Upper Serpentine River

This data report provides a summary of the nutrients at the Upper Serpentine River sampling site in 2018 as well as historical data from 2004–18. This report was produced as part of the Regional Estuaries Initiative. The river continues downstream of the site, passing through the Serpentine Lakes before discharging into the Peel Inlet. Nutrients (nitrogen and phosphorus) are compounds that are important for plants to grow. Excess nutrients entering waterways from effluent, fertilisers and other sources can fuel algal growth, decrease oxygen levels in water and harm fish and other species. Total suspended solids, pH and salinity data are also presented as they help us better understand the processes occurring in the catchment.

About the catchment

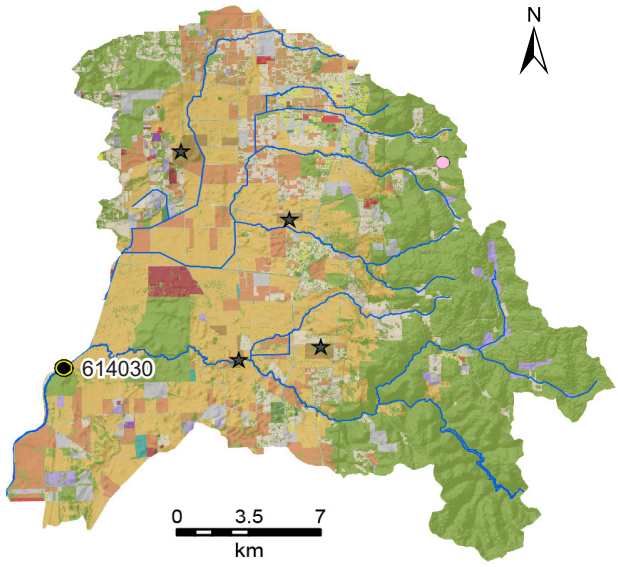
The Upper Serpentine River has a catchment area of about 490 km^2, just over half of which has been cleared, mostly for beef and sheep grazing on the Swan Coastal Plain. There are four dairies and a piggery present in the catchment. The Serpentine River is a natural waterway, though it is dammed just upstream of the Upper Serpentine catchment boundary by the Serpentine Dam. The northern part of the catchment is drained by the Birriga Main Drain. There are numerous other drains present which were constructed to remove water from agricultural land.

Soils on the coastal plain portion of the catchment have a low phosphorus-binding capacity. This is often so poor that any phosphorus applied to them can be quickly washed into drains and other waterways. The soils present in the Darling Scarp have a high phosphorus-binding capacity, helping to prevent it entering drains and other waterways.

Water quality is measured at site 614030, Dog Hill, near Wilkinson Road in Baldivis. The catchment area upstream of the sampling site is about 333 km^2.

Results summary

Nutrient concentrations (total nitrogen and total phosphorus) were moderate at the Upper Serpentine River sampling site. Total nitrogen loads were moderate and total phosphorus loads large compared with the other monitored catchments. The combination of agricultural land use, highly modified rivers and construction of drains to reduce surface water ponding all contributed to the nutrient concentrations and moderate to large nutrient loads at this sampling site.

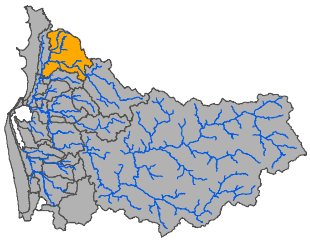


Legend

- Monitoring sites
- Dairy sheds
- Piggery
- Hydrology

Land use

- Beef & sheep
- Cropping
- Dairy
- Horses
- Horticulture
- Industry, manufacturing & transport
- Intensive animal use
- Lifestyle block
- Native vegetation
- Offices, commercial & education
- Plantation
- Point sources
- Recreation
- Residential
- Viticulture



Location of Upper Serpentine River catchment in the greater Peel-Harvey catchment.

Facts and figures

Sampling site code	614030
Catchment area	490 km^2
Per cent cleared area (2015)	55 per cent
River flow	Permanent
Annual flow (2018)	51 GL
Main land use (2015)	Native vegetation and beef and sheep grazing

Upper Serpentine River

Nitrogen over time (2004–18)

Concentrations

Total nitrogen (TN) concentrations fluctuated over the reporting period at the Upper Serpentine River sampling site. While all years had some samples above the Australian and New Zealand Environment and Conservation Council (ANZECC) trigger value, all annual medians (with the exception of 2016) were below the trigger value. Compared with the other sites sampled in the Peel-Harvey catchment, TN concentrations at the Upper Serpentine River sampling site were moderate.

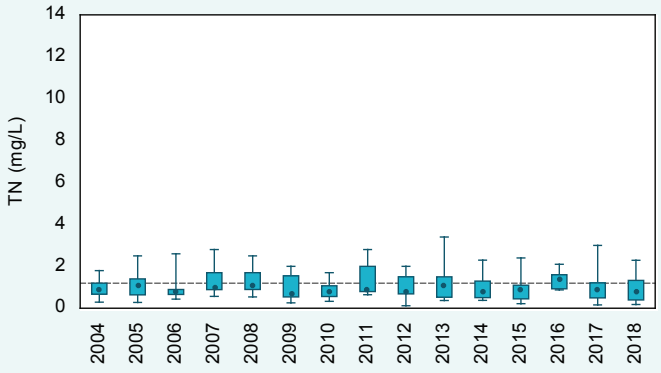
Trends

There was no trend in TN concentrations at the Upper Serpentine River sampling site over either the short- (2014–18) or long-term (2004–18).

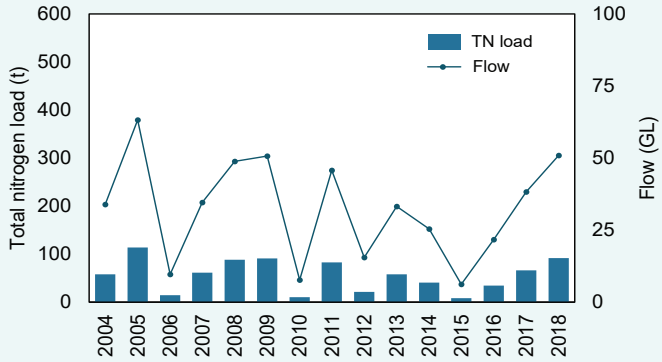
Estimated loads

Estimated TN loads at the Upper Serpentine River sampling site were moderate compared with the other sites in the Peel-Harvey catchment. In 2018, the Upper Serpentine had an estimated TN load of 91 t, the third largest of the 10 sites where it was possible to calculate loads. Only the sites in the Harvey River (250 t) and Middle Murray (401 t) had larger loads. The load per unit area was also moderate, at 274 kg/km^2 in 2018, similar to the site in the Dirk Brook catchment which had a load per unit area of 289 kg/km^2. TN loads were closely related to flow volume, years with high annual flow having large TN loads and vice versa.

Upper Serpentine River



Total nitrogen concentrations, 2004–18 at site 614030. The dashed line is the ANZECC trigger value for lowland rivers.



Total nitrogen loads and annual flow, 2004–18 at site 614030.

The weir at the Upper Serpentine River sampling site with the gauging station in the background, October 2016.

Upper Serpentine River

Nitrogen (2018)

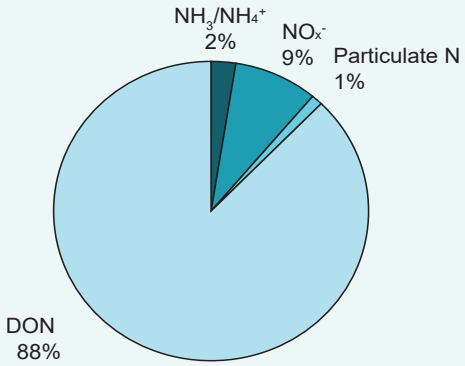
Types of nitrogen

Total N is made up of many different types of N. At the Upper Serpentine River sampling site, most of the N was present as dissolved organic N (DON) which consists mainly of degrading plant and animal matter but may also include other forms. Most forms of DON need to be further broken down to become available to plants and algae, though some forms are readily bioavailable. Eleven per cent of the N was present as highly bioavailable dissolved inorganic N (DIN—consisting of ammonia N, NH_3/NH_4^+ and oxides of N, NO_x^-). Likely sources of these types of N include fertilisers and animal wastes as well as natural sources.

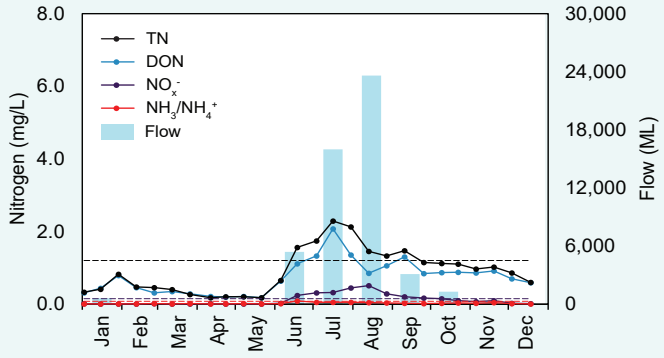
Concentrations

Total N, DON and NO_x^- all showed a seasonal pattern in 2018, being at their highest during the period when rainfall and flow were at their highest. This suggests much of the N at this time was being washed into the drain from surrounding land use via surface flows as well as coming from in-stream sources. Groundwater and in-stream sources were the largest contributors of N for the rest of the year. The small peak in late January coincided with a peak in flow which occurred 12 days earlier. It is likely this flow washed DON into the river from surrounding land use as well as mobilising N present in the river.

Upper Serpentine River



2018 average nitrogen fractions at site 614030.



2018 nitrogen concentrations and monthly flow at 614030. The dashed lines are the ANZECC trigger values for lowland rivers for the different N species.

Looking upstream from the sampling site, March 2016. While the Serpentine River normally flows year round, it will cease to flow following a low rainfall year.

Upper Serpentine River

Phosphorus over time (2004–18)

Concentrations

Compared with the other sites sampled in the Peel-Harvey catchment, TP concentrations were moderate to high. TP concentrations fluctuated over the reporting period, with two-thirds of the annual medians below the Peel-Harvey Water Quality Improvement Plan (WQIP) target.

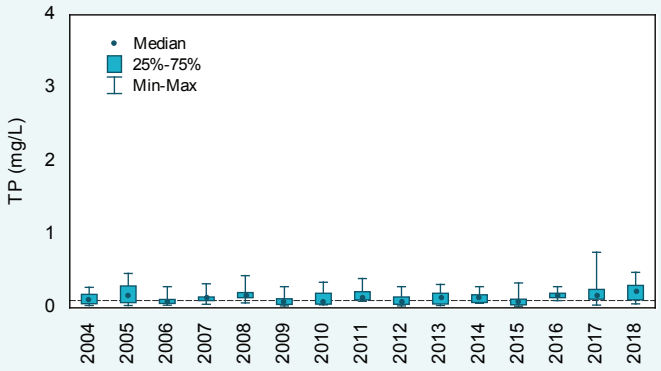
Trends

There was a small short-term (2014–18) increasing trend in TP concentrations of 0.02 mg/L/yr. This may be because of natural fluctuations at this site or an actual increase in TP concentrations. Ongoing monitoring will help determine if the water quality is getting better at this site. There was no long-term (2004–18) trend present.

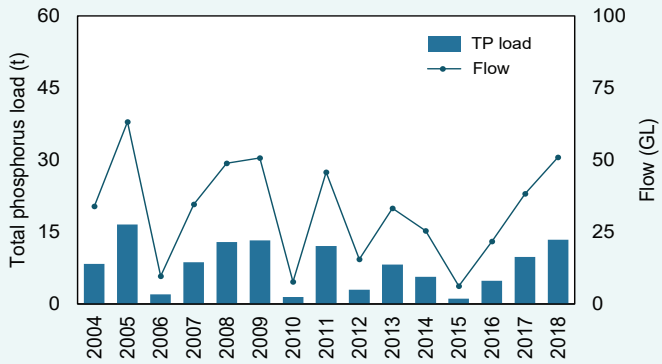
Estimated loads

Estimated TP loads at the Upper Serpentine River sampling site were large compared with the other sites in the Peel-Harvey catchment. In 2018, the site had an estimated TP load of 13.4 t, the second largest TP load of the 10 sites in the Peel-Harvey catchment where it was possible to calculate loads. The only catchment with a larger load was the Harvey River (33.2 t).
The load per unit area of 40.1 kg/km^2 was moderate compared with the other Peel-Harvey sites. TP loads were closely related to flow volume, years with high annual flow having large TP loads and vice versa.

Upper Serpentine River



Total phosphorus concentrations, 2004–18 at site 614030. The dashed line is the Peel-Harvey WQIP target for winter median TP concentrations.



Total phosphorus loads and annual flow, 2004–18 at site 614030.

Elevated nutrient concentrations contribute towards excess macrophyte growth in warm shallow waters. The sampling site, December 2008.

Upper Serpentine River

Phosphorus (2018)

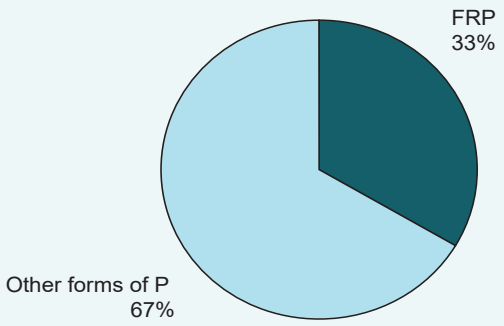
Types of phosphorus

Total P is made up of different types of P. At the Upper Serpentine River sampling site a third of the P was present as highly bioavailable filterable reactive P (FRP). This form of P is readily used by plants and algae to fuel growth and is likely sourced from fertilisers and animal waste as well as natural sources. The remaining P was present as either particulate P or dissolved organic P (DOP) or both. Particulate P generally needs to be broken down before becoming bioavailable to algae. The bioavailability of DOP varies and is poorly understood.

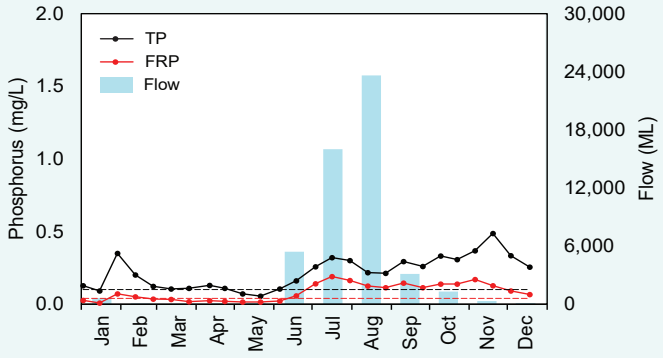
Concentrations

Total P and FRP both showed a seasonal pattern at the Upper Serpentine River sampling site. With the exception of the peak in late January, TP and FRP concentrations were relatively low in the beginning of the year. The peak in January followed a peak in flow which occurred 12 days before. It is likely this flow washed P into the river from surrounding land use as well as mobilising P in the river. When rainfall and flow increased in June so did TP and FRP concentrations, suggesting P was being washed into the drain via surface flows at this time as well as coming from in-stream sources. Both FRP and TP remained relatively high for some time after the original peak in July, with TP slowly increasing before peaking again in November. Why TP and FRP did not fall along with streamflow is unclear.

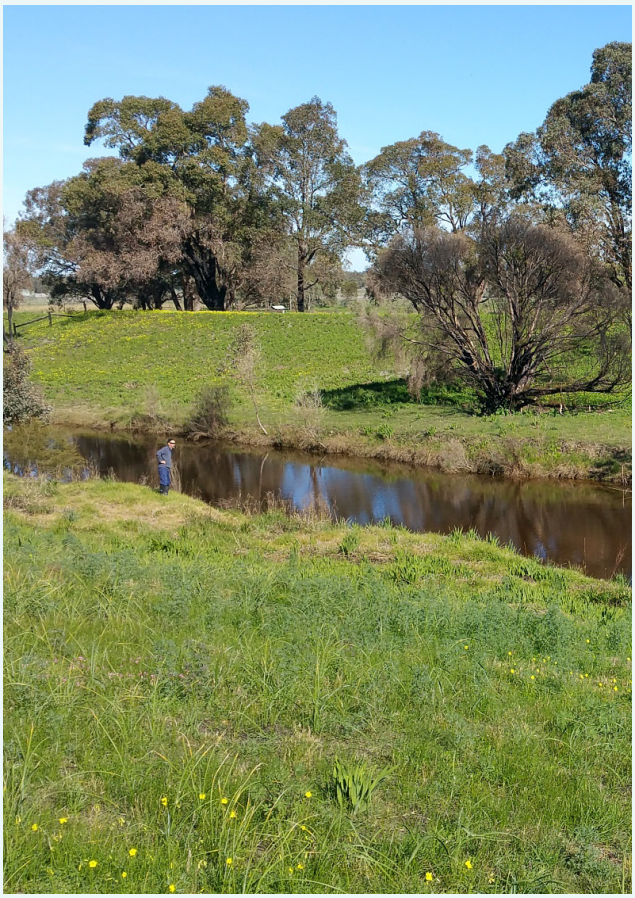
Upper Serpentine River



2018 average phosphorus fractions at site 614030.



2018 phosphorus concentrations and monthly flow at 614030. The dashed black line is the Peel-Harvey WQIP target, the red line is the ANZECC trigger value for lowland rivers.



In some places, the Upper Serpentine River has been converted into a drain, July 2015.

Upper Serpentine River

Dissolved organic carbon over time (2004–18)

Concentrations

Dissolved organic carbon (DOC) concentrations fluctuated at the Upper Serpentine River sampling site. Using the Statewide River Water Quality Assessment (SWRWQA) bands, all annual medians were classified as high with the exception of 2009–10, which were just classified as moderate.

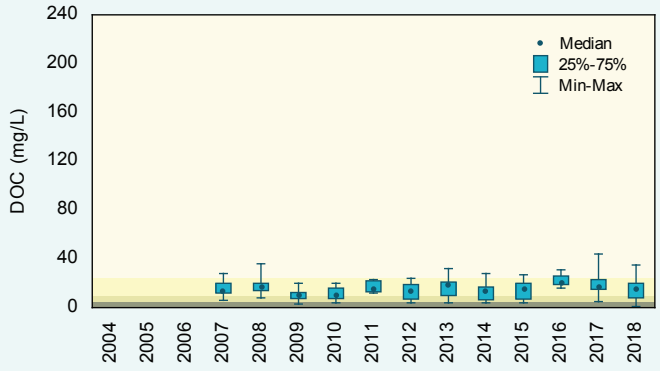
Trends

There were no trends in DOC concentrations at the Upper Serpentine River sampling site over either the short- (2014–18) or long-term (2007–18).

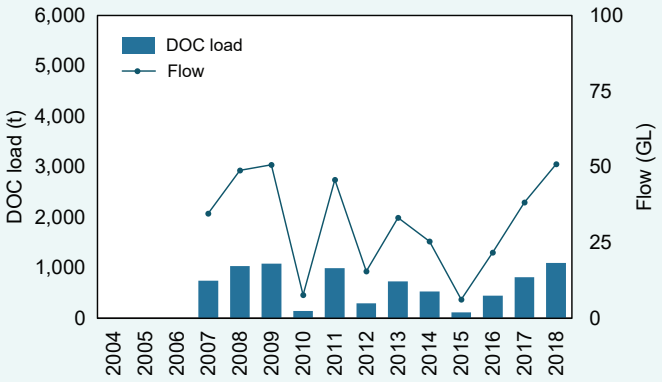
Estimated loads

Estimated DOC loads at the Upper Serpentine River sampling site were large compared with the other sites in the Peel-Harvey catchment. In 2018, the estimated DOC load was 1,094 t, the third largest of the 10 sites in the Peel-Harvey catchment where it was possible to calculate loads. The load per unit area of 3,285 kg/km^2 was moderate compared with the other Peel-Harvey catchment sites. DOC loads were closely related to flow volume, years with high annual flow having large DOC loads and vice versa.

Upper Serpentine River



Dissolved organic carbon, 2004–18 at site 614030. The shading refers to the SWRWQA classification bands.



Dissolved organic carbon loads and annual flow, 2004–18 at site 614030.

very high high moderate low

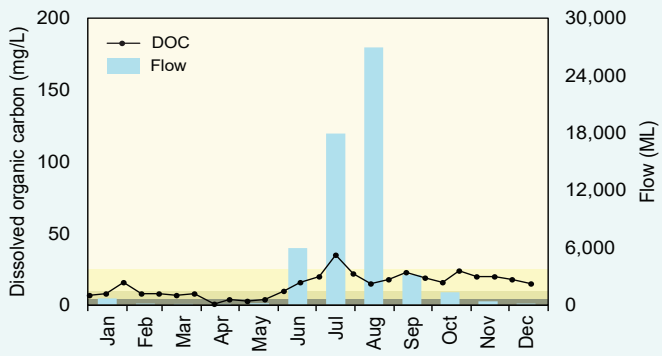
A weir on the Serpentine River, upstream of the Serpentine Dam. The river here is in a much more natural state than further down on the Swan Coastal Plain, August 2017.

Dissolved organic carbon (2018)

Concentrations

Dissolved organic carbon concentrations showed a seasonal pattern at the Upper Serpentine River sampling site. Concentrations increased in May to June as rainfall and flow increased before peaking in July. After the peak, concentrations fell again. There was also a peak in January which followed a peak in flow that occurred 12 days before. It is likely this flow washed DOC into the river from surrounding land use as well as mobilising DOC present in the river. DOC is sourced mainly from degrading plant and animal matter, including natural organic matter in soils and wetlands, with many wetlands on deep sands typically generating high DOC concentrations. It varies widely in its bioavailability. At the Upper Serpentine River sampling site, DOC was coming from surface flow and groundwater as well as in-stream sources.

Upper Serpentine River



2018 dissolved organic carbon concentrations and monthly flow at 614030. The shading refers to the SWRWQA classification bands.

very high high moderate low

Taking flow measurements during high flow at the Upper Serpentine River sampling site, June 2014.

Upper Serpentine River

Total suspended solids over time (2004–18)

Concentrations

Total suspended solids (TSS) concentrations fluctuated over the reporting period at the Upper Serpentine River sampling site, though they were generally low compared with the other sites sampled in the Peel-Harvey catchment. Using the SWRWQA classification bands, all annual medians were classified as low with the exception of 2016 and 2017 which were moderate. Most years had some samples which fell into the moderate and high bands, though the annual range in concentrations was generally quite small.

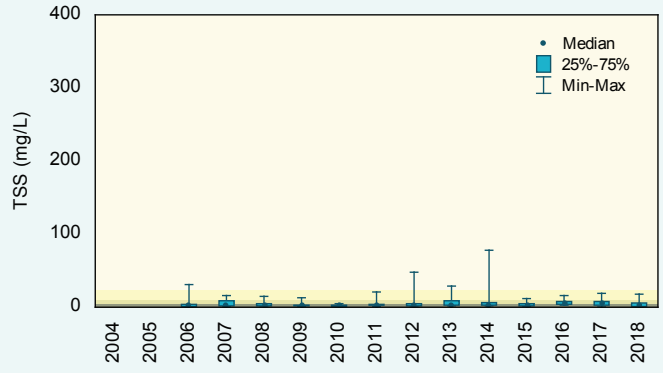
Trends

There was no trend in TSS concentrations at the Upper Serpentine River sampling site over either the short- (2014–18) or long-term (2006–18).

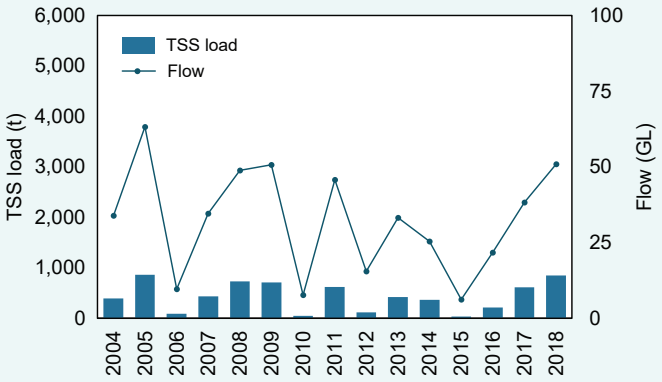
Estimated loads

Estimated TSS loads at the Upper Serpentine River sampling site were moderate compared with the other 10 sites in the Peel-Harvey catchment where it was possible to calculate loads. In 2018, the estimated TSS load at this site was 845 t, similar to the load at the Mayfield Drain sampling site of 812 t. The load per unit area of 2,538 kg/km^2 was moderate to large compared with the other Peel-Harvey catchment sites. TSS loads were closely related to flow volume, years with high annual flow having large TSS loads and vice versa.

Upper Serpentine River



Total suspended solids concentrations, 2004–18 at site 614030. The shading refers to the SWRWQA classification bands.



Total suspended solids loads and annual flow, 2004–18 at site 614030.

very high high moderate low

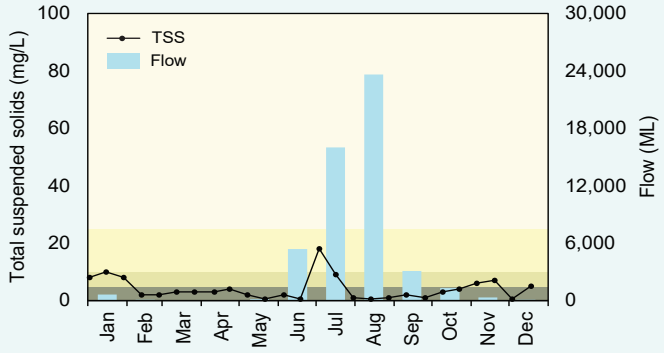
Trees growing next to the Upper Serpentine River at the sampling site flooded during high flows, July 2018.

Total suspended solids (2018)

Concentrations

Most of the TSS samples collected in 2018 at the Upper Serpentine River sampling site fell into the low band of the SWRWQA. There was a peak in TSS in July which was likely caused by the increase in rainfall and flow at this time, which flushed particulate matter into the river as well as mobilising any that was present in the river. The reason for the peak in January and November is unclear. There was a peak in flow in January; however, the peak in TSS concentrations occurred before the increase in flow.

Upper Serpentine River



2018 total suspended solids concentrations and monthly flow at 614030. The shading refers to the SWRWQA classification bands.

very high | high | moderate | low

The weir at the Upper Serpentine River sampling site during high flows, June 2014. High flows generally transport more particulate matter than low flows.

Upper Serpentine River

pH over time (2004–18)

Levels

pH at the Upper Serpentine River sampling site fluctuated over the reporting period. However, all annual medians were between the upper and lower ANZECC trigger values.

Trends

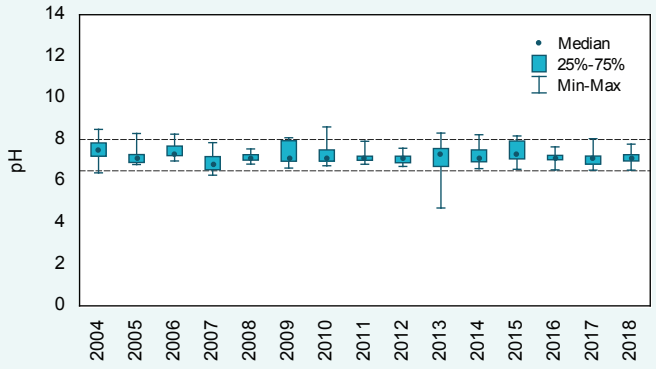
There was no trend in pH at the Upper Serpentine River sampling site over either the short- (2014–18) or long-term (2004–18).

pH (2018)

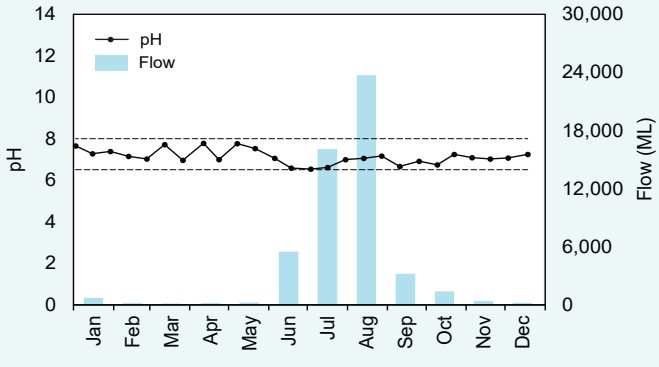
Levels

In 2018, pH at the Upper Serpentine River sampling site showed a very slight inverse relationship to flow. pH levels fluctuated for the first part of the year but then decreased slightly in June, when rainfall and flow increased before slowly increasing again.

Upper Serpentine River



pH levels, 2004–18 at site 614030. The dashed lines are the upper and lower ANZECC trigger values for lowland rivers.



2018 pH levels and monthly flow at 614030. The dashed lines are the upper and lower ANZECC trigger values for lowland rivers.

The Serpentine River flowing under Karnup Road Bridge during high flows, August 2005.

Upper Serpentine River

Salinity over time (2004–18)

Concentrations

Salinity at the Upper Serpentine River sampling site fluctuated over the reporting period. While all annual medians were classified as fresh using the SWRWQA bands, most years had a number of samples that fell into the marginal band.

Trends

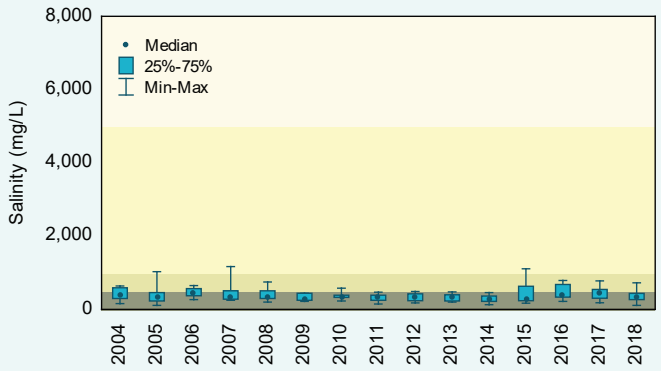
There was a short-term (2014–18) increasing trend in salinity of 15 mg/L/yr. This may be because of natural fluctuations at this site or an actual increase in salinity. Ongoing monitoring will help determine if this site is getting more salty. There was no long-term (2004–18) trend present.

Salinity (2018)

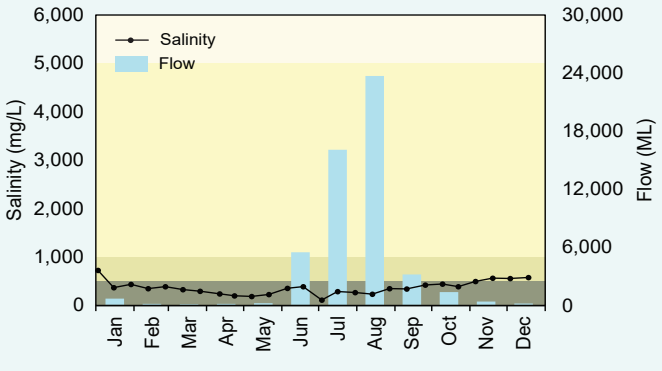
Concentrations

In 2018, most of the salinity readings at the Upper Serpentine River sampling site were classified as fresh using the SWRWQA bands, with the exception of one collected in January and those collected from mid-November which fell into the marginal band. It is likely that salt is entering the river via both surface flow and groundwater at this site.

Upper Serpentine River



Salinity concentrations, 2004–18 at site 614030 The shading refers to the SWRWQA classification bands.



2018 salinity concentrations and monthly flow at 614030. The shading refers to the SWRWQA classification bands.

saline brackish marginal fresh

Native forest alongside the Serpentine River, upstream of Serpentine Dam, November 2015.

Upper Serpentine River

Background

The Regional Estuaries Initiative is a State Government program to improve the health of waterways and estuaries in the south-west of Western Australia. Healthy Estuaries WA is a Royalties for Regions program launched in 2020 and will build on the work of the Regional Estuaries Initiative. Collecting and reporting water quality data, such as in this report, helps build understanding of the whole system. By understanding the whole system, we can direct investment towards the most effective actions in the catchments to protect and restore the health of our waterways.

You can find the latest data on the condition of Peel-Harvey estuary at estuaries.dwer.wa.gov.au/estuary/peel-harvey-estuary/

The Regional Estuaries Initiative partners with the Peel-Harvey Catchment Council to fund best-practice fertilisers, dairy effluent and watercourse management on farms.

- To find out how you can be involved visit estuaries.dwer.wa.gov.au/participate
- To find out more about the Peel-Harvey Catchment Council go to peel-harvey.org.au
- To find out more about the health of the rivers in the Peel-Harvey Catchment go to rivers.dwer.wa.gov.au/assessments/results

Methods

Total phosphorus concentrations were compared with the Peel-Harvey WQIP target. This target represents the median winter concentration that is required for each of the subcatchments to meet their load reduction target. Where possible, other parameters were compared with the ANZECC trigger values for lowland rivers in south-west Australia. These values provide a value above which there may be a risk of adverse effect. For pH there is both an upper and lower trigger value which represent the acceptable pH range. Where there were no ANZECC trigger values available (for DOC, TSS and salinity) the SWRWQA classification bands were used to allow samples and sites to be classified and compared.

Trend testing was carried out using either the Mann or Seasonal Kendall tests as appropriate. Where there were flow data available and there was a flow-concentration relationship, the data were flow-adjusted before trend analysis.

Annual loads were calculated by multiplying daily flow with daily nutrient concentrations and aggregating over the year. Measured daily concentrations were not available as samples were collected fortnightly at best, so daily concentration data were calculated using the locally estimated scatterplot smoothing algorithm (LOESS).

Glossary

Bioavailable: bioavailable nutrients refers to those nutrients which plants and algae can take up from the water and use straight away for growth.

Concentration: the amount of a substance present in the water.

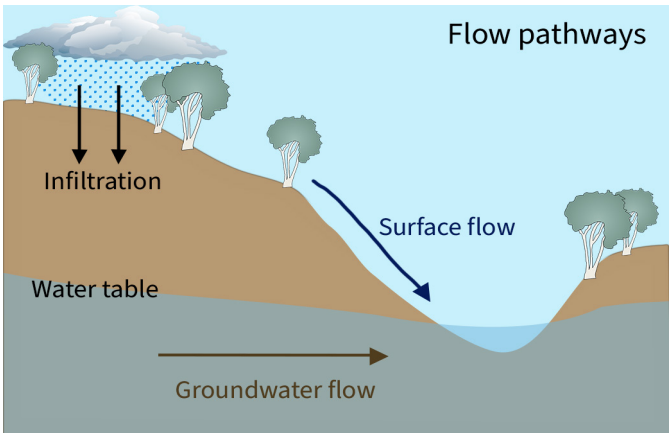
Evapoconcentration: the increase in concentration of a substance dissolved in water because of water being lost by evaporation.

Laboratory limit of reporting: this is the lowest concentration (or amount) of an analyte that can be reported by a laboratory.

Load: the total mass of a substance passing a certain point.

Load per unit area: the load at the sampling site divided by the entire catchment area upstream of the sampling site.

The schematic below shows the main flow pathways which may contribute nutrients, particulates and salts to the waterways. Connection between surface water and groundwater depends on the location in the catchment, geology and the time of year.



Upper Serpentine River Issue 1
Publication date: May 2021
ISSN: 2209–6779 (online only)