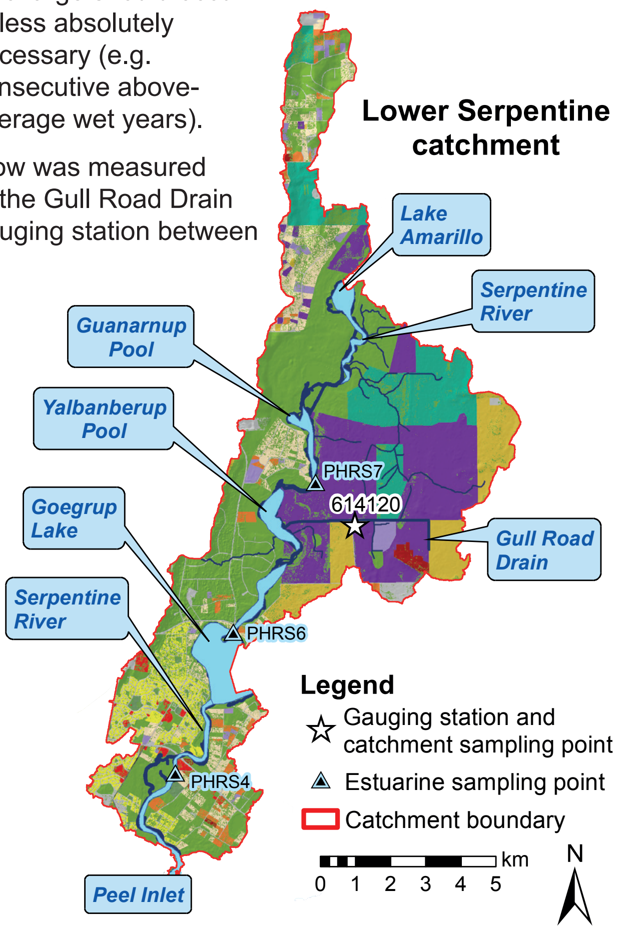
Lower Serpentine River

The lower Serpentine catchment drains to the Serpentine River and Lakes between Lake Amarillo and the Peel Inlet. The catchment encompasses land to either side of the Serpentine River and Lakes.

The lower Serpentine River itself is tidal so was not monitored as part of the catchment program. Water quality was monitored at a sampling point in Gull Road Drain (614120), which flows from the east to Yalbanberup Pool. The sampling site's nutrient concentrations have been of concern for many years and are attributed to excess volume from Wandalup Farms' (piggery) treatment ponds being discharged there in the past. The surface water discharge from Wandalup ceased in 2005 and while licence conditions still enable it, no surface water discharge should occur unless absolutely necessary (e.g. consecutive above-average wet years).

Flow was measured at the Gull Road Drain gauging station between March 2005 and April 2008. The drain ceases to flow between December and May in most years.



Most of the lower Serpentine catchment is situated on dunes with leached sands and nearly 90% of the catchment has a moderate to very high risk of phosphorus leaching to waterways.

To the Serpentine River's west and south of Goegrup Lake, much of the catchment has been urbanised, yet large areas of natural vegetation remain. To the river's east, north of Goegrup Lake, the land has been cleared – mostly for agriculture such as stock grazing, as well as plantations and horticulture. Most of this area is subject to inundation (67%).

Between 2003 and 2006 the area used for 'horticulture' reduced to a third, while land dedicated to 'plantations' nearly doubled.

The lower Serpentine catchment is one of the smallest subcatchments in the Peel-Harvey catchment (1%), however in 2006 it had the largest area and percentage area dedicated to 'mixed grazing'.

Land use classification (2006)	Area (km^2)	Area (%)
Animal keeping – non-farming (horses)	1.8	1.9
Cattle for beef (predominantly)	6.1	6.5
Conservation and natural	42	44
Horticulture	1.7	1.8
Industry, manufacturing and transport	4.8	5.1
Intensive animal use	0.52	0.55
Lifestyle block	5.6	5.9
Mixed grazing	18	19
Offices, commercial and education	0.66	0.70
Plantation	9.5	10
Recreation	0.44	0.46
Residential	3.6	3.8
Viticulture	0.01	0.01
Total	**94**	**100**

In 2009 Gull Road Drain had the highest median TN and TP concentrations of the 13 sites sampled in the Peel-Harvey catchment.

Nutrient summary: median concentrations, loads and status classification at 614120

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Annual flow (GL)										0.87*	0.03	0.31		
TN median (mg/L)	5.0	7.2	5.8	16	19	4.7	14	12	3.9	4.7	4.3	4.4	4.9	4.1
TP median (mg/L)	4.7	3.4	2.0	3.7	3.4	1.6	3.4	4.4	2.3	2.1	4.8	1.6	1.5	1.1
TN load (t/year)										4.1*	0.15	1.4		
TP load (t/year)										2.0*	0.07	0.64		

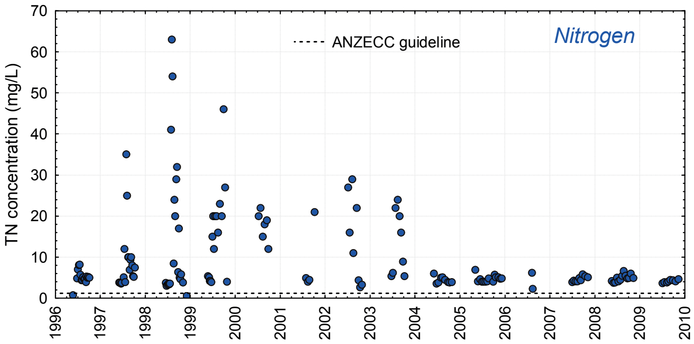
Status classification: Low · Moderate · High · Very high

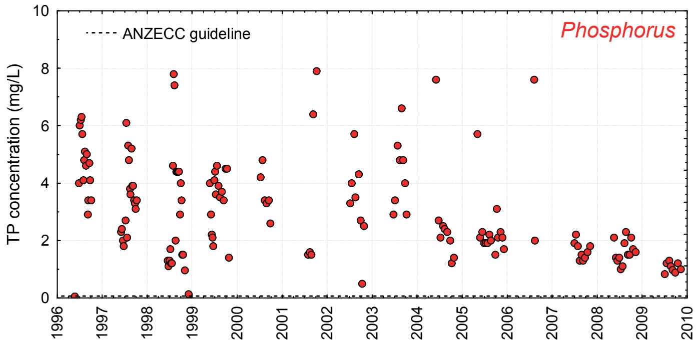
Status reported for three-year period end (i.e. 1996–98 reported in 1998)

TN = total nitrogen   TP = total phosphorus

* best estimate using available data

Total nitrogen (TN) and total phosphorus (TP) concentrations (1996–2009)





TN concentration:

Between 1996 and 2009, all but two samples (1996 and 1998) exceeded the ANZECC[1] guideline for lowland rivers (1.2 mg/L).

Between 1996 and 2004, 31% of samples exceeded 12 mg/L, 10 times the ANZECC[1] guideline. After 2004 nitrogen concentrations reduced – reflecting the cessation of surface water discharge from Wandalup Farms. However, between 2005 and 2009 35% of samples were still four times greater than the guideline (4.8 mg/L).

TN trend:

Trend analysis was undertaken using data from 2005 to 2009 inclusive.

No trend was detected.

Before construction of the weir on Gull Road Drain (downstream view February 2005)

TP concentration:

Between 1996 and 2009, all samples exceeded the ANZECC[1] guideline for lowland rivers (0.065 mg/L).

Between 1996 and 2004, 91% of samples exceeded 1.3 mg/L (20 times the ANZECC[1] guideline). This dropped to 72% between 2005 and 2009 when surface water discharge from Wandalup Farms ceased.

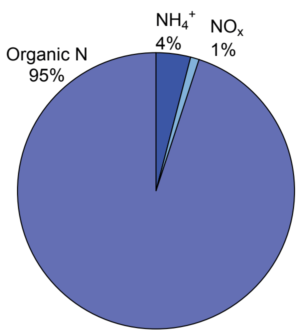
Despite a decrease in maximum concentrations between 2004 and 2009, all samples still exceeded 0.65 mg/L (10 times the guideline).

TP trend:

Trend analysis was undertaken using data from 2005 to 2009 inclusive.

Once the data were adjusted for seasonality, an emerging decreasing trend (0.25 mg/L/year) was detected.

Nutrient fractions (2005–09)



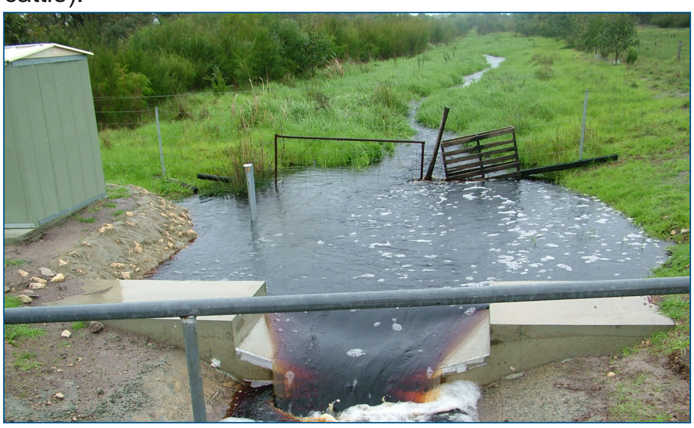
Nitrogen:

Most of the nitrogen (N) present was organic in nature. Organic N consists of both dissolved organic and particulate nitrogen. It is derived from degrading plant and animal matter and fertilisers. It often needs to be further broken down before it can be used by plants and algae.

The remaining N was dissolved inorganic N (DIN) such as ammonium (NH_4^+) and N oxides (NO_x).

DIN is also derived from animal wastes and fertilisers but is readily available to plants and algae.

Gull Road Drain had the highest percentage of organic N of the routine sites sampled in the Peel-Harvey catchment. This was likely due to animal-dominated land use adjacent to Gull Road Drain (mixed grazing, piggery and cattle).

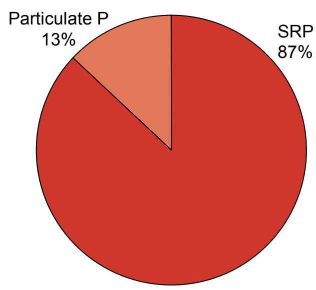


Upstream view of Gull Road Drain – June 2005

Phosphorus:

Most of the phosphorus (P) was present as soluble reactive phosphorus (SRP). SRP is derived from fertilisers and animal wastes and is readily available for uptake by plants and algae.

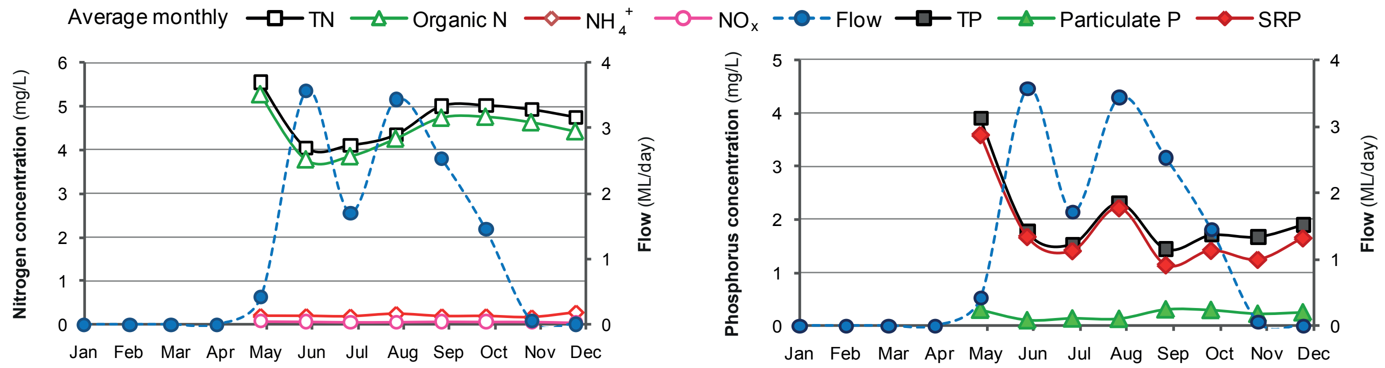
The remaining P was present as particulate P, which consists of sediment-bound forms of P and organic waste materials.



Particulate P is not readily available for uptake by plants and algae, but may become available over time as organic matter decomposes or soil particles release bound phosphorus.

Gull Road Drain had the highest percentage of SRP of the sites sampled in the Peel-Harvey catchment. All other sites had less than 60% SRP.

Seasonal variation in nutrient concentrations (2005–09) and riverine flow (2005–07)



No samples were collected between January and April as the sampling site was not flowing. Only two samples were collected in both May and December.

Graphed flow represents average daily flow in each month with each year being markedly different. Peak flow in June was due to unseasonal flow in 2005 when total monthly flow was 320 ML, which was greater than the total annual flow in 2007 (306 ML) and 10 times the total flow in 2006 (33 ML).

Nitrogen:

Average monthly TN and organic N concentrations were greatest in May during the first flush. Concentrations were diluted in June then slowly increased throughout winter.

Average monthly NH_4^+ and NO_x concentrations remained fairly constant irrespective of flow.

All average monthly concentrations of TN and NH_4^+ exceeded ANZECC[1] guideline values.

Historically (1996–2003) nitrogen was predominantly organic in nature with NH_4^+ concentrations increasing during the winter months and dominating in August.

	ANZECC 2000	Months exceeded
TN	1.2 mg/L	May – Dec
NH_4^+	0.08 mg/L	May – Dec
NO_x	0.15 mg/L	None
TP	0.065 mg/L	May – Dec
SRP	0.04 mg/L	May – Dec

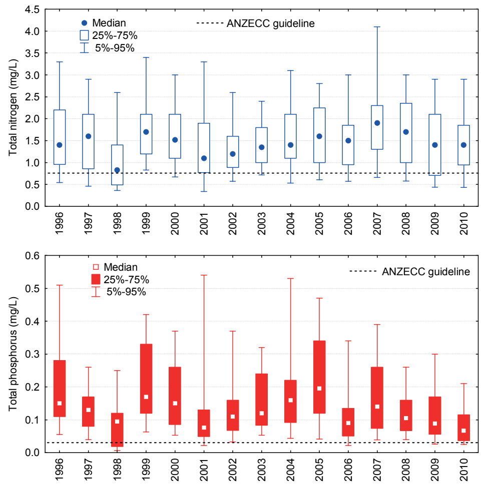
Phosphorus:

Average monthly TP and SRP concentrations were greatest in May during the first flush. Concentrations decreased in June before a second peak occurred in August (the only month with consistent flow).

All average monthly TP and SRP concentrations exceeded ANZECC[1] guideline values.

Serpentine River – estuarine water quality

Water quality monitoring along the Serpentine River's tidal section occurred at three sites between 1996 and 2010. Annual median TN and TP concentrations within the tidal river exceeded ANZECC[1] guidelines for estuarine waters (TN = 0.75 mg/L and TP = 0.03 mg/L).



Most of the nitrogen present was organic, with DIN concentrations increasing slightly with winter flows. Phosphorus was present mostly as particulate P, however SRP concentrations increased substantially in winter and were the dominant form of phosphorus in August.

Estuarine sediment analysis

Sediment sampling occurred in the lower Serpentine River on two occasions (1996 and 1998). Five transects were sampled to assess the sediment composition, store of nutrients and other contaminants[2]. The two surveys indicated that bound nutrients and organic matter were greatest in and around Goegrup Lake, which may be acting as a sedimentation basin and nutrient sink.

Fish deaths

Six reports of dead fish in the lower Serpentine River have occurred since 2000. Two were located in Goegrup Lake (December 2006 and November 2008). Most of the incidents were attributed to deoxygenation caused by rainfall events creating stratified conditions or from the collapse and decomposition of algal blooms.

Lyngbya

The toxic blue-green macro-algae Lyngbya bloomed in the Peel-Harvey estuary in 2000 and 2001 and has established itself in the Serpentine River. In November 2006 a toxic Lyngbya bloom covered 5 km of the Serpentine River and by the following month covered two-thirds of Goegrup Lake.

Lyngbya: Serpentine River – November 2006

Lyngbya: Goegrup Lake – November 2006

Modelled results (1997–2007)[3]

This page reports results from the Streamflow Quality Affecting Rivers and Estuaries (SQUARE) model. It estimated flow, nitrogen and phosphorus loads from the 13 subcatchments of the Peel-Harvey estuary.

Nutrient sources

There were two main sources of nitrogen load in the lower Serpentine catchment: 'septic' and 'mixed grazing'. The two categories were responsible for 75% of the nitrogen load within the catchment (41% and 34% respectively).

'Mixed grazing' was responsible for nearly half the phosphorus load. 'Horticulture', 'intensive animal use' and 'residential properties' accounted for a further 39% of the phosphorus load despite only contributing a combined 6% of the area. Only 4% of the phosphorus load was due to 'septic'.

Annual exports to Peel Inlet

The lower Serpentine catchment is 1.1% of the area that drains to the Peel Inlet. On average it contributed to the Peel Inlet:

- 1% of the flow (6.2 GL/year)
- 1% of the nitrogen load (9.7 tonnes/year)
- 4% of the phosphorus load (2.9 tonnes/year).

Remediation priority

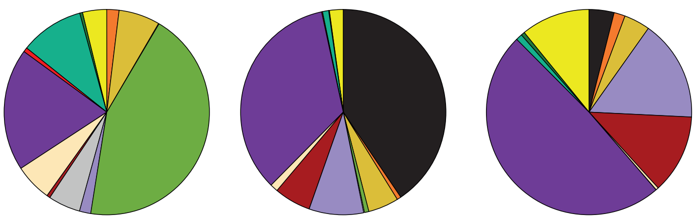
The SQUARE-modelled data indicated that based on nutrient loads per cleared area (kg/ha/year):

- The lower Serpentine catchment requires low-priority nitrogen and phosphorus remediation action.

The lower Serpentine catchment had the lowest TN and TP load per cleared area of all the catchments of the Peel-Harvey estuary (except the upper Murray).

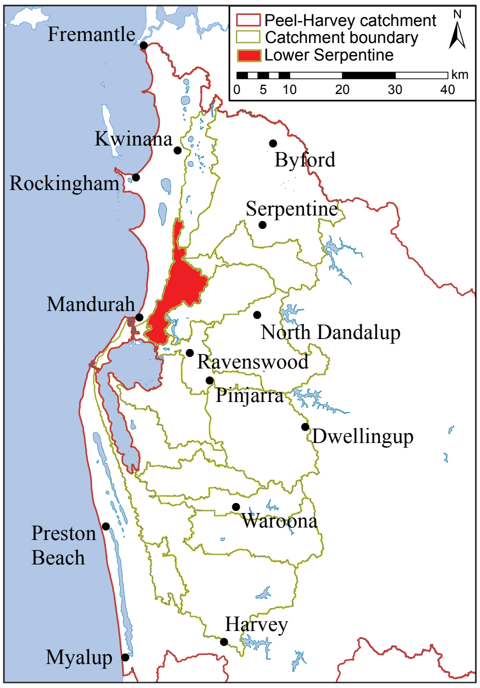
It had the smallest area dedicated to 'cattle for beef' (6.5%) of all the Peel-Harvey catchments (except the upper Murray).

Area: **Nitrogen:** **Phosphorus:**



- Septic
- Animal keeping – non-farming (horses)
- Cattle for beef (predominantly)
- Conservation and natural
- Horticulture
- Industry, manufacturing and transport
- Intensive animal use
- Lifestyle block
- Mixed grazing
- Offices, commercial and education
- Plantation
- Recreation
- Residential
- Viticulture

How the lower Serpentine fits within the Peel-Harvey catchment: location and statistics



Catchment draining to estuary	Area (km²)	Flow (GL)	TN load (tonnes/ year)	TN load per cleared area (kg/ha)	TP load (tonnes/ year)	TP load per cleared area (kg/ha)
Peel Main Drain	120	11	26	3.0	4.5	0.52
Upper Serpentine	502	55	106	3.8	21	0.75
Dirk Brook – Punrak Drain	134	18	51	7.5	5.6	0.82
Nambeelup	143	19	44	3.6	10.5	0.86
Lower Serpentine	**94**	**6.2**	**9.7**	**1.6**	**2.9**	**0.49**
Mandurah	24	3.0	7.9	5.0	1.3	0.84
Upper Murray	6 752	286	204	0.51	4.9	0.01
Lower Murray, mid Murray and Dandalup	638	74	198	6.4	4.9	0.16
Coolup (Peel)	151	23	42	3.2	15	1.2
Subtotal Peel Inlet	**8 558**	**496**	**701**	**1.4**	**73**	**0.14**
Coolup (Harvey)	113	16	26	3.3	14	1.8
Mayfield Drain	119	19	33	3.1	7.1	0.67
Harvey	710	142	259	6.9	39	1.0
Meredith Drain	56	11	16	4.3	8.3	2.2
Subtotal Harvey Estuary	**998**	**188**	**334**	**5.6**	**69**	**1.2**
Total Peel-Harvey Estuary	**9 556**	**684**	**1 035**	**1.8**	**142**	**0.25**

References

[1] ANZECC & ARMCANZ 2000, *Australian guidelines for water quality monitoring and reporting,* National Water Quality Management Strategy, Paper no. 7, Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

[2] Water and Rivers Commission 1998, *Sediments of the Murray and Serpentine rivers – a preliminary study*, draft.

[3] Kelsey, P, Hall, J, Kretschmer, P, Quinton, B & Shakya D 2010, *Hydrological and nutrient modelling of the Peel-Harvey catchment*, Water Science Technical Series, Report no. 33, Department of Water, Western Australia.

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