Overview of the Peel Inlet and Harvey Estuary – genesis to water quality

Mark Rivers

Department of Agriculture, Western Australia. 120 South West Highway, Waroona, Western Australia, 6215
(Email: *mrivers@agric.wa.gov.au*)

Abstract
The Peel-Harvey Catchment has a regionally central location, high annual rainfall, reliable sources of irrigation water during summer, and some of the most productive soils in the south west of WA. Since European settlement the area has been extensively cleared for agriculture and an intensive network of channels has been constructed for drainage control. Much of the biodiversity in the area was lost during this period and today only small remnants remain, managed by community groups, landholders and government agencies.

The major environmental/farming risks threatening the agricultural industry in the Peel-Harvey Catchment are waterlogging, eutrophication, soil acidification and irrigation salinity. One or more of these threats affects most landholders in the Peel-Harvey Catchment. Each threat requires specific management, however whole farm planning is a management tool that has been used successfully for the management of all of these issues.

Keywords
Peel-Harvey Catchment; eutrophication; landcare

LOCATION

The Peel-Harvey Catchment lies approximately 70km south of Perth in Western Australia and covers an area of approximately 3072km^2. Approximately 190,000 hectares (ha) of this comprises the coastal portion of the catchment which extends east into forested portions of the Darling Scarp and on the coast extends as far north as Kwinana and south to Harvey (Figure 1).

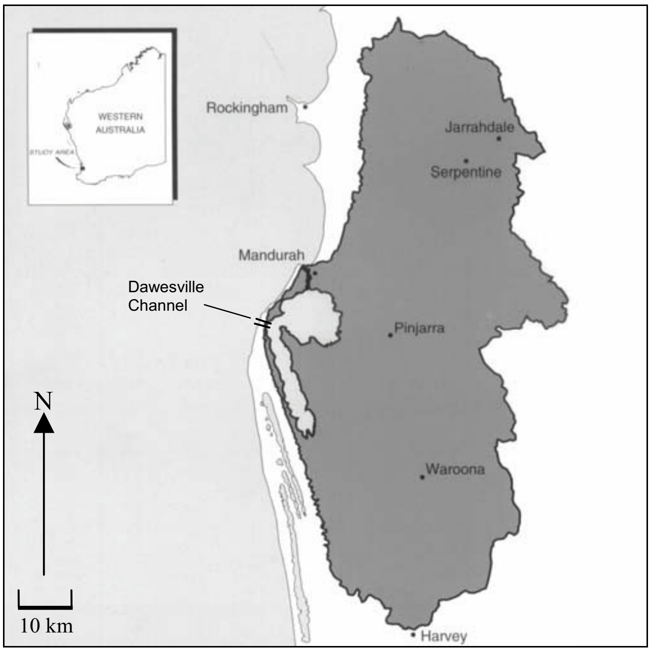

Figure 1: Location of the Peel Harvey Catchment

CLIMATE

The region experiences a Mediterranean climate, characterised by warm dry summers and cool wet winters. During summer (September to March) a belt of anticyclones lies over the region producing dry easterly winds and high temperatures. During winter this belt moves north and the predominant winds blow onshore from the south-west bringing cool temperatures and cold fronts that produce 90% of the region's total annual rainfall. Average annual rainfall varies between 700mm and 1100mm and the average daily temperatures range from 17°C to 30°C in summer and from 6°C to 17°C in winter.

GEOLOGY AND LANDFORMS

(Adapted from Weaving, 1999)

Geology

The Peel-Harvey Catchment can be divided geomorphically and geologically into two distinct regions: the Swan Coastal Plain in the west and the Darling Plateau to the east. These regions are separated by the Darling Fault, expressed at the surface as the Darling Scarp.

The Darling Plateau comprises Archaean granitic rocks and younger dolerite intrusions. Over much of the Darling Plateau, the basement rocks have been weathered to form a surface capping of laterite.

The rocks underlying the Swan Coastal Plain are sedimentary in origin. There are limestones, sandstones, sands, silts and clays. Units exposed at the surface are all younger than two million years old and deposition is still occurring in some places. The oldest exposed geological unit is the Yoganup Formation, followed in age by the Guildford Formation, Bassendean Sand, Muchea Limestone, Tamala Limestone, Tamala Sand and the Safety Bay Sand.

The older sedimentary units underlying the area consist primarily of sandstone, siltstone, claystone and shales with minor coal beds. They contain significant groundwater reserves.

Soil-Landscape Systems of the Peel-Harvey Catchment

The coastal plain portion of the Peel-Harvey Catchment consists of a series of alluvial (water borne) deposits in the east and a series of aeolian (wind borne) deposits or dune systems in the west. The area may be divided into five geomorphic elements or landforms (Figure 2). Their major characteristics are also summarised in Table 1.

Ridge Hill Shelf (Foothills). The Ridge Hill Shelf is a narrow dissected strip of land, from 1 to 3 km in width, forming the foothills of the Darling Scarp. It slopes gently westwards and consists of stream deposited coalescing alluvial fans and remnants of marine terraces. In many areas there is residual laterite at the surface.

Pinjarra Plain. The Pinjarra Plain is an alluvial tract that slopes very gently westwards. The surface of the plain is slightly undulating and consists of coalescing piedmonts and riverine deposits (Wells, 1989). In the west, low-lying areas have fine textured alluvium of mottled duplex soils and yellow-grey clays. At the junction between the Pinjarra and Bassendean systems there is a complex of sand and clay soils. Drainage is poor with frequent swampy areas. The central plain has mottled duplex soils.

The soils of the Pinjarra Plain System are the most productive of the Swan Coastal Plain for grazing. In eastern areas, they have a good ability to hold nutrients. However, low permeability in some areas may lead to waterlogging and accumulation of salt.

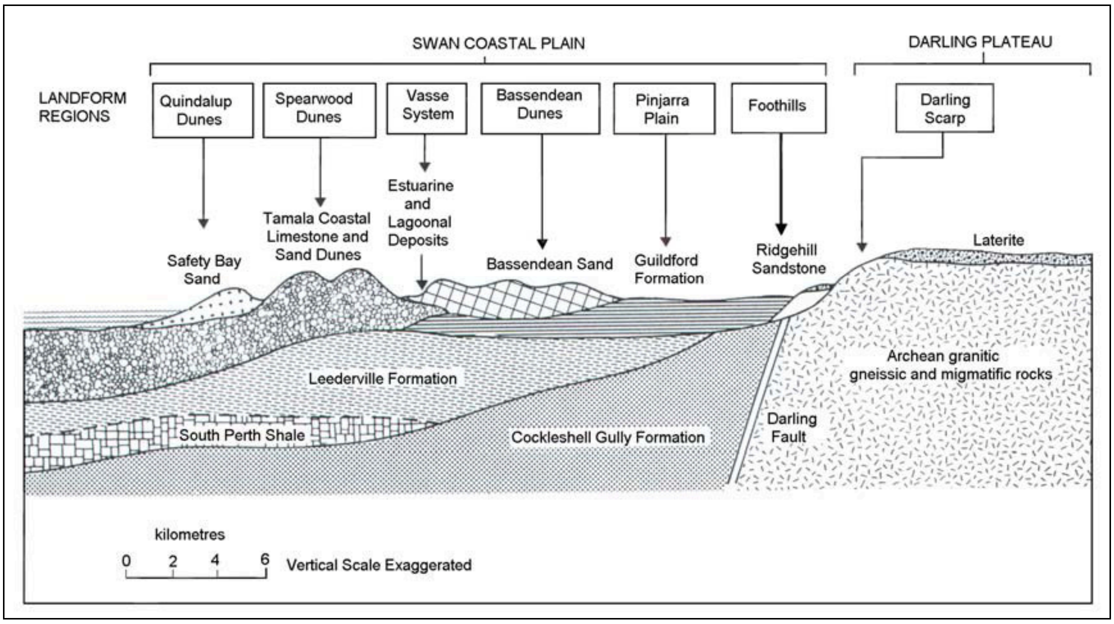

Figure 2: Cross-section of the Swan Coastal Plain showing the relationship of geomorphic elements to the underlying geology (adapted from Wells 1989).

Bassendean Dune System. This system is directly west of the Pinjarra Plain. It consists of low hills of leached siliceous sand interspersed with sand flats and seasonal swamps. It is the oldest of the dune systems on the coastal plain (Wells, 1989). The soils have low fertility and are susceptible to leaching. In the Peel region these soils may become waterlogged because of high groundwater and may become flooded in areas. Many of the Bassendean Dunes System soils also have a poor ability to hold nutrients.

Spearwood Dune System. The Spearwood Dune System is west of the Bassendean Dune System. It consists of yellowish brown siliceous sands overlying limestone at varying depths. These dunes are intermediate in age, between the Bassendean and the Quindalup Dune System. They are more hilly and elevated, often separated from the other Systems by a series of lakes and swamps. The Spearwood Dunes also encompass flat to gently undulating terrain overlying marine limestone which is associated with coastal lakes such as Lake Clifton (Wells, 1989).

The agricultural potential of this system is moderate but relies on large quantities of groundwater and added nutrients. The soils have good phosphorus retention capability and are regarded as being the most productive of the sandy soils of the Swan Coastal Plain.

Quindalup Dune System. The Quindalup Dune System fringes the present coastline and consists of the most recent unconsolidated aeolian deposits on the coastal plain. The major landforms are complex nested parabolic dunes with gentle seaward slopes and steep inland faces. These dunes are fronted by low relief foredune ridges (Wells, 1989). The agricultural potential of the Quindalup Dunes System is regarded as severely limited.

Vasse estuarine and lagoonal deposits. Low-lying poorly-drained terraces, flats and beach ridges fringing the Peel-Harvey estuarine system, the coastal lakes and major river mouths. The soils are variable, being formed on unconsolidated Holocene estuarine alluvium and lagoonal deposits. They are often highly saline and subject to inundation (Wells, 1989).

Table 1: Characteristics of the major soil landscape systems in the Peel-Harvey Catchment

System	**Location**	**Land uses**	**Environmental risks**	**Vegetation communities**	**Soils**
Ridge Hill Shelf	Foothills of the Darling Scarp. 1-3 km wide.	Horticulture, sand mining.	Good nutrient retention but poor drainage leads to Phosphorus export with sediment.	Jarrah-Banksia.	Gravels and deep sands.
Pinjarra Plain	Foothills of the Darling Scarp and along the major water courses.	Very good grazing, irrigation land.	Good nutrient retention but poor drainage leads to Phosphorus export with sediment.	Marri.	Sandy and loamy duplexes.
Bassendean Dunes	Aligned north-south parallel to the Darling Scarp. Located generally immediately west of the Pinjarra Plain soils.	Predominantly grazing.	Waterlogging. Wind erosion. Acidification. Non-wetting. Poor water retention. Poor nutrient retention.	Banksia, but little remnant vegetation.	Deep grey sands "Silver loams". Iron/organic hardpans down the soil profile.
Spearwood Dunes	Aligned north-south between the Bassendean and Quindalup systems.	Very good horticulture, sand mining.	Prone to wind erosion. Good Phosphorus retention. Poor Nitrogen retention.	Tuart.	Deep yellow sands with iron staining.
Quindalup Dunes	Still being formed along the present coastline.	High demand for urban development.	Poor Nitrogen retention. Moderate Phosphorus retention. Prone to wind erosion.	Coastal Heath.	Calcareous sands.
Estuarine and Lagoonal deposits	Immediately adjacent to the Peel-Harvey estuary.	Urban development. Poor agricultural potential. Some reserves.	High potential risks linked to proximity to the estuary.	Estuarine heath communities.	Variable sediments. Highly saline.
Darling Plateau	Western edge of the Darling Plateau.	Mining, reserves, some agricultural development.	Good nutrient retention. May be prone to water erosion.	Jarrah-Marri.	Iron rich and lateritised loams and duplexes.

Darling Plateau. Moderately inclined to steep, incised, high relief slopes forming the western edge of the Daring Plateau. Upper areas are capped with laterite and the remainder have variable soils formed from weathering of Archaen granitic and gneissic rocks. Soils are well drained and rock outcrops are common. The area has limited agricultural potential, except for small areas within lower pans of the valley systems. These areas are suitable for horticulture if sufficient water is available (Wells, 1989).

LAND USE

Although there are a number of significant urban areas within the Peel-Harvey Catchment (Figure 1), land use in the 190,000ha of the coastal potion of the catchment is dominated by agriculture (Figure 3).

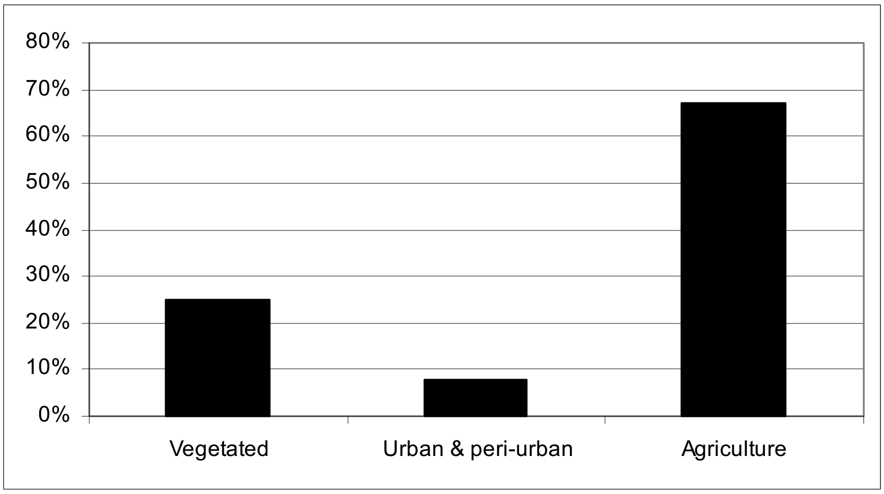

Figure 3: Land use within the coastal portion of the Peel-Harvey Catchment (Lavell *et al*, submitted)

Within this dominant landuse, there are a variety of farming systems (Figure 4), but this is dominated by grazing for beef production. Grazing properties are widely distributed across the catchment, while more intensive and productive industries tend to be located on the more productive soils or strategically close to processing facilities.

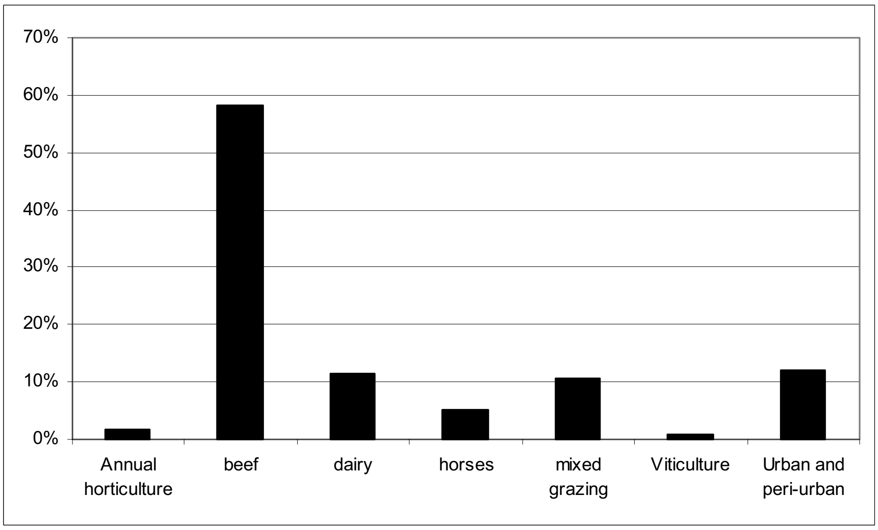

Figure 4: Agricultural landuses within the Peel-Harvey Catchment (Lavell *et al*, submitted)

MAJOR SUSTAINABILITY ISSUES IN THE PEEL-HARVEY CATCHMENT

Loss of Biodiversity

As the Peel-Harvey Catchment has historically been targeted for agricultural development, much of the original native vegetation has been lost and replaced by pasture or crops. The area was once part of a complex network of interconnected streams and wetlands. Since European settlement, the area has been extensively cleared and channels have been constructed for drainage control. Today only remnants of the original wetland vegetation remain, mainly on private property, along road and rail reserves and in river and drainage channels and wetlands adjacent to these.

The loss and fragmentation of habitat through clearing, draining and in-filling of wetlands and the decline in habitat quality through grazing, land degradation and the introduction of domestic and feral animals has resulted in a rapid decline of native wildlife in the Peel-Harvey Catchment. As with vegetation, some of the native animal communities of the Peel-Harvey Catchment are of regional significance and some species are endemic to the South West area.

Waterlogging

Waterlogging is common throughout the Peel-Harvey Catchment in winter and early spring when rainfall is high and evaporation is low. The area's flat topography severely retards drainage resulting in the development of waterlogged conditions in these seasons. Much of the waterlogging experienced in the Peel-Harvey Catchment is natural and pre-dates European settlement. The clearing of native vegetation, which uses considerable amounts of water, has had a major effect on the water balance and has lead to an increase in waterlogging in the Peel-Harvey Catchment. There are several approaches that are being used to tackle waterlogging problems in the Peel-Harvey Catchment. These include: The use of waterlogging tolerant crops and pastures; construction of drainage systems to remove excess water; adoption of lower recharge farming systems; and promotion of whole farm planning techniques.

Eutrophication

Eutrophication is the enrichment of a water body with organic and inorganic plant nutrients (Ryding and Rast, 1989). These nutrients can stimulate biological activity in a water body and can lead to increased algal growth. Eutrophication is a natural process, however when human activities accelerate the process it is viewed as a form of degradation (artificial eutrophication), especially when it results in algal blooms that kill other plants and animals present in a water body (Ryding and Rast, 1989).

In the Peel-Harvey Catchment eutrophication is a consequence of nutrient loss (export) from both the region's farming systems and urban areas. Excess nutrients enter a water body either dissolved in water or attached to sediment particles. Water is the major exporter of nutrients, both overland (through runoff) and through the soil (via groundwater flow). The clearing of native vegetation and construction of drainage networks throughout the Peel-Harvey Catchment has greatly increased the rate at which water flows over and through the landscape.

Coupled with this is a heavy reliance on inorganic, highly water-soluble, fertilisers such as superphosphate, which are often applied at rates greater than immediately required by the crops and pastures (Tille, Mathwin and George, 2001). Excess nutrients, not taken up by plants, are easily leached through the soil or incorporated into runoff.

Together these factors contribute towards the eutrophication of the already nutrient-rich water load that is entering the Peel-Harvey Estuary.

Soil Acidity

Soil acidification is the net accumulation of hydrogen ions in a soil. It is a natural process that is generally accelerated by the use of nitrogenous fertilisers and leguminous crops and pastures. Acidic soils may induce toxicities and nutrient deficiencies that reduce plant root growth and legume nodulation (Hills and Miller. 2000).

The dark grey peaty sands of the swamp lands in the Peel-Harvey Catchment are naturally very low in pH (acidic). However, with the introduction of agriculture many the soils in the Peel-Harvey Catchment are becoming more acidic due to leaching of fertiliser and legume derived nitrogen from the root zone and export of 'alkaline' nutrients in the removal of produce (crops, pasture, meat and wool).

The way in which plants absorb nutrients also results in an overall increase in soil acidity, with the majority of alkaline nutrients present in the soil absorbed by the dry matter within the plant. Under natural conditions the alkaline nutrients absorbed by the plant would return to the soil during decomposition; and there would be no net change in soil pH. As agriculture removes plant material from the soil (as harvest or pasture), less alkalinity is returned, and the soil becomes more acidic. Absorption of alkaline nutrients varies between different crops; the removal of such nutrients per hectare will vary accordingly.

Irrigation Salinity

Predominantly an issue in the Harvey Irrigation Area (HIA) in the southern portion of the Peel-Harvey Catchment, irrigation salinity is the salinisation of land that is artificially irrigated. It involves an accumulation of soluble salts in the root zone, which restricts plant growth. Sodium chloride (NaCl) is the dominant salt involved (Houghton and Charman. 1986). Irrigation salinity in the HIA is believed to have led to increased levels of soil sodicity, which has resulted in soil-structural decline (e.g. pugging) in some areas.

The primary cause of irrigation salinity is the addition of water and salts to the land through irrigation (up to 250 kg ha^{-1} of salt is deposited annually by rainfall alone in some areas of the Peel-Harvey Catchment). Seven dams located in the Darling Range provide irrigation supply water to the HIA. Quality of the water from the northern dams is generally very good, being less than 150 mg L^{-1} of Total Dissolved Salts (TDS). However, salinity levels in the water supplied by the Wellington Dam to the south (which services 40% of the SWIA) has in recent years fluctuated around 1,000 mg L^{-1} TDS. This presents significant irrigation and land management challenges to farmers in this district.

In general, the soils on the western margins of the HIA are most prone to salinisation because they are poorly drained. These soils tend to have heavier textures, are lower lying and have shallower water tables. They remain nearly saturated for much of the year and are therefore subject to almost continual evaporation, which concentrates salt in the topsoil.

ATTEMPTS TO ADDRESS SUSTAINABILITY ISSUES

Particularly over the last two decades, a significant amount of human and financial resources have been directed to addressing the challenges associated with environmental and land management constraints within the Peel-Harvey Catchment. A number of comprehensive government and community reviews have taken place which have developed strategic plans to move towards a more sustainable set of land uses. These reviews have resulted in three essential approaches to dealing with sustainability challenges or their environmental consequences and have focussed predominantly on the most obvious of the issues - eutrophication:

The Dawesville Channel

In 1994, the 2.5km long, 200m wide Dawesville Channel was officially opened. This artificial channel, constructed at a cost of $50 million, breached the narrow coastal dune system opposite Point Grey (Figure 1) allowing increased oceanic flushing of the Peel Inlet and Harvey Estuary. This approach was designed to assist in the export of nutrient-rich runoff from the shallow, poorly mixed estuary system, and alter the salinity regime to make the estuarine environment less palatable to micro-algal species.

Collection and disposal of macroalgae

One of the results of eutrophication of the Peel-Harvey waterways has been significant macro and micro-algal blooms. In a region where much emphasis is placed on the amenity of the foreshore and coastal areas, these blooms have historically had a significant impact on the local and tourist communities. To counteract this, local and state waterways management authorities have allocated significant resources to harvesting and removing algae from waterways and foreshores. Levels of algal blooms in public-access areas have decreased significantly in recent years and harvesting operations have, subsequently, been reduced from the levels a decade ago, but harvesting as a management method still continues in some areas.

Integrated Catchment Management

The two approaches described above obviously treat the "symptoms' rather than the "problems, or causes" of landuse and environmental conflict. The last of the three approaches formally directed to address sustainability issues in the region is the one which attempts to address the problems at their source. Integrated Catchment Management in the Peel-Harvey context has been a matrix of many management actions. The Landcare movement in the region has been successful in raising community awareness of the problems and in recruiting active participants into on-ground action programs such as tree planting, fencing of waterways and fertiliser management education programmes. This programme continues to evolve, and is presently focussed on working with specific industry groups to develop suites of industry-endorsed environmental Best Management Practices.

REFERENCES

Houghton, P. and Charman, P. (1986). Glossary of Terms used in Soil Conservation. Soil Conservation Service of N.S.W.

Hills, A. and Miller, A. (2000). Management of soil acidity in agricultural land. Farmnote No.80. Department of Agriculture, Western Australia, Perth, Western Australia.

Lavell, K., Summers, R.N., , Weaver, D., Clarke, M.F., Grant, J. and Neville, S. (2004). An audit of the uptake of agricultural nutrient management practices in the Peel-Harvey catchment. Paper submitted to *Water Science and Technology*.

Ryding, S.O. and Rast, W. (1989) The control of eutrophication in lakes and reservoirs. UNESCO and The Parthenon Publishing Group, Paris

Tille, P., Mathwin, T. and George, R. (2001). The South-West Hydrological Information Package: Understanding and managing hydrological issues on agricultural land in the south-west of Western Australia. Agriculture Western Australia. Perth, Western Australia.

Weaving, S. (1999). Peel-Harvey Catchment Natural Resource Atlas. Agriculture Western Australia. Perth, Western Australia.

Wells, M. (1989). Land Capability study of the Shires of Mandurah and Murray, Land Resources Series No.2, Department of Agriculture, Western Australia. Perth, Western Australia.