Department of Environment

WN 34 October 2005

Natural Heritage Trust

Water notes

Water notes for river management

Advisory notes for land managers on river and wetland restoration

The Wheatbelt's ancient rivers

Western Australia's Wheatbelt has undergone massive changes in recent history that have affected, and will continue to affect, its waterways and river systems for many years to come.

These changes are not the first in this ancient landscape and this Water note provides background on the development of river systems in the Wheatbelt, from prehistoric times to the present. It is intended that this information will provide the community and land managers with additional knowledge and understanding about this part of Western Australia, and how the geology and climate of prehistoric times has shaped the landscape to what we see today.

An ancient landscape

The South West of Western Australia is an ancient landscape even by geological standards. The oldest rocks still present in the Archaean Yilgarn Craton (one of the South West's major tectonic units) are estimated to have been lain down as sediments 3300 million years ago (mya) and metamorphosed around 3000 mya to form gneiss (see Figure 1 for geological time series and Figure 2 for basement geology showing location of Yilgarn Craton). Other crystalline basement rocks exposed in hills are the widespread greenstones that occur in belts formed between 2900 and 2700 mya and granites formed around 2600 mya. Dolerite, formed during two phases of dolerite dyke intrusions at 2400 mya and 1800 mya, is also present as bedrock in places. Elsewhere these crystalline basement rocks are now mostly covered by a regolith of clay or clayey sand (formed from weathering basement materials) to depths of 40 m to 70 m.

Since formation, erosion and weathering forces have been working on the land surface. This has included glaciation about 280 mya during the Carboniferous–Early Permian. At this time Australia was still part of the Gondwana super continent, which was covered in a continental ice sheet (Figure 3).

The erosive forces of prehistoric times can be estimated today by examining the layers of sediment left behind by ancient rivers. This gives us an indication of ancient climates and topography of the ancient land surface. Based on information gathered it appears that there has been minimal erosion of the Yilgarn Craton, at least since the Jurassic/Cretaceous. The landscape therefore appears to have been moderately stable since the age of the dinosaurs. This stability has strongly influenced the evolution of our flora and fauna and also our rivers and streams.

				Years
Phanerozoic	Cenozoic	Quaternary	Holocene	present
			Pleistocene	10,000 years ago
		Tertiary	Pliocene	2 mya
			Miocene	5 mya
			Oligocene	25 mya
			Eocene	38 mya
			Palaeocene	55 mya
	Mesozoic	Cretaceous		65 mya
		Jurassic		146 mya
		Triassic		208 mya
	Paleozoic	Permian		245 mya
		Carboniferous		290 mya
		Devonian		354 mya
		Silurian		417 mya
		Ordovician		443 mya
		Cambrian		490 mya
Precambrian	Proterozoic			543 mya
	Archaean			2500 mya
	Priscoan			3800 mya
				4600 mya

Figure 1. Geological time series.

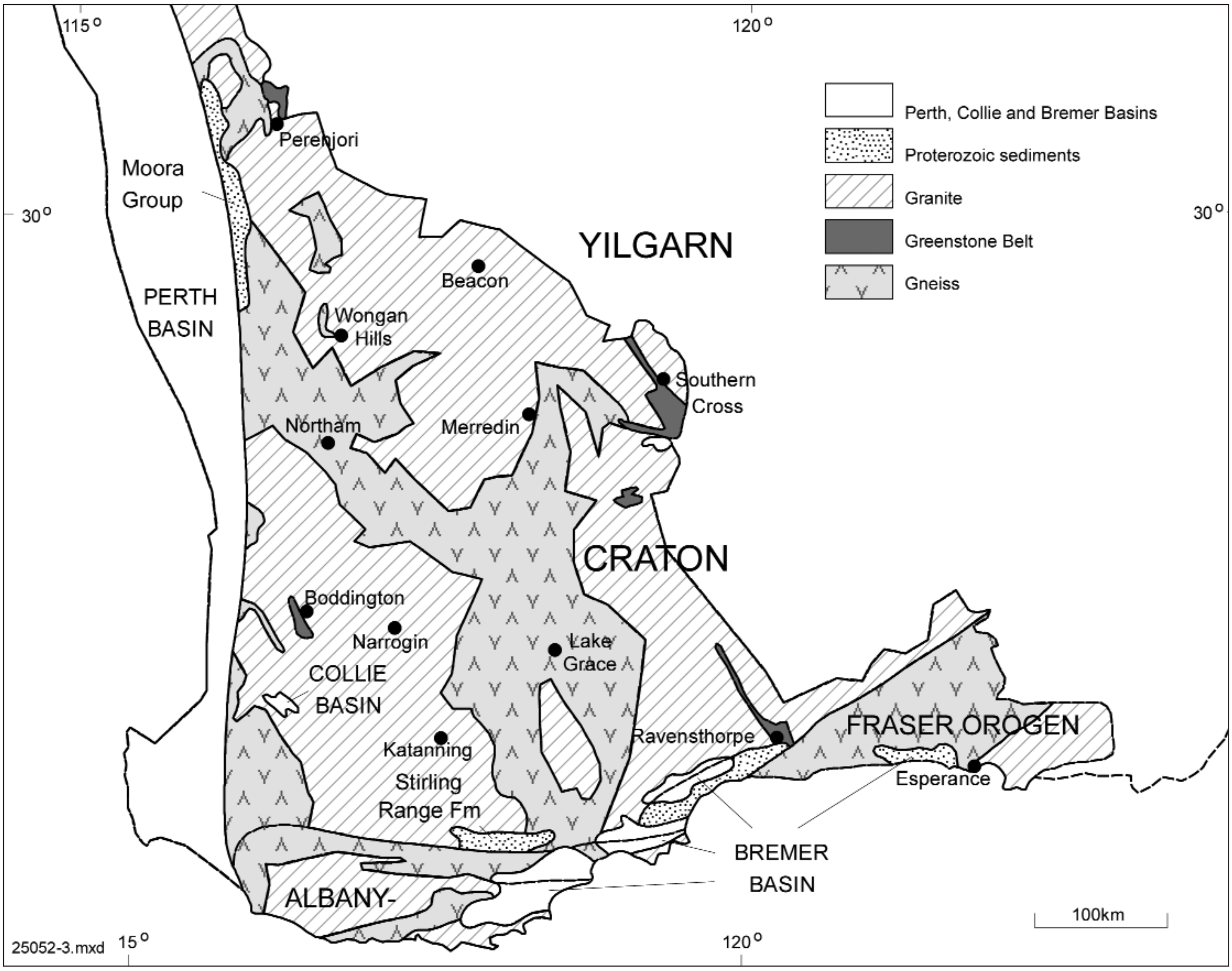

Figure 2. Solid geology of agricultural area (after Myers and Hocking 1998).

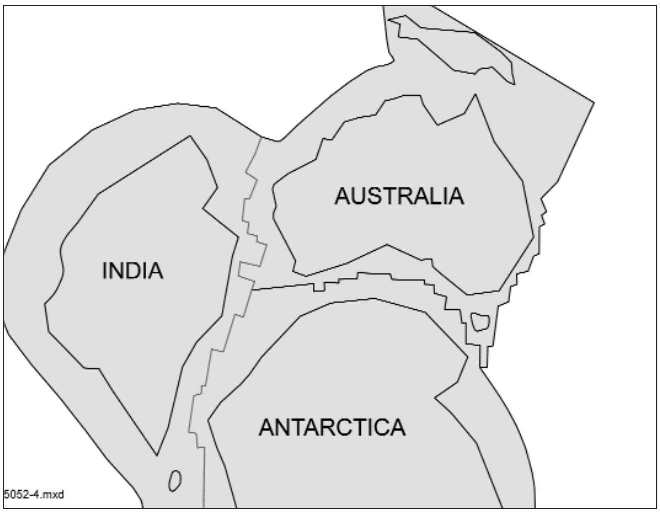

Figure 3. Gondwana super-continent (Geological Survey of Western Australia 1990).

Old river sediments

During the Jurassic (150 to 200 mya) and Cretaceous (65 to 150 mya) periods, the climate of what is now the Australian continent was much wetter than present.

The abundant rainfall of these prehistoric times formed large rivers that shaped valleys still present in the modern landscape. These valleys are known as palaeodrainages (palaeo being the Latin word for old). They were first named by John Beard in the 1970s, in the course of his vegetation mapping.

The formation of palaeodrainages in the South West appears to have taken place over a range of geological periods and eras. For example the Camm, Lockhart and Pingrup palaeochannels may represent southward draining rivers, formed following the opening of a seaway between Australia and Antarctica in the Jurassic (150 mya). As indicated by the age of sediments found in the ancient river beds, others appear to have been formed during the Eocene—about 45 mya (see Figure 4).

Some of the Wheatbelt valleys, especially the west flowing ones, seem to be much younger. At Yenyening, Toolibin, and Yarra Yarra lakes, the spores and pollen in the valley sediments indicate a Pliocene age (5 mya).

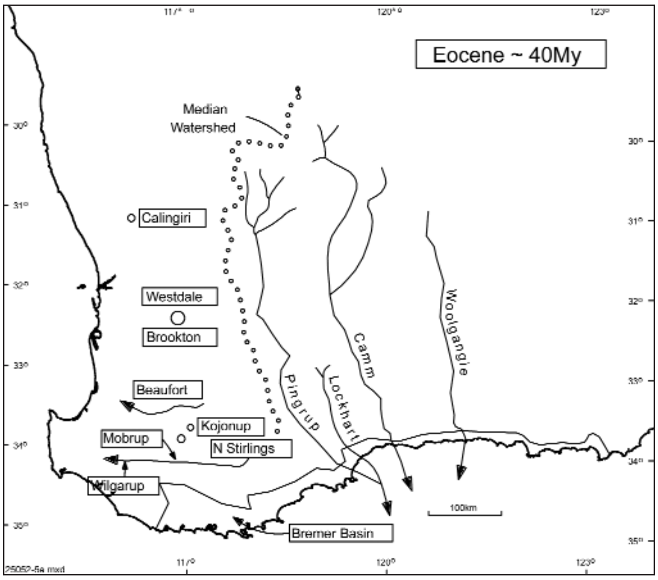

Figure 4. Eocene sediment localities and possible drainage pattern (Commander et. al. 2001; Beard 1999).

Laterite

Following deposition of sediments in the Eocene (45 mya), the landscape seems to have stabilised, with little erosion and sediment movement until the Pliocene (5 mya). During this period, the landscape was cemented in place by an iron-rich duricrust (hardened soil), now exposed only in breakaways and gravel pits. This laterite duricrust appears to reflect humid conditions, allowing deep weathering of the underlying crystalline rocks to take place. This may be associated with iron precipitation by proteaceous plants.

Rifting and tilting

As with modern river systems, the ancient rivers were by no means static. Although we said earlier that the land surface has been relatively stable since the time of dinosaurs, this was in geological-terms, as there hasn't been major volcanic or tectonic activity leading to further metamorphosis of sediments. The South West (and entire continent) has however been subject to tilting and uplifting, which has been sufficient enough to significantly impact on drainage systems, effectively reversing the flow of rivers in some cases.

The rifting (a geological term for the separation of continents), caused by the separation of Australia, first from India and then from Antarctica, caused tilting and uplifting which had a major effect on the drainage systems of the South West. Rivers that once flowed south to Antarctica or west to India were cut off as the Yilgarn Craton rose along the margins of the rift valleys. The slopes of the rivers were decreased or even reversed (in the case of the formerly south flowing Camm, Lockhart and Pingrup rivers), causing increased deposition of sediments and in-filling of river valleys.

Along 'sea' sides of the rift valleys new rivers were formed, cutting back into the rising plateau and in some places, capturing old river channels.

Uplift along the Darling Range during the Late Miocene to Early Pleistocene (11–2 mya) caused further changes to the palaeodrainage systems, rejuvenating drainage (i.e. forming new young drainage systems) as far east as the Meckering Line (Figure 5). Within this zone of rejuvenated drainage, the rivers cut back into the laterite bedrock and Eocene deposits to form the generally youthful and incised river valleys that exist today.

Additional rejuvenation of drainage has occurred along the south coast as a result of continued uplift of the whole continent to the north. The uplift in the north of the continent has had the opposite effect on north flowing rivers, leading to increasingly internal drainage and the development of salt lakes, along with the diversion of some systems south. The capture of the Beaufort River by the Blackwood and the southern diversion of the Yarra Yarra palaeodrainage are examples of this.

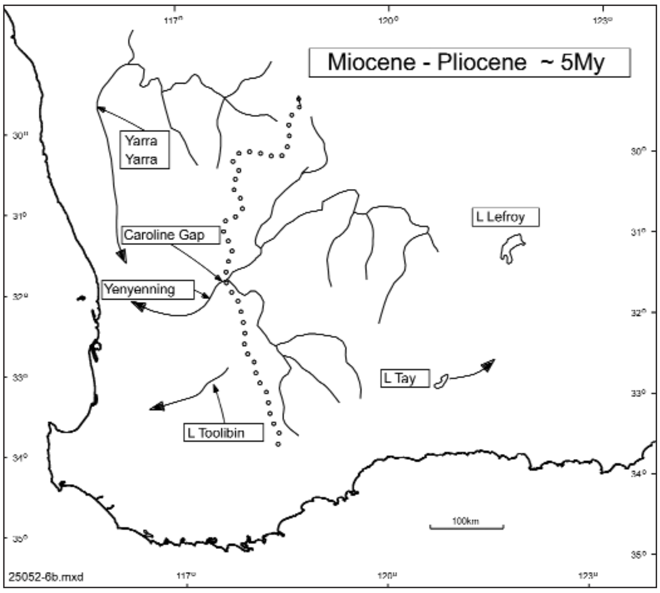

Figure 5. Late Miocene-Pliocene sediment localities and drainage pattern (Commander et al. 2001).

Rivers reversed

As a result of our geological history, many of our large rivers are different to those found elsewhere in the world. Typically rivers start in hills or mountains and then make their way onto flat plains and then out to sea. In the South West of Western Australia our rivers start in flat plains (zones of ancient drainage), have hills in the middle (Darling Scarp and the Zone of Rejuvenated Drainage) and then pass once more onto flat plains (Swan Coastal Plain) and to the sea. Our rivers are therefore often referred to as backwards or reversed rivers.

Modern drainage

Today the areas along the west and south coast with relatively elevated slopes and rainfall are referred to as the Zone of Rejuvenated Drainage (Figure 6).

Figure 6. Drainage pattern in the South West of Western Australia (Commander et al. 2001).

Further inland we pass through a zone of mature drainage to the zone of ancient drainage where palaeodrainages still exist, but due to decreased slope (caused by tilting and uplifting) and low rainfall, they have become choked with millions of years of sediments. The ancient rivers formed during the Jurassic and Eocene now lay hidden below these sediments which can be up to 60 m thick. Surface drainage into disconnected chains of salt lakes occurs, however they only link up and flow into one another during exceptionally wet years.

The size of salt lakes has by no means been static in the relatively recent history of the Quaternary Period (1.5 mya to present). The Quaternary Period has been characterised by cyclic periods of aridity and humidity. Aridity coincided with ice ages, when a greater proportion of the earth's water was stored in polar ice caps. In between ice ages the climate was generally more humid with greater rainfall. The effects of this climate change on our Wheatbelt valleys would have included increases and decreases to the size of salt lakes, and changes in the frequency and magnitude of flushing. Periods of flushing are thought to have been important influences on the amount of salt stored in Wheatbelt soils and groundwater.

The modern landscape

A schematic representation of the geology of a typical Wheatbelt valley, as found in our landscape today is shown in Figure 7. The relatively recent Quaternary sediments, which contain a series of salt lakes, form the modern day broad flat valley floor.

Because of internal drainage into these salt lakes, and only episodic flushing, the trace amounts of salt found in rainfall has slowly accumulated. In other words, over tens of thousands of years, the tiny amounts of salt found in each winter's rain has been left behind in the bed of the salt lakes, as the water evaporates. Today groundwater in the vicinity of salt lakes can be as much as six times as salty as sea water. This groundwater in shallow valley floor aquifers occurs in Tertiary alluvium, from old stream lines in the top 3 m of sediments.

Deep below the salt lakes and shallow valley floor aquifers, saline water has accumulated over hundreds of thousands of

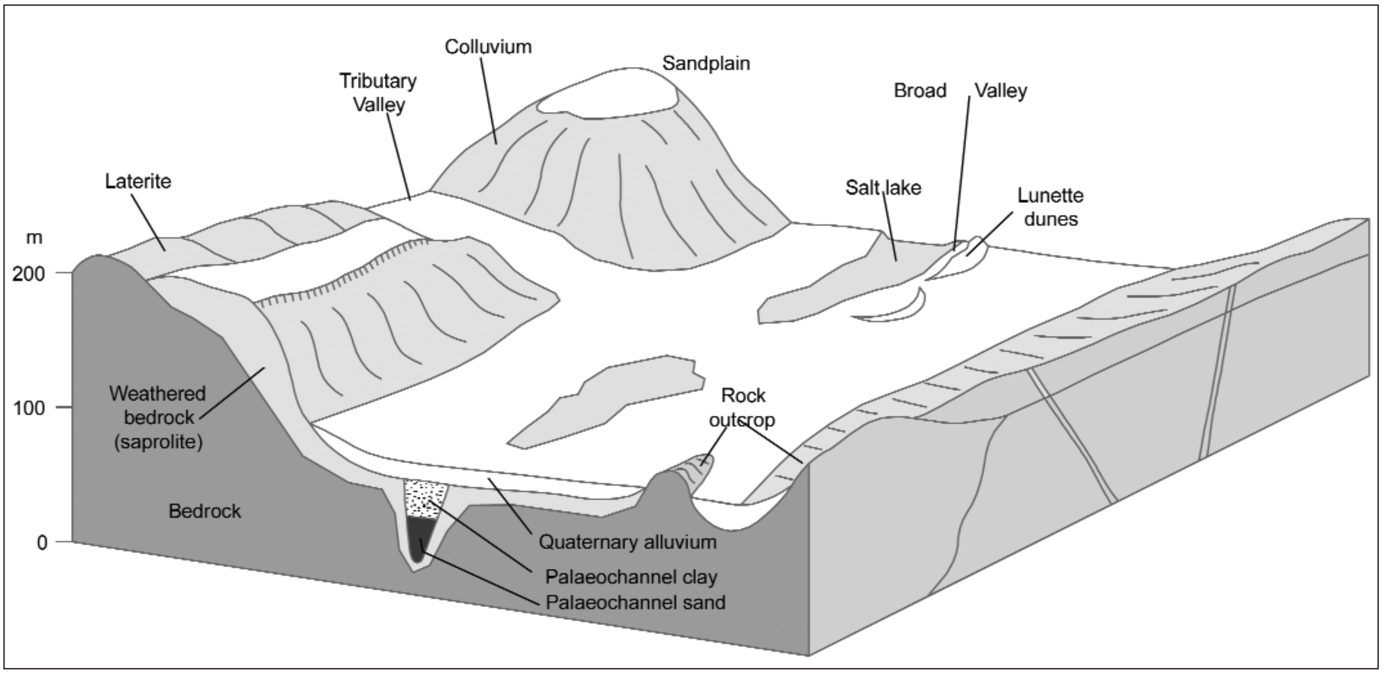

Figure 7. Block diagram showing schematic geology of a Wheatbelt valley (Commander et al. 2001).

years, within the palaeochannels ancient river sands. Palaeochannels are generally less than a kilometre wide, and occupy a small proportion of the broad flat valleys. They are completely concealed and must be found with geophysical methods using the difference in gravitational or electrical properties with the surrounding bedrock.

In the southern Goldfields water from palaeochannel aquifers (hypersaline in the southern Goldfields and eastern Wheatbelt) is used for mineral processing and has the potential to be used elsewhere for saline aquaculture. Modern rivers such as the Blackwood, Avon and Moore drain saline water from the palaeochannels at a low rate, which contributes to their salinity levels. There are also a number of palaeochannels in the western Wheatbelt that—now abandoned by modern drainage lines—form dry valleys and contain fresh water. The Beaufort, (from Boscabel to Towerrinning, and westwards) and the Avon (west of Mt Kokeby near Brookton, to Darkin Swamp) are two of the largest systems found to contain fresh groundwater.

The movement of water into and out of palaeochannel aquifers occurs over very long, essentially geological, timeframes. The interaction between these and shallower valley floor aquifers is limited, due to the presence of clay layers that prevent or greatly restrict water movement.

The large scale clearing of deep-rooted perennial vegetation and replacement with shallow-rooted crops and pastures, that occurred in vast areas of the Wheatbelt, lead to a reduction in the consumption of groundwater by vegetation, and the transfer of water to the atmosphere via evapotranspiration. This in turn has caused groundwater levels to rise, and in doing so, groundwater's have dissolved large quantities of salt previously stored deep in the soil. The resulting salinisation and waterlogging has affected, and will continue to affect, large areas of the state's agricultural zone. It is important to note that it is the shallow valley floor aquifers that have responded to clearing in the Wheatbelt, causing salinisation and waterlogging. Water note 33 provides information on the ecology of Wheatbelt aquatic systems, and the potential impacts from altered salinity and hydrology.

What is yet to be documented is how the increased salinity and waterlogging of soils and drainage systems in WA's Wheatbelt has affected river restoration activities in these areas. Alterations in Wheatbelt land use will undoubtedly mean that—in the majority of river systems—we have altered hydrology. We need to be aware of this when managing our rivers. The way we manage waterways in the Wheatbelt must recognise the differences in these systems, and consider differences when adapting or adopting techniques developed for streams and rivers in the zone of rejuvenated drainage.

Further reading

Beard, J 1999, 'Evolution of the river systems of the south-west drainage division, Western Australia', *Journal of the Royal Society of Western Australia*, vol. 82, pp. 147–164.

Commander, DP, Schoknecht, N, Verboom, W & Caccetta, P 2001, 'The geology, physiography and soils of Wheatbelt valleys', in *Dealing with salinity in Wheatbelt valleys: processes, prospects and practical options: proceedings of a conference held at Merredin, Western Australia — 30th July-1st August 2001*, Viv Read and Associates, Perth.

Department of Environment 2005, *The ecology of Wheatbelt lakes*, Water note No. 33, DoE, Perth.

Geological Survey of Western Australia 1990, *Geology and mineral resources of Western Australia*, Western Australia Geological Survey, Memoir 3.

Myers, JS & Hocking, R 1998, *Geological map of Western Australia 1:250 000*, 13th edn, Geological Survey of Western Australia, Perth.

For more information and technical assistance please contact

Government of Western Australia
Department of Environment

Department of Environment
PO Box K822
Perth WA 6842
Telephone (08) 9364 6500
Facsimile (08) 9364 6520

This Water note is produced as part of the Waterways WA program: managing and enhancing our waterways for the future. Prepared by Mike Braimbridge and Phil Commander. Acknowledgments to Verity Klemm, Shawan Dogramaci, Bernie Kelly and Greg Davis for their review. Publication coordinated by Mike Braimbridge and Chrystal King.

Printed on recycled paper October 2005

ISSN 1832-6897