Sources of nutrients to the Swan and Canning rivers

The role of nutrients in our waterways

High concentrations of nutrients, especially nitrogen and phosphorus, usually determine the maximum biological productivity of an aquatic system. Excess levels of nutrients can stimulate the growth of plants to the extent that they begin to dominate an aquatic system, often to the exclusion of other species. Such systems experience a loss of biodiversity and typically contain high populations of only a few plant species. Once simplified ecosystems occur, the natural cycling of nutrients in the system is interrupted and problems become persistent and recurring. The increasing occurrence of phytoplankton bloom activity in the Swan and Canning rivers is indicative of advancing eutrophication and is affecting the recreational use of the rivers.

Nutrients come from both natural processes and human activities

Nutrients present in a catchment are either stored in soils or vegetation and are transported to waterways via flowing water. Natural sources of nutrients are weathering of rock, fixation of atmospheric nitrogen by some plants, decomposition of biological material and leaching of soils. Human impact through sewage outfalls, land clearing, fertiliser application, industrial effluent, urban runoff and inappropriate disposal of domestic detergents and soaps can add to the store of nutrients in catchments or increase nutrient export from the catchment to waterways. Nutrients from these sources can either be delivered directly to waterways via point sources or indirectly (and more slowly) via diffuse sources.

Point sources of nutrients derived from residential and commercial land use (sewage, fertilisers and detergents) and industries (chemical effluent) on the Swan Coastal Plain are well known. Other potential sites for point source pollution include land-fill sites, industrial contaminated sites and agricultural properties with intensive livestock practices (e.g. piggeries, poultry farms, dairies, stock holding yards). The composition of nutrients from point sources depends on the type of chemical discharged and any treatment processes occurring prior to discharge. The discharge rate of nutrients from a point source to a waterway can vary from regular periods (e.g. controlled discharge) to inconsistent, event-based occurrences (e.g. chemical spills, overflows). Point sources are generally characterised by reduced travel times of pollutants through the catchment.

In contrast, diffuse sources are derived from large areas in the catchment. Diffuse sources are believed to provide a majority of nutrients delivered to the waterways on the Swan Coastal Plain. Diffuse sources of nutrients mainly originate from rural practices including fertilised arable lands, pasture, orchards and intensive horticulture practices, although diffuse sources from open sewerage systems and fertilisers applied to urban gardens and parks are also appreciable. The transport of diffuse sources of nutrients to waterways is slow and can occur via a variety of hydrologic pathways, such as surface runoff, subsurface flow and groundwater. However, both nitrogen and phosphorus are mobilised and transported through the catchment by different mechanisms.

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Cows on farm property with innundated area, September 2000.

Nutrients from cow faecal material are rapidly mobilised and transported under these conditions.

Nitrogen and phosphorus to the waterways

Nitrogen exists in several forms, most of which are soluble and rapidly transported through the catchment. Travel and residence times of nitrogen in the catchment will largely depend on flow rates of surface, subsurface and groundwater flows. Oxidised forms of nitrogen (nitrates and nitrites) are common in arable soils and flowing waters, while reduced forms of nitrogen (ammonia and ammonium) are common in surface runoff and stagnant waters. Organic nitrogen, associated with biological material, is not soluble and is less mobile. Mobilisation of soluble forms of nitrogen also depends on rates of mineralisation/assimilation processes and the rate of denitrification (N_2 gas emission). Microbial denitrification can also be an important removal process in saturated sandy soils and some studies have shown that as little as 20% of nitrogen added to a sandy catchment may reach the estuary.

Total Nitrogen and Total Phosphorus	
Total Nitrogen (TN) =	Dissolved Inorganic N (NO_3^-, NO_2^-, NH_3, NH_4^+) + Organic N
Total Phosphorus (TP) =	Dissolved Inorganic P (PO_4^{3-}) + Particulate P

Phosphorus, mostly as inorganic phosphate, is not as mobile and tends to strongly adsorb to most soils (particularly with iron and aluminium oxides) and in water tends to adsorb to particulate material. Particulate forms of phosphorus, including organic material or inorganic minerals (e.g. apatite) are less mobile. The nett accumulation of phosphorus in the soil results in a plume of phosphorus slowly moving through the catchment. Travel and residence times of phosphorus therefore depend on the recharge rate to groundwater, rate of adsorption to soil particles and the extent of soil saturation. Mobilisation of phosphorus depends on both the physio-chemical processes occurring at the soil-water interface, erosion processes occurring at exposed soil surfaces and sediment resuspension in waterways.

Travel time for the dissolved form, phosphate, can be quite slow in soils with high iron that can bind the phosphorus to the soil particles. For example in the Avon catchment (Darling Plateau) the travel time of dissolved phosphate is estimated to be hundreds of years per metre of soil. Depending on landuse, travel times per metre of soil in the laterites of the Darling Scarp may range from centuries to millennia. Many soils on the Swan Coastal Plain are sands which have very low phosphorus retention capacity and transport rates ranging from one to fifty years per metre.

In contrast the loss of particulate phosphorus, often attached to soil particles, from the Darling Plateau and Scarp is very fast, transported with surface runoff during storm events. Stream bank collapse and sediment loss from degrading streams add to the load of phosphorus and nitrogen entering the rivers.

Monitoring data are used to determine nutrient status

There are currently 15 sampling sites situated on major rivers and drains of the Swan-Canning catchment which are being monitored. Nutrient samples are taken at each sampling site only while the waterway is flowing.

We describe the current condition or status of the monitored waterways using a classification system. A nutrient class is assigned to each sampling site using a median nutrient concentration over the most recent three-year period (i.e. 1997-99). The three-year period is used to diminish the influence of wet and dry years on the nutrient classification. The classes range from ‘low’ nutrient concentrations (representing close to natural conditions) through to ‘extreme’ nutrient concentrations (Table 1). The ‘low’ nutrient concentration corresponds to median concentrations that comply with nutrient guideline concentrations – 1.0 mg/L for Total Nitrogen (TN) and 0.1 mg/L for Total Phosphorus (TP). These guideline nutrient concentrations have been adapted from ANZECC guidelines (1992) to suit freshwater riverine systems of south-west WA.

Most waterways classify as low to moderate

The nutrient status of waterways in the Swan-Canning catchments is shown in Table 2. Many waterways that drain the Darling Scarp and Plateau, including the Avon River, Susannah Brook, Jane

Table 1. *The various classifications used to assess the status of nitrogen and phosphorus concentrations in a waterway.*

TN		TP	STATUS
> 4.0 mg/L	extreme	> 0.5 mg/L	extremely enriched
3.0 - 4.0 mg/L	very high	0.3 - 0.5 mg/L	highly enriched
2.0 - 3.0 mg/L	high	0.2 - 0.3 mg/L	enriched
1.0 - 2.0 mg/L	moderate	0.1 - 0.2 mg/L	mildly enriched
< 1.0 mg/L	low	< 0.1 mg/L	close to natural

Table 2. *Monitored catchments of the Swan and Canning basins, with area (upstream of the monitored site), average annual discharge (as a percentage of total basin contribution) and common land uses for all monitored catchment sites. The current TN and TP status for the 1997-99 monitoring period is also given for each monitored site.*

BASIN	**Subcatchment** (upstream of monitored site)	**Area** (km^2)	**Average annual discharge** ($10^6\ m^3$)	**Land Use**	**Current TN Status (1997-99)**	**Current TP Status (1997-99)**
SWAN	Avon River	119 035	362 (81%)	• Rural – broad acre grazing, animal agistment, cereal crops. • Urban – townships are common.	Low	Low
	Ellen Brook	664	37 (8.3%)	• Rural – broad acre grazing, animal agistment, horticulture and viticulture. • Urban – several small townships.	Moderate	Very High
	Bayswater Main Drain	262	12 (2.7%)	• Urban – high density residential. • Commercial. • Light to medium industry.	Moderate	Low
	Helena River	161	10 (2.3%)	• Urban – medium density residential. • Rural – broad acre grazing, viticulture and horticulture. • Light industry.	Moderate	Low
	Bennett Brook	99	10 (2.3%)	• Urban – low density residential. • Rural – livestock agistment, viticulture and horticulture.	Low	Low
	Claisebrook Main Drain	16	5.4 (1.2%)	• Urban – high density residential. • Commerce – central business district. • Light industry.	no data available	no data available
	Blackadder Creek	13	3 (< 1%)	• Urban – medium density residential. • Light industry. • Commercial areas.	Moderate	Low
	South Belmont Main Drain	10	3 (< 1%)	• Urban – high density residential. • Industry – light to medium industry.	Low	Moderate
	Jane Brook	135	2.3 (< 1%)	• Remnant vegetation – large tracts of native forest. • Semi-rural – broad acre grazing, viticulture, horticulture. • Urban – isolated pockets of residential developments.	Low	Low
	Susannah Brook	19	0.4 (< 1%)	• Rural – broad acre agriculture, viticulture, grazing. • Remnant vegetation – forested areas upstream. • Urban – some pockets of low density residential.	Low	Low
CANNING	Southern River	149	21 (30%)	• Semi-rural – broad acre agriculture, horticulture, intensive livestock agistments. • Urban – rapidly developing residential areas.	Moderate	Moderate
	Canning River	163	17 (24%)	• Urban – medium density residential. • Remnant vegetation – forested areas upstream. • Semi-rural – animal agistment, horticulture, turf farms.	Low	Low
	Yule Brook	53	13 (19%)	• Rural – horticulture, intensive animal agistment. • Urban – rapidly developing residential areas. • Industry – areas of light to medium industry. • Remnant vegetation – parklands.	Low	Low
	Bannister Creek	23	9.2 (13%)	• Urban – medium density residential. • Commercial areas. • Industry – light to heavy.	Moderate	Moderate
	Bickley Brook	72	5.0 (7%)	• Urban – medium density residential. • Commerce/industry areas. • Semi-rural – broad acre agriculture, horticulture. • Remnant vegetation – forested areas upstream.	Moderate	Low
	Mills Street Main Drain	12	4.9 (7%)	• Urban – medium density residential. • Commercial district. • Light industry.	High	High

Brook, Helena River and Canning River had low levels of nutrients. This is likely to be attributed to a number of factors. Firstly, the high proportion of clays and lateritic soils in the upper catchments readily bind phosphorus and inhibit its transport through the catchment. Secondly, many of these waterways drain large areas of remnant vegetation (such as jarrah forest) and conservation areas protected for water supply dams. Nutrient uptake in these areas is efficient and limits nutrient export to the waterways. Thirdly, most nutrients exported from the Darling Scarp and Plateau occur during storm events which are sampled infrequently with the fixed interval sampling regime used in the Swan-Canning catchment. This means that the nutrient status may be somewhat biased towards low concentrations for those waterways where the headwaters start on the Darling Plateau.

Vineyard on Jane Brook. Changes in land use may affect streams currently classified as low.

Ellen Brook and Southern River supply the second and third largest volumes of water to the Swan-Canning estuarine system respectively. Both had moderate to very high nutrient levels indicating some degree of nutrient enrichment (Table 2). These riverine systems are situated on the Swan Coastal Plain and drain a predominantly semi-rural district adjacent to the Darling Scarp. The catchments consist of nutrient deficient sands and duplex soils which have little or no surface nutrient retention capacity. A strong groundwater gradient in Ellen Brook and Southern River catchments is generated from the Gnangara and Jandakot Mounds respectively. These gradients assist the rapid hydrologic transport of nutrients through the catchment. Low-lying areas that are prone to inundation also promote the rapid transport of nutrients via overland and subsurface flows.

The main sources of nutrients to these two waterways are from livestock faecal waste and fertiliser applied to pasture, however a large proportion of nitrogen is believed to originate from naturally occurring organic deposits. The export of nutrients from these catchments is likely to have also been exacerbated by the degradation of riparian zones and extensive land clearing. Both Ellen Brook and the Southern River are important sources of nutrients to the Swan and Canning rivers and are believed to strongly influence estuarine ecology for both systems.

Most of the waterways in the metropolitan area of Perth are drains or modified natural watercourses. These drains tend to have low to moderate nutrient concentrations (Table 2). Mills Street Main Drain was the exception, having high levels of nutrients, possibly associated with point source influences. Recent surveys have shown that many Perth companies continue to discharge wastewater inappropriately, either directly to drains or indirectly via soil soaks.

Diffuse sources, however, provide the major source of nutrients to surface drainage in the Perth metropolitan area and are derived mainly from the excessive application of fertilisers to urban gardens, parks and market gardens. Extensive clearing of remnant vegetation and the use of imported water for irrigation has elevated groundwater levels. Combined with predominantly leachable sandy soils this has produced conditions that are conducive for the rapid mobilisation and transportation of nutrients to surface drainage.

Clearly, catchments which are classified as moderate to very high require concerted management actions to reduce nutrient export, but those classified as low require attention to land use changes that may cause an increase in nutrient losses.

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