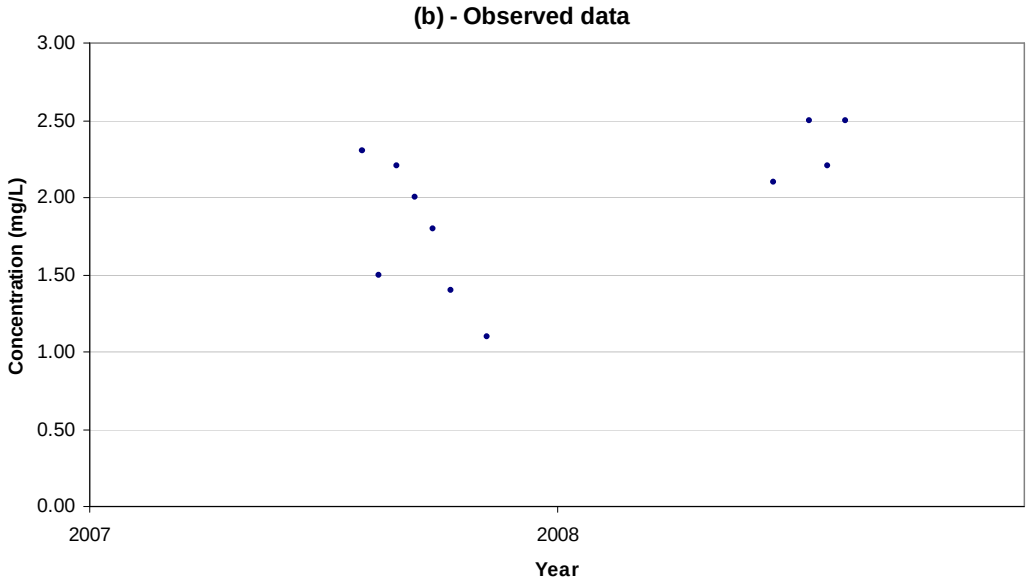
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	11	0	0	2007–2008
TP	11	0	0	2007–2008

Total nitrogen and total phosphorus statistics for 6121231

Statistic	Total nitrogen	Total phosphorus
Median	2.1	0.066
5th percentile	1.25	0.058
95th percentile	2.5	0.1
Lowest concentration	1.1	0.057
Highest concentration	2.5	0.11

Total nitrogen – Punchbowl Canal (Hayward Road)

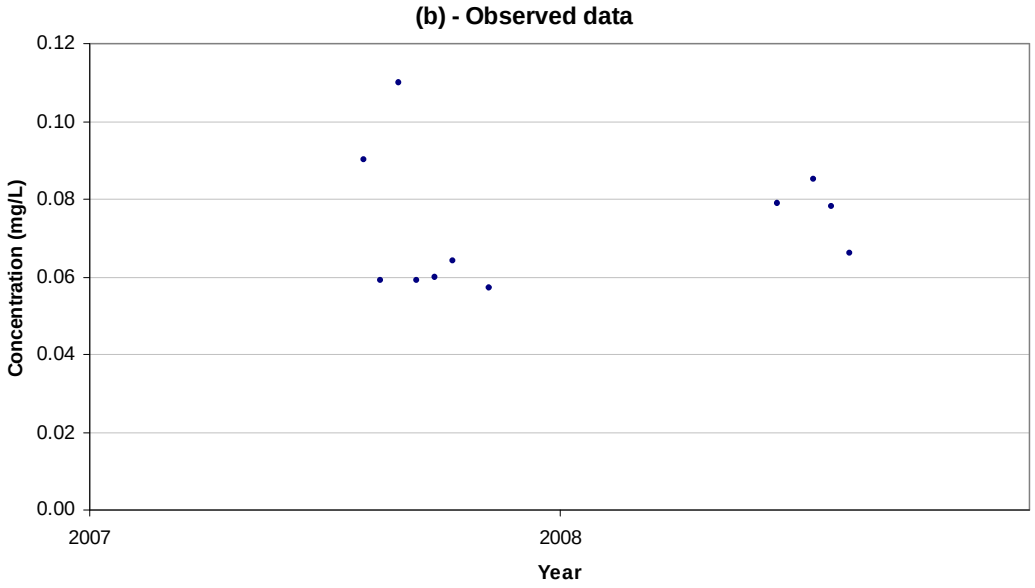
Only two years of data



No trends

Total phosphorus – Punchbowl Canal (Hayward Road)

Only two years of data



No trends

6121232: Charterhouse Street (St Marks Park Lake)

	Period	Status	Trend
TN	2007–2008	1.1	None
TP	2007–2008	0.028	None

Data summary for 6121232

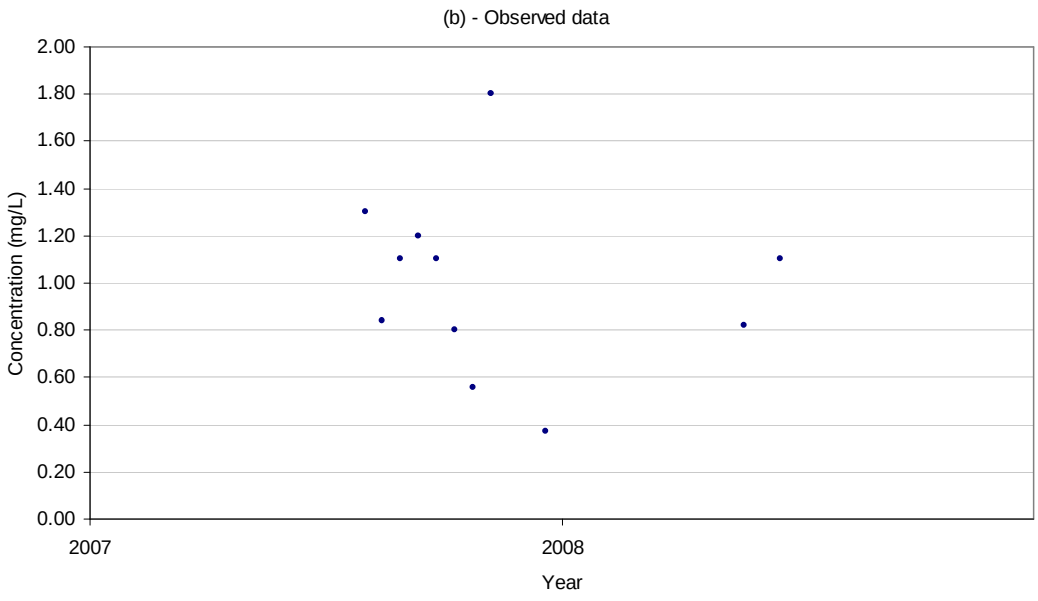
	Total number of measurements	Number of rejected measurements	Number < LOR	Period of record
TN	11	0	0	2007–2008
TP	11	0	0	2007–2008

Total nitrogen and total phosphorus statistics for 6121232

Statistic	Total nitrogen	Total phosphorus
Median	1.1	0.028
5th percentile	0.465	0.014
95th percentile	1.55	0.154
Lowest concentration	0.37	0.012
Highest concentration	1.8	0.24

Total nitrogen – Charterhouse Street (St Marks Park Lake)

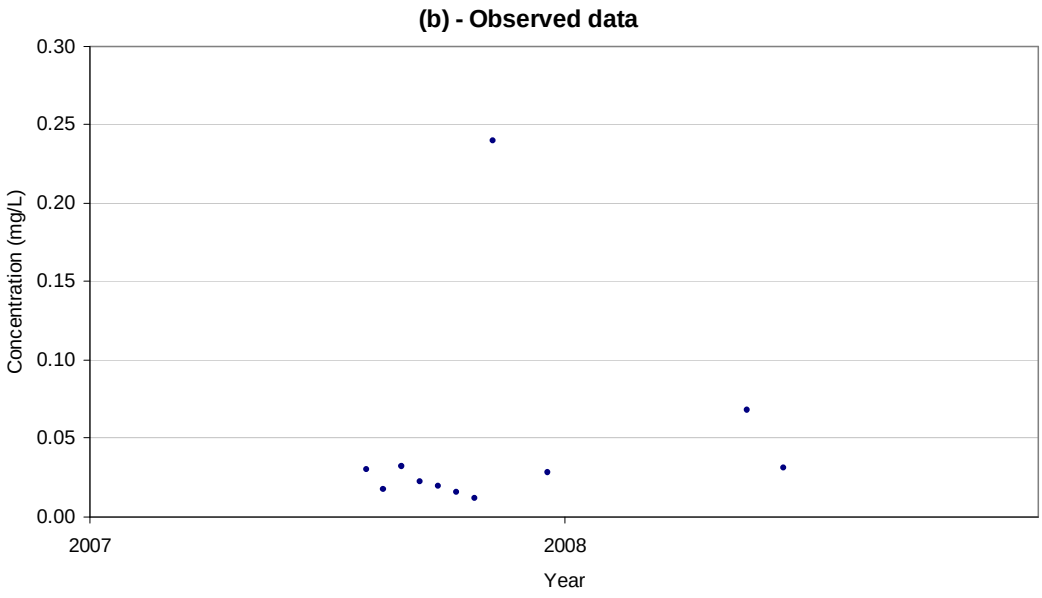
Only two years of data



No trends

Total phosphorus – Charterhouse Street (St Marks Park Lake)

Only two years of data



No trends

References

Bayley, GV & Hamersley, JM 1946, 'The 'effective' number of independent observations in an auto-correlated time series', *Supplement to the Journal of the Royal Statistical Society* **8**:184-197.

Cleveland, WS 1979, 'Robust locally weighted regression and smoothing scatterplots', *Journal of the American Statistical Association*, Vol. 74, pp. 829-836.

Close, ME 1989, 'Effect of serial correlation on groundwater water quality sampling frequency', *Water Resources Bulletin* **25**: 507-515.

Department of Water 2006, Nutrient loads, status and trends in the Leschenault catchment, Department of Water, Western Australia, June (unpublished)

Department of Water 2007, *The Leschenault Estuarine System, South-Western Australia,* Department of Water, Western Australia.

Department of Water 2010, *Nutrient-export modelling of the Leschenault catchment*, Department of Water, Western Australia.

Department of Water 2009, *Statewide river water quality assessment* website: <www.water.wa.gov.au/idelve/srwqa/index.jsp>.

DoW – see Department of Water

DA Lord & Associates Pty Ltd in collaboration with JDA Consultant Hydrologists 2001, *Aggregated emissions of total nitrogen and total phosphorus to the Peel-Harvey catchment, a submission to the National Pollutant Inventory, Environment Australia,* Dept Env. Protection, WA, Report no. 00/163/2.

Donohue, R & Nelson, S 1999, 'Predicting error in nutrient loads using Kernel density estimators', *Proceedings of International Conference of Diffuse Pollution,* CSIRO Land and Water.

Esterby, SR 1996, 'Review of methods for the detection and estimation of trends with emphasis on water quality applications', *Hydrological Processes* **10** (2): 127-149.

Gilbert, RO 1987, *Statistical methods for environmental pollution monitoring*, Van Nostrand Reinhold, New York. 250pp.

Helshel, DR & Hirsch, RM 1992, *Statistical methods in water resources*, Elsevier, Amsterdam, p. 288.

Hipel, KW & McLeod, AI 1994, *Time series modelling of environmental and water resources systems,* Elsevier, Amsterdam.

Kelsey, P 2008, Sampling and analysis plan, project: SW-C-LESCHDSS, prepared for Department of Water use, Version 2.2, Water Science Branch 06/10/08,

Lachance, M 1992, Monitoring lakes in Quebec. Case study in: *Design of water quality monitoring systems,* R. Ward, J. Loftis & G. McBride. Van Nostrand Reinhold, New York.

Lettenmaier, DP 1976, Detection of trends in water quality from records with independent observations, *Water Resources Research*, **12** (5):1037-1046.

Loftis, J 1996, 'Trends in groundwater quality', *Hydrological Processes* **10** (2): 335-355.

Robson, AJ & Neal, C 1996, 'Water quality trends at an upland site in Wales', *Hydrological Processes* **10** (2): 183-203.

Ward, R, Loftis, J & McBride, G 1990, *Design of water quality monitoring systems*, Van Nostrand Reinhold, New York.

Water and Rivers Commission 2002, *Aggregated emissions of total nitrogen and total phosphorus to the Blackwood and Scott river catchments*, Water and Rivers Commission, Western Australia.

WRC – see Water and Rivers Commission

Zhou, Yangxiao 1996, Sampling frequency for monitoring the actual state of groundwater systems, *Journal of Hydrology* **180**: 301-318.

Water *Science*
technical series

Looking after all our water needs

Department of **Water**
168 St Georges Terrace, Perth, Western Australia
PO Box K822 Perth Western Australia 6842
Phone: (08) 6364 7600
Fax: (08) 6364 7601
www.water.wa.gov.au

2262 00 0610