Government of **Western Australia**
Department of **Water**

West Canning Basin groundwater allocation limit report

Background information and method used to set an allocation limit for aquifers in the West Canning Basin

October 2012

Looking after all our water needs

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Contents

Figures

Tables

Summary

This report explains how the Department of Water developed the allocation limits for the West Canning Basin. It supports the *Pilbara groundwater allocation plan* (Department of Water 2012).

The West Canning Basin includes the Broome Sandstone and Wallal aquifers in the Canning–Kimberley groundwater area and the Wallal aquifer in the Pilbara groundwater area.

The West Canning Basin is an extensive and largely undeveloped resource that could provide fresh and fit-for-purpose water for a variety of important uses. These include industrial and town water supply for Port Hedland, pastoral and diversified agricultural activities and mining.

This report focuses on the Wallal aquifer as it is substantially larger than the Broome Sandstone aquifer within the West Canning Basin and has greater potential as a water resource. The report summarises available hydrogeological, environmental, cultural and social information for both aquifers, reviews aquifer and groundwater subarea boundaries and describes the methods used to set allocation limits.

Allocation limits are a management tool used to maintain the sustainability of the resource. To set allocation limits we considered results of previous hydrogeological investigations and monitoring data, groundwater modelling results, groundwater-dependent ecosystems and current and future water use.

The Department of Water has set a total of 41 GL/yr of groundwater that can be taken from the Broome Sandstone and Wallal aquifers in the Pilbara part of the West Canning Basin. The allocation limits are 10 GL/yr from the Broome Sandstone and 31 GL/yr from the Wallal. In recognition of the potential for the Wallal aquifer to support growth in Port Hedland, 10 GL/yr has been reserved for public water supply.

Details of how the department will manage allocation limits are included in the *Pilbara groundwater allocation plan*.

The allocation limits were based on the best available information and will meet short to medium term demand to support population growth, pastoral diversification and both local and remote mining operations.

Subject to the results of current investigations by the department and proponents into water availability it is likely that the allocation limit for the Wallal will be increased if, as expected, it is shown that greater quantities of water can be abstracted sustainably.

1 Introduction

1.1 Resource area and location

The West Canning Basin is located in the Pilbara region of Western Australia, about 100 km east of Port Hedland (Figure 1). It covers an area of about 3 500 km^2 and comprises a substantial groundwater resource that is largely untapped.

In this report, the West Canning Basin refers to the West Canning Basin and West Canning Basin–Pardoo subareas of the Canning–Kimberley groundwater area and the Wallal aquifer in the Pilbara groundwater area (Figure 3). These resources are proclaimed as the Canning–Kimberley and Pilbara groundwater areas under the *Rights in Water and Irrigation Act 1914*. This means that a licence is required to legally take groundwater, except for stock and domestic purposes from the superficial Broome Sandstone aquifer.

1.2 Water allocation planning in the Pilbara region

The Department of Water manages water abstraction though individual water licences issued under the *Rights in Water and Irrigation Act 1914*. As demand and the volume of water used increases, a water allocation plan is needed to guide our licensing decisions for a specified area.

This report supports the *Pilbara groundwater allocation plan* (Department of Water 2012). The plan sets out how much water can be abstracted from coastal alluvial and sedimentary aquifers and how that abstraction will be managed now and in the future. The plan will also inform water licensing across other areas of the Pilbara where water is abstracted predominantly from fractured rock aquifers.

1.3 Allocation limits

An allocation limit is an annual volume of water set aside for consumptive use from a water resource. For administrative purposes, the allocation limit can include:

- water that is available for licensing
    - general licensing
    - public water supply
- water use that is exempt from licensing
- water that is reserved for future public water supply.

Figure 1 Location of the West Canning Basin

Under the *Rights in Water and Irrigation Act 1914* abstraction from artesian aquifers requires a licence. This applies to the Wallal aquifer and therefore there is no exempt water use. The Broome Sandstone aquifer is not artesian and water can be abstracted for stock and domestic use without a licence.

Previous allocation limits and approach

Allocation limits of 10 GL/yr were set for each of the Broome Sandstone and Wallal aquifers in 1997. These allocation limits were based on a limited groundwater exploration drilling program carried out by the Geological Survey of Western Australia (GSWA) during the 1970s (Leech 1974, 1979).

For the Broome Sandstone aquifer, a potential yield of 18 GL/yr was estimated. This was based on an 'effective area' of 1575 km^2, a recharge rate of 3% and annual rainfall of 250 mm (Skidmore 1996). Because water quality is variable 10 GL/yr was considered a suitable annual limit.

For the Wallal aquifer a potential yield of 21 GL/yr was estimated (Leech 1979). This calculation used transmissivities based on aquifer thickness and mean hydraulic conductivity derived from aquifer tests (Haig 2009). Leech (1979) estimated that the volume of water suitable for domestic purposes was 14 GL/yr. Because estimates were regional in scale, 10 GL/yr was set as an annual limit.

The regional nature of Leech's (1979) investigations meant that yields were only estimations of the volume of water available. Given the estimated size of the resource, the level of uncertainty and the limited demand for water, allocation limits of 10 GL/yr were acceptable at the time.

The 1997 allocation limits have been reviewed in 2012 because of increasing regional demand for public water supply and pastoral diversification and increased knowledge of the aquifers following recent investigations.

1.4 Allocation planning

The Department of Water follows the process shown in Figure 2 when developing a water allocation plan and setting allocation limits. This report describes how we assessed the information available on the water resources in the West Canning Basin (Section 2) and how we set the objectives and allocation limits (Section 3). Our management approach is described in the *Pilbara groundwater allocation plan*.

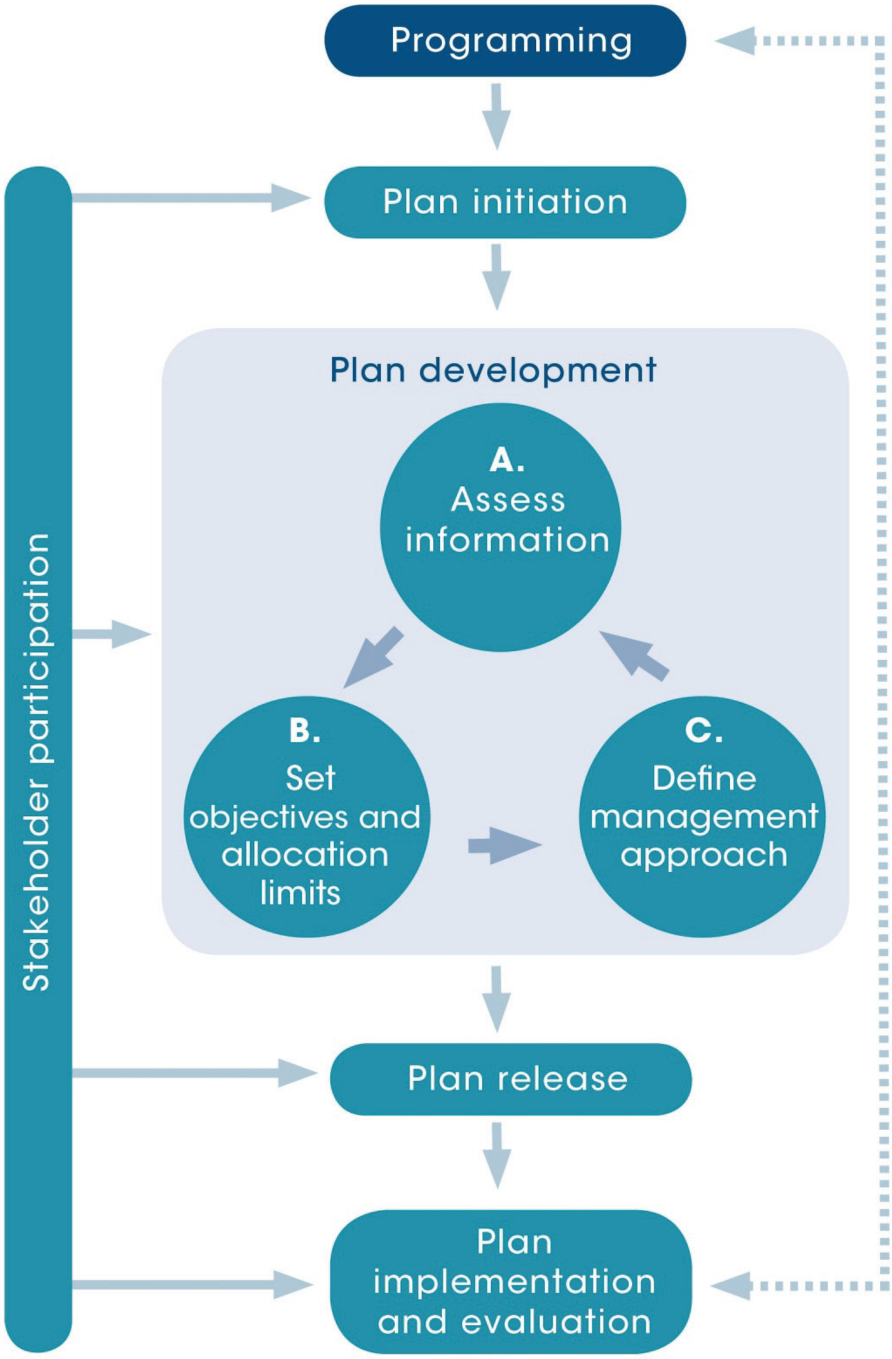

Figure 2 Water allocation planning process

For more information about allocation planning see *Water allocation planning in Western Australia: a guide to our process* (Department of Water 2011), which is available online at <www.water.wa.gov.au>.

1.5 Working with water users and other stakeholders

The Department of Water works with stakeholders to develop water allocation plans.

In the West Canning Basin, we have consulted with stakeholders (traditional owners, agricultural, industrial, public water supply) to identify water related values and discuss water resource issues. The main concerns raised were:

- water availability
- water quality
- managing impacts between different users
- water related Indigenous cultural values.

Understanding how water is used and valued by the community helped us set objectives, allocation limits and a management approach for the West Canning Basin.

2 Assessing information

In part A of the allocation planning process we assessed information on:

- the resource hydrogeology
- how much water needs to be left in the system
- current use
- future demand.

Information from part A informs the plan objectives and the Department of Water's allocation limit decisions.

2.1 Understanding the resource

Resource boundaries

We reviewed the Wallal aquifer boundaries and subarea boundaries (Figure 3) because the extent of the aquifer was redefined in the West Canning Basin groundwater model (Aquaterra 2010). Figure 3 shows the previous boundaries and Figure 4 and Figure 5 show the new boundaries.

Boundary changes included:

- amending the Canning–Wallal aquifer boundary
- creating the West Canning Basin (Wallal aquifer) and West Canning Basin–Yarrie (no aquifer) subareas
- renaming the Canning–Pardoo subarea as West Canning Basin–Pardoo subarea (Broome Sandstone aquifer)
- amending the Canning–La Grange (Wallal) and Canning–Kimberley (no aquifer) subarea boundaries.

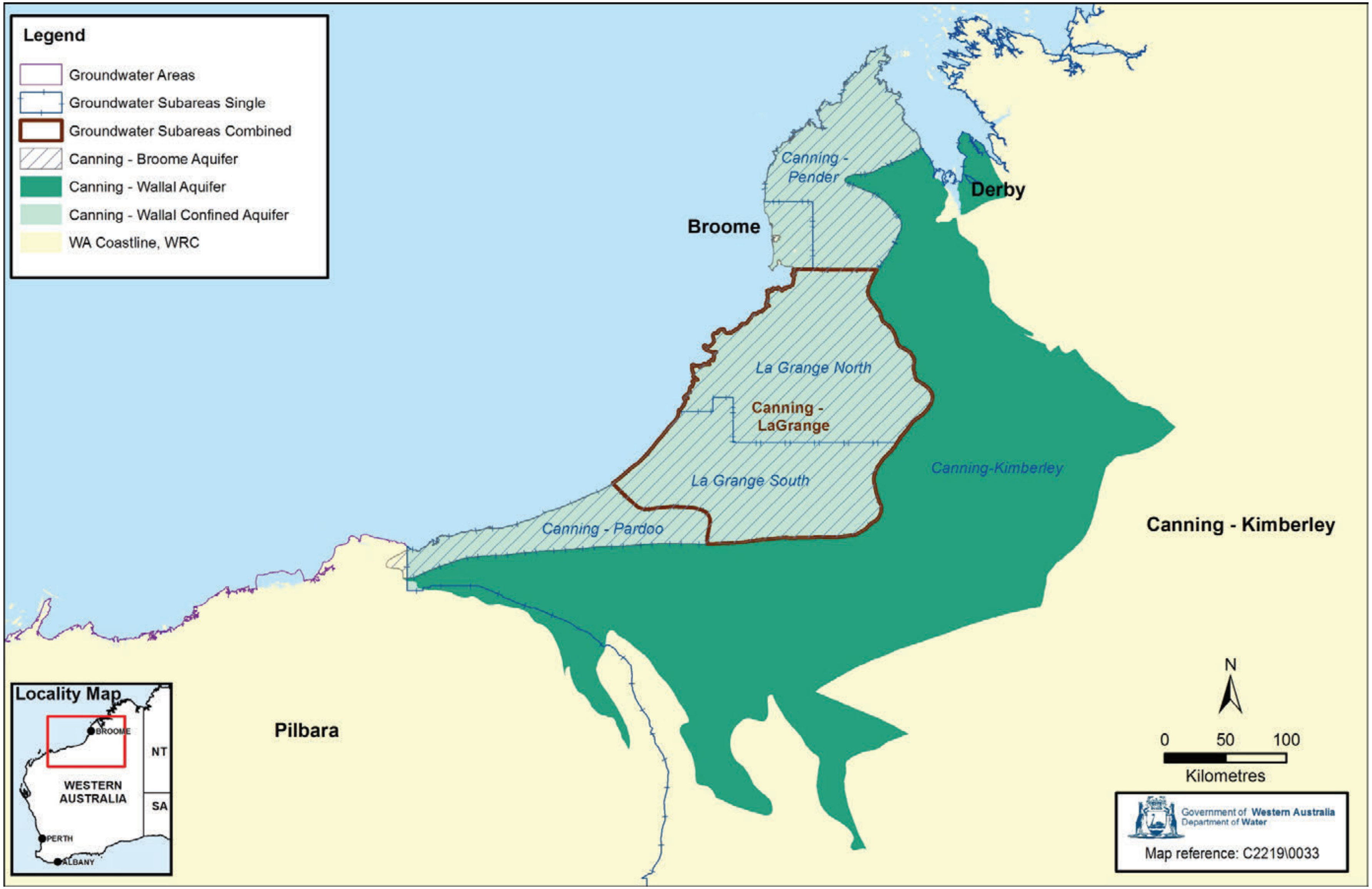

Figure 3 Previous aquifer and subarea boundaries

Figure 4 Revised boundaries of the Broome aquifer subareas

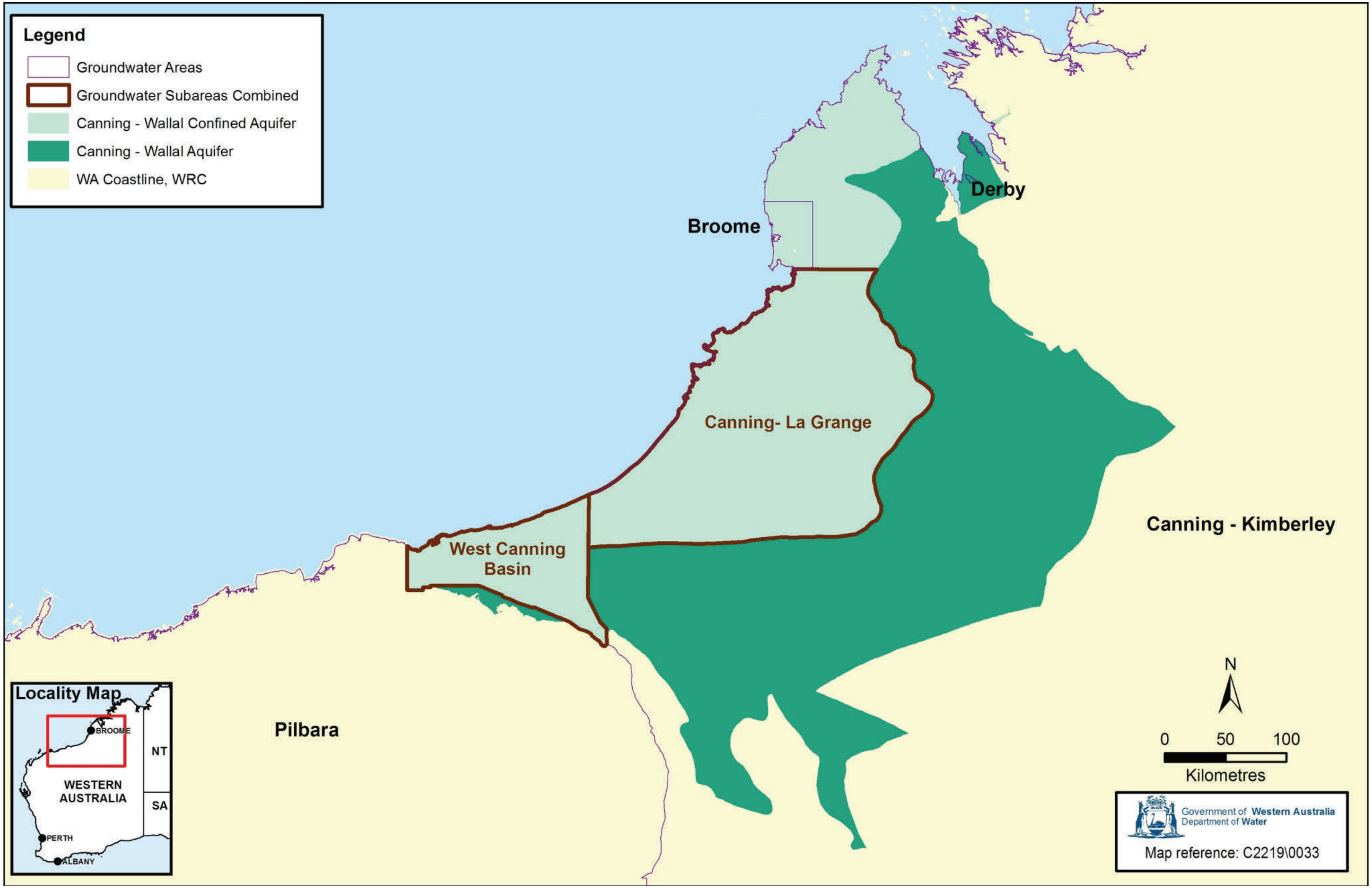

Figure 5 Revised boundaries of the Wallal aquifer subareas

Climate and rainfall

The Canning Basin is classified as arid tropical, with a wet season from October to April and dry season from May to September. Rainfall is highly variable and largely results from cyclonic events and localised thunderstorms between December and March.

Rainfall data is recorded at Bureau of Meteorology (BoM) stations at Mandora on the north-eastern edge of the West Canning Basin and Pardoo in the south-west (Table 1). Annual averages are similar at the two sites, with no rain recorded in four years at Pardoo and in 10 years at Mandora over the 100-year record. Maximum rainfall was more variable, ranging from 816 mm at Pardoo to 1033 mm at Mandora.

Table 1 West Canning Basin rainfall data summary (1913 to 2012)

	Mandora (BoM station 04019) mm	**Pardoo (BoM station 04028) mm**
Average annual rainfall	325	301
Maximum annual rainfall	1033	816
Minimum annual rainfall	0	0
Number of no rainfall years	10	4

Hydrogeology

The geology of the greater Canning Basin is well understood at a regional scale through oil exploration wells and various hydrogeological investigations, but this scale has not been appropriate for water management. The groundwater resources of the entire basin are considered to be substantial (Laws 1990).

The West Canning Basin is a low-lying flat plain with no surface water systems other than ephemeral creeks in the upper reaches of the De Grey River and Pardoo Creek drainages (Haig 2009).

The West Canning Basin contains multi-layer aquifers (Figure 6). The Wallal (sandstone) is mostly fresh and extensively confined. It is separated from the overlying, unconfined and mostly brackish Broome Sandstone by the Jarlemai Siltstone. In the southernmost parts of the West Canning Basin and in the west towards the De Grey River, the Jarlemai Siltstone is absent and the unconfined Wallal is directly overlain by the Broome Sandstone.

The western half of the West Canning Basin is on the Lambert Shelf (Appendix A). The eastern half is in the Wallal Embayment where the Wallal Sandstone aquifer is likely to be thicker and is flanked by the Wallal Platform in the east.

The western half of the West Canning Basin was studied during a groundwater exploration program by the Geological Survey of Western Australia during the 1970s (Leech 1974, 1979), but the eastern half remains relatively unexplored.

Investigations of the western half of the West Canning Basin include recent work commissioned by the Department of Water as part of the Australian Government's Water for the Future program. An airborne gravity survey (Fugro 2010) was used to re-examine aquifer characteristics including aquifer size, shape, thickness and water quality. Radiocarbon age dating and isotopic analyses were used to determine groundwater flow paths and residence times (Meredith 2009).

Our understanding of groundwater levels, pressure trends and response to recharge across the West Canning Basin is still limited despite previous investigations. This is because there is a lack of temporal groundwater level monitoring data across the area.

The department is currently rehabilitating groundwater monitoring bores and undertaking further radiocarbon dating and geochemical investigations as part of the Western Australian government's Royalties for Regions program.

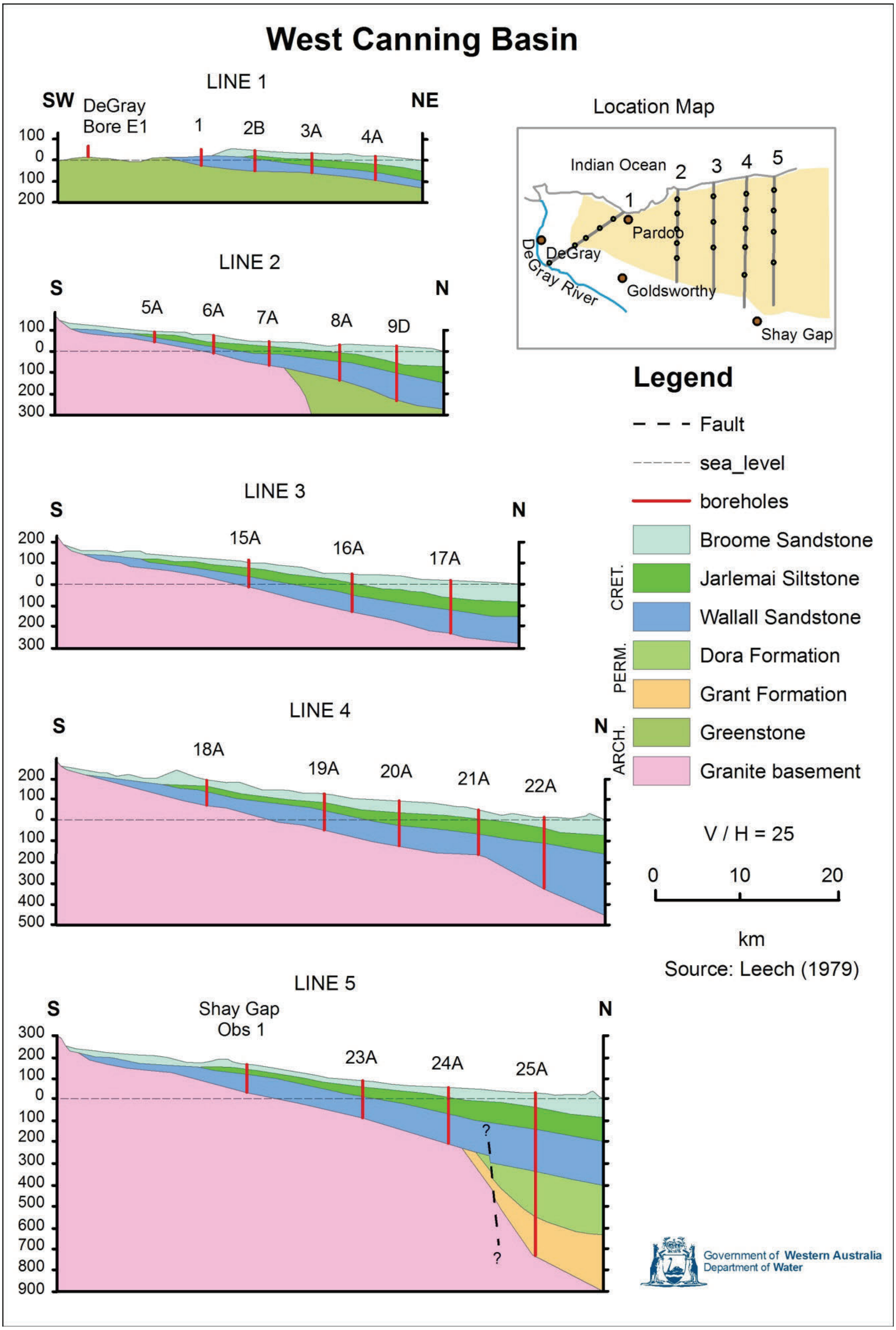

Figure 6 Conceptual hydrogeology of the West Canning Basin

Broome Sandstone aquifer

The unconfined Broome Sandstone aquifer is present over the entire West Canning Basin. It ranges in thickness from 10 m in the south of the basin to 130 m in the northeast. The aquifer is overlain by recent superficial sediments (alluvium and sand dunes) up to 5 m thick.

There is only limited information regarding the depths to water in the Broome Sandstone. However, bore WCB-24B on the north-eastern edge of the West Canning–Pardoo subarea (Figure 6), has a screened interval of 34 to 40 m below ground level and has recorded water levels between 30 and 33 m below ground level since 1980 (Haig 2009).

The Broome Sandstone is recharged directly by percolation of rainfall or indirectly through overlying sediments (Aquaterra 2010). Groundwater flow in the aquifer (within the West Canning Basin) is generally in a northerly direction, with groundwater discharge to the ocean. There is also potential for discharge through seepage and evapotranspiration along the coastal strip where depths to water are less than 3 m (Figure 7). In the western corner, flow becomes north-westerly towards the De Grey River alluvium (Aquaterra 2010).

Wallal aquifer

The Wallal Sandstone aquifer has a greater volume of water and generally better quality water than the Broome Sandstone aquifer.

The Wallal aquifer ranges in thickness from 20 m in the south to 220 m in the north-east. Along the coast, the top of the confined Wallal aquifer is at considerable depth (60 to at least 100 m below ground level).

In the coastal strip the Wallal aquifer is artesian, with the measured potentiometric head sitting between 2 m and 30 m above ground level (Figure 8). In the eastern half of the West Canning Basin, there are records of heads as high as 50 m above ground level (Aquaterra 2010). Further from the coast (10 to 20 km) the Wallal aquifer is shallower and becomes non-artesian.

The Wallal aquifer is likely to be recharged from direct rainfall where it outcrops from the Jarlemai Siltstone or from groundwater throughflow from other sources (e.g. from the Paterson Formation in the Oakover Valley). Groundwater flow in the Wallal aquifer is mostly to the west, but in the east flow is to the north-west (Figure 8).

Recent isotopic analyses (Meredith 2009) in the western half of the West Canning Basin shows that the aquifer has zones of very old brackish water (30 to 40 000 years old) in the western corner, to relatively young fresher water in the east (5 to 7000 years old). This could mean that the eastern portion is receiving more recharge and that the aquifers are compartmentalised into zones by geological faults.

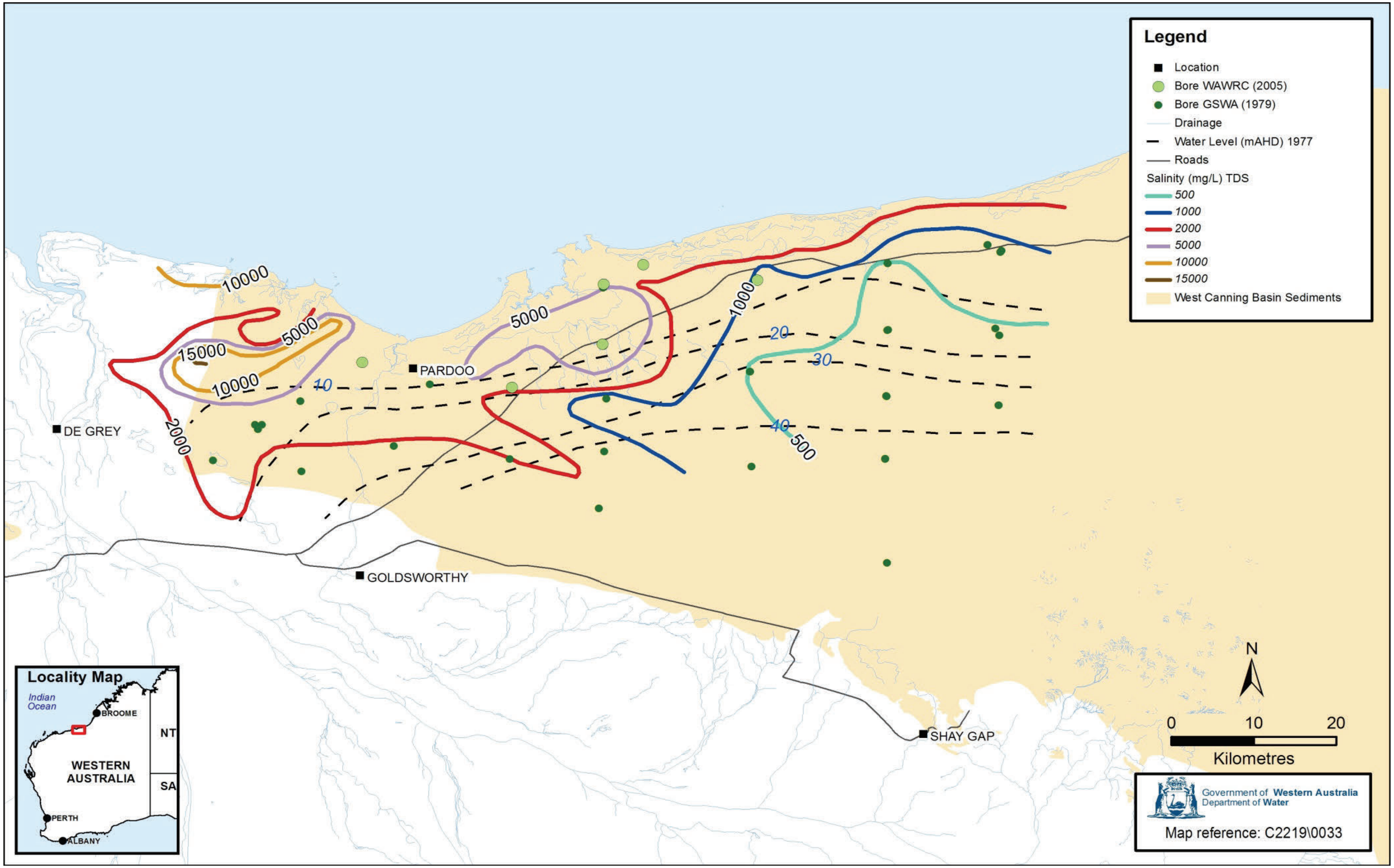

Figure 7 Salinity and water levels in the unconfined Broome Sandstone aquifer

Groundwater quality

Broome Sandstone aquifer

Salinities in the Broome Sandstone aquifer generally decrease moving west to east. Along the coast to the west of Pardoo salinity ranges from 1500 mg/L to more than 5000 mg/L (Figure 7) decreasing to less than 1000 mg/L in the east. Although water may be suitable for domestic use or irrigation where salinities are less than 1000 mg/L, elevated nitrates (probably naturally occurring) mean that the water may require treatment before use (Haig 2009). In addition, sodium absorption ratio analysis shows a medium to high salinity hazard, indicating that the Broome Sandstone aquifer may not be suitable for irrigation (Leech 1979).

Wallal aquifer

Groundwater salinity in the Wallal aquifer also generally decreases from west to east (Figure 8). However, the controls on salinity are not well known (Leech 1979). To the west of Pardoo Station, salinity is greater than 1000 mg/L, the water is hard and the levels of calcium, sodium and chloride may exceed the limits given in the *Australian drinking water guidelines* (NHMRC & NRMMC 2004). Water quality in the west may not be appropriate for agriculture, but may be suitable for industrial purposes.

Moving east from Pardoo Station, salinities decrease from close to 5000 mg/L to 1000 mg/L and 500 mg/L. Further east, groundwater salinity is less than 500 mg/L and is suitable for domestic and agricultural use.

Leech (1979) reported nitrate concentrations of 23 to 25 mg/L in the vicinity of Shay Gap bore field. This could have been the result of bore construction and/or local contamination from other nearby land uses. The *Australian drinking water guidelines* (NHMRC & NRMMC 2004) limit for nitrate in a potable water supply is 50 mg/L.

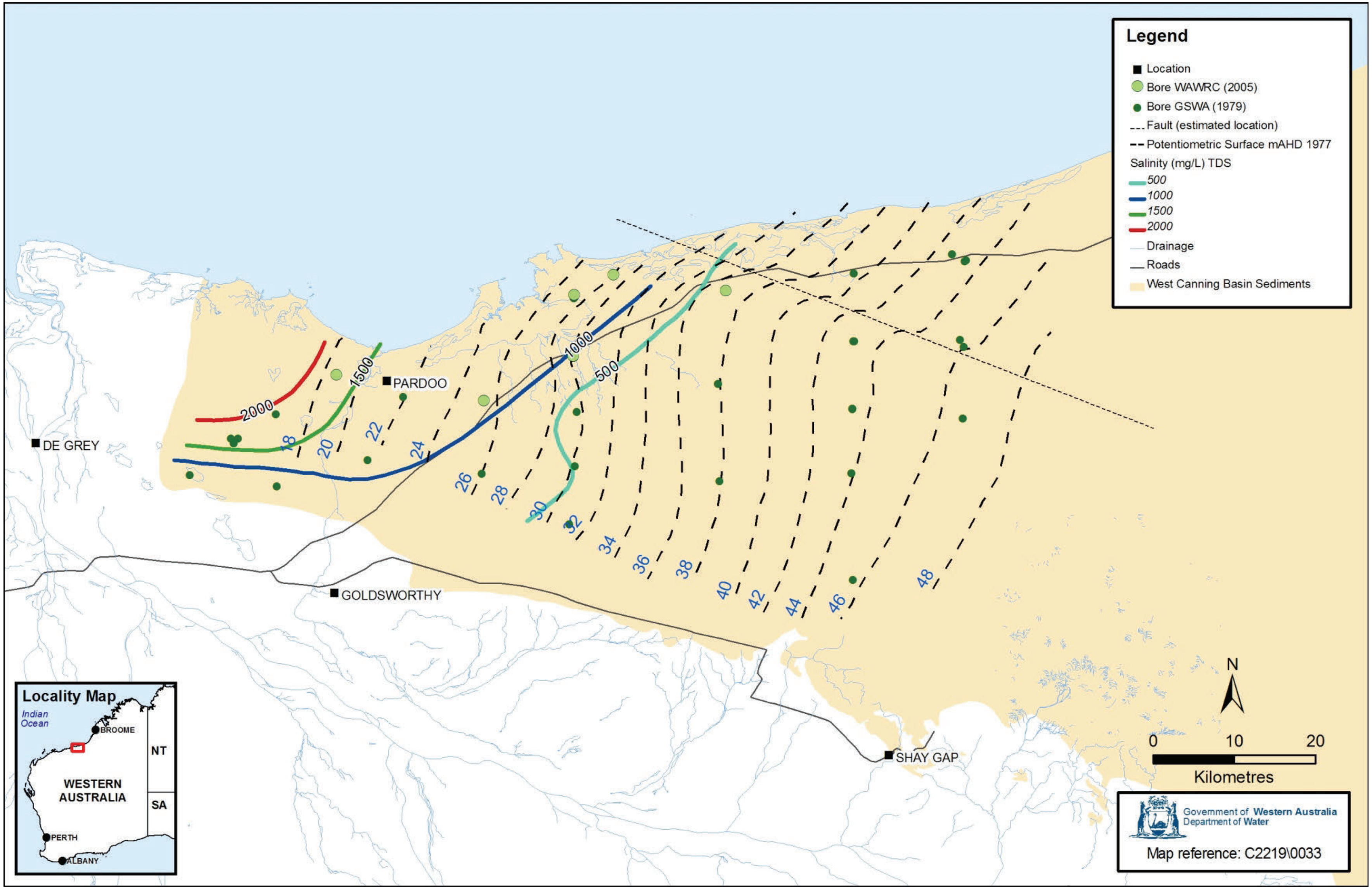

Figure 8 Pressure heads and salinity in the Wallal aquifer

Surface water and groundwater interaction

The Eighty Mile Beach wetlands occur along the coastal zone of the West Canning Basin and are likely to be supported by the Broome Sandstone. If the water in the wetlands comes from the aquifer it would be because the discharge of freshwater into the coastal zone is impeded by coastal muds forming clusters of wetlands (V & C Semeniuk Research Group 2000).

Several groundwater springs also occur in the coastal zone within 20 km of Pardoo Homestead (Leech 1979). It has been suggested that the springs result from minor upward leakage from the Wallal Sandstone. Although some springs have been dry for some years, others still produce water.

If the source of the springs is the Wallal aquifer it would be by one of two mechanisms:

- groundwater from the Wallal aquifer flows into the Broome Sandstone aquifer via a conduit causing mounding and seepage where the watertable intersects the ground surface
- groundwater from the Wallal aquifer discharges directly to the surface via a conduit (Aquaterra 2010).

These wetlands and springs are unlikely to be a significant part of the overall water balance of the West Canning Basin. Although the origin of the water is unclear (Aquaterra 2010) the springs may be useful indicators of changes in groundwater pressure in the Wallal aquifer.

The department is doing further work to confirm the source of the groundwater feeding the springs and, if possible, the coastal wetlands. See Section 2.2 and Appendix B for more information on the ecology of the springs.

The West Canning Basin groundwater model

In 2010, a numerical groundwater model of the West Canning Basin was completed with funding from the Commonwealth Water for the Future program. The model covers an area of about 9 400 km^2 which will be referred to as the model area (Figure 9). It was developed using information from earlier hydrogeological investigations and recent isotopic and geophysical investigations completed by the department. It was based on good hydrogeological information in the western half of the model area but very limited information in the eastern half (this area will be targeted by planned investigations see Section 3.4).

We used model results together with monitoring data to assess a range of allocation options (see Section 3.2). The lack of on-going groundwater level data across the Wallal aquifer, and gaps in hydrogeological understanding, meant model results were treated with some caution.

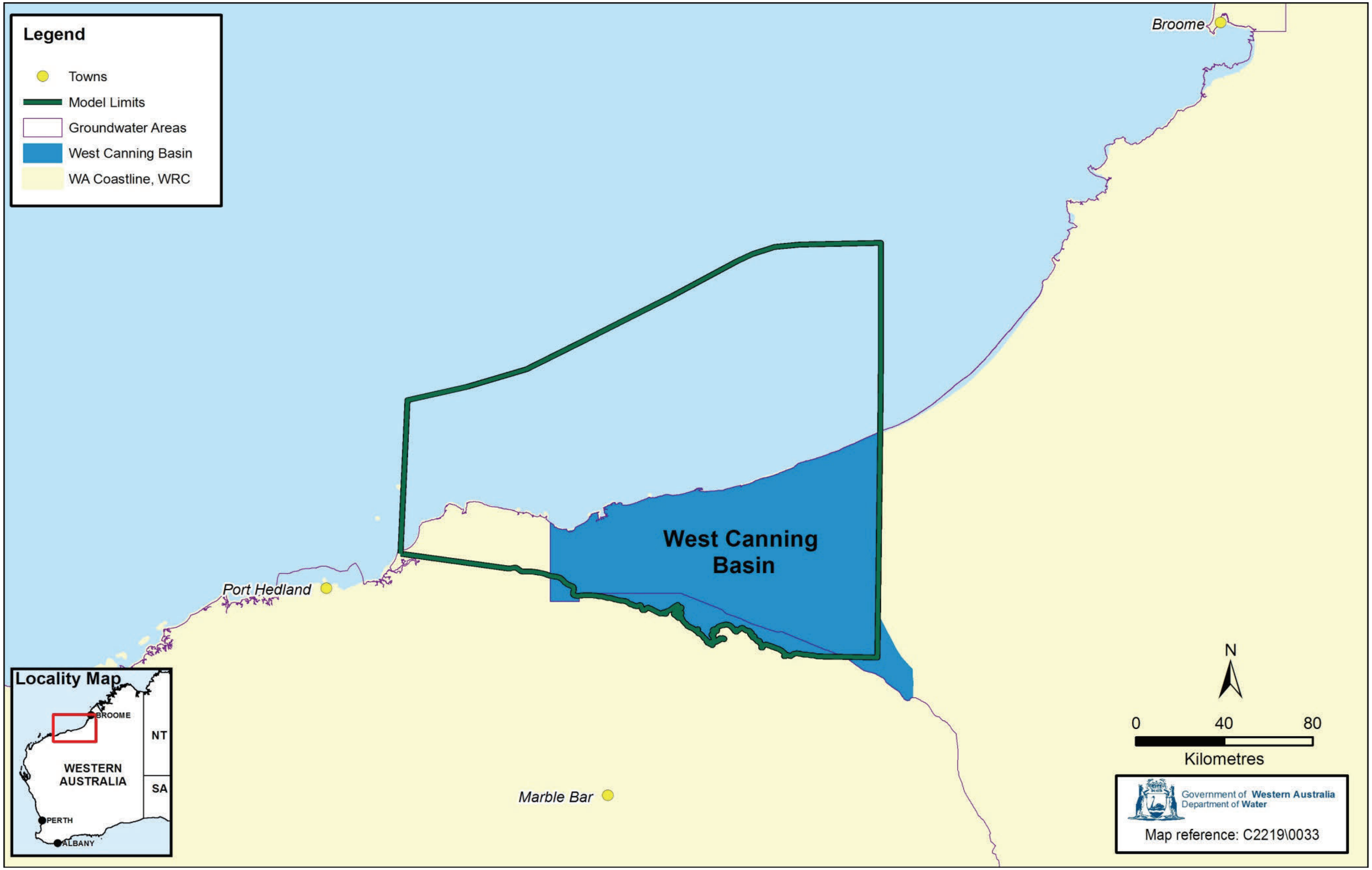

Figure 9 West Canning Basin groundwater model area

2.2 Water left in the groundwater system

The starting point for deciding an allocation limit is to estimate the resource yield. We consider the yield as the amount of water that can be taken out, once in situ groundwater requirements are met. To do this we consider the groundwater needed to maintain:

- groundwater quality and productivity of the resource
- ecological values
- social and cultural values.

Maintaining groundwater quality and resource productivity

Resource productivity is the on-going ability of a resource to provide water suitable for its intended use. An important consideration for maintaining the long-term productivity of the Broome Sandstone and Wallal aquifers is preventing landward movement of the seawater interface. Too much abstraction from these resources could allow the interface to move inland and so reduce groundwater quality.

For the Wallal aquifer the seawater interface is likely to be some distance offshore. However, in the Broome Sandstone aquifer the interface can be up to several kilometres inland from the coastline. Adequate fresh groundwater throughflow to the coast in both aquifers is required to maintain the position of the seawater interface.

Maintaining adequate pressure in the Wallal aquifer is also important to prevent significant incursion of the seawater interface.

Groundwater related ecological values

As mentioned in Section 2.1, a series of wetlands occur along the coast as part of the Eighty Mile Beach system. This system is Ramsar listed.

Although the Eighty Mile Beach wetlands are not connected to the deep groundwater of the Wallal aquifer, discharge from the Broome Sandstone aquifer is likely to provide some hydrological support.

There are also several springs along the coastal zone. They vary in form from small surface ponds with no flowing discharge to small humus mound springs with flowing discharge. Although some springs retain vegetation, most have been dug out as watering points or disturbed by stock. Six springs on Pardoo Station were visited in November 2007 (Figure 10). All have been highly degraded by long-term stock access and have limited ecological value (see Appendix B for more information).

It is not clear if the coastal springs are maintained by discharge from the Wallal or the Broome Sandstone.

The nationally significant and Ramsar-listed Mandora Marsh occurs in the eastern sector of the basin and is associated with mound springs of the Canning Basin.

Groundwater modelling indicates that the Eighty Mile Beach wetlands, the coastal springs and the Mandora Marsh will not be adversely affected by abstraction from the Wallal aquifer in the Pardoo area. Potential effects of abstraction from the Broome Sandstone were not modelled.

We have not determined ecological water requirements for the wetlands and springs of the West Canning Basin because:

- ecological values are low and there is a high degree of degradation of the coastal springs
- of uncertainty in knowing which groundwater sources are supporting the Eighty Mile Beach wetlands
- modelling has shown that there are no adverse effects on the Eighty Mile Beach wetlands, coastal springs or Mandora Marsh.

In the absence of known ecological water requirements the department will consider the potential for impacts to wetlands and springs in our management strategy and through assessment of individual licences.

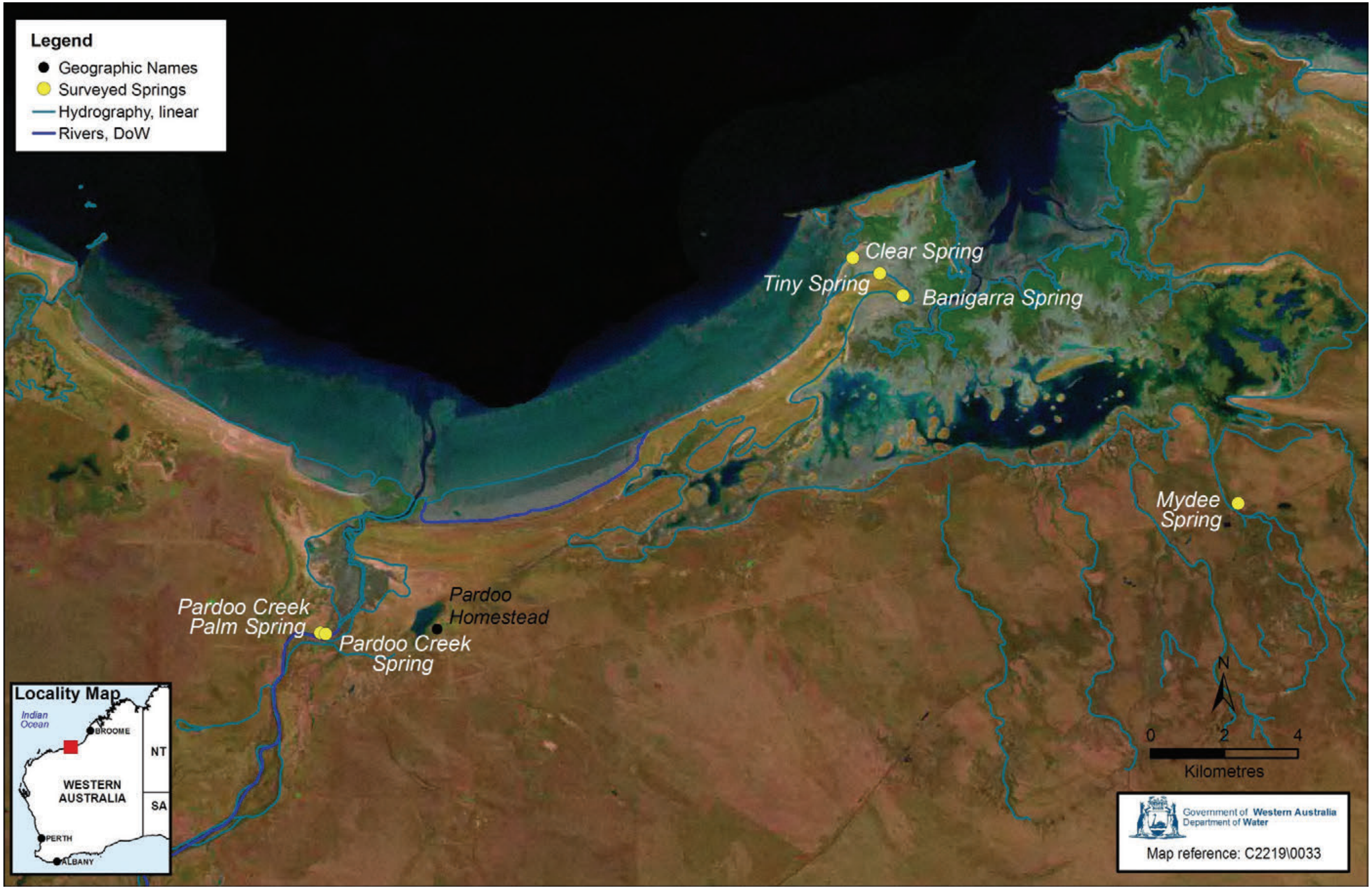

Figure 10 Springs in the West Canning Basin

Water related social and cultural values

Water requirements to maintain the social and cultural value associated with groundwater are considered in the allocation process.

The excerpt below is taken from the report *'We used to get our water free…' – Identification and protection of Aboriginal cultural values of the Pilbara Region* (Rumley & Barber 2004).

> Aboriginal people in the Pilbara region of Western Australia have strongly articulated cultural beliefs about water sources in their country based on their traditional religion. This religion, or cultural belief system, stems from the Dreamtime when it is believed that the landscape and all geographical features within it, including surface and groundwater sources as well as all species of flora and fauna, were created by Dreamtime beings. All these features are important to Aboriginal people in a variety of cultural, social and economic ways.
>
> … it is traditionally believed that the Dreamtime beings left part of their mythical essence in all the features and flora and fauna which they created. As far as water sources in the Pilbara region are concerned, this mythical essence is believed to remain in all water sources, rivers, creeks, soaks, pools and springs and takes the form of a water snake or water serpent.

The Department of Water's approach to engagement with Aboriginal people in the Pilbara has been shaped by these themes. We see water allocation planning as more than an identification and documentation of sites of significance but rather an opportunity to build longer term water management partnerships with traditional owners in the Pilbara. We have met with the traditional owners of the West Canning Basin to outline the role of the Department of Water and our approach to allocation planning.

Water requirements to maintain water related social and cultural values are usually closely related to ecological water requirements. As discussed, we have not determined ecological water requirements but will consider the potential for adverse effects on wetlands through our management strategy and through assessment of individual licences (see Section 3.2).

2.3 Understanding demand and trends

Current use

Use of groundwater in the West Canning Basin is currently quite low. Groundwater is abstracted from the Wallal aquifer for the Yarrie mine site and camp, and by pastoral stations. Abstraction by pastoral stations is expected to increase as they undertake the staged development of pastoral diversification projects. Current use is approximately 1.8 GL/yr from the Wallal aquifer.

There is currently no licensed abstraction from the Broome Sandstone aquifer. However, some stock watering bores do obtain water from this aquifer.

Future demand

There is considerable interest in the Wallal aquifer given the significant volumes of water that may be available. The resource could support:

- expansion of the Port Hedland Water Supply Scheme to support both industry and population growth
- agriculture, in particular pastoral diversification
- both local and remote mining operations.

The department, with other government agencies, examined demand and water supply options for the coastal Pilbara towns. With the expected expansion of towns and increase in iron ore production, demand for water in Port Hedland (town and ports) is estimated to reach 20 GL/yr by 2015 (from current 13 GL/yr supplied from the De Grey and Yule bore fields) and 25.5 GL/yr by 2021. If the projections produced by the Pilbara Cities project are realised, demand could be up to 33 GL/yr by 2021.

In the long term there is potential for development of unconventional gas reserves in the West Canning Basin. This kind of development may have significant water demands.

Given this potential demand and the high economic value of supporting Port Hedland and mining, currently available water resources will be fully used.

The Wallal aquifer has been identified as an option for meeting future demand. The costs associated with pipeline construction to transport the water to Port Hedland are a significant constraint on the viability of this option.

Although 10 GL/yr is available for allocation from the Broome Sandstone aquifer there has been little indication of future demand from this resource, most likely due to the generally poor water quality.

2.4 Points to consider from assessing information

From the information we have on the Broome Sandstone and Wallal aquifers, there are a number of points that we need to consider when setting objectives and allocation limits:

- The West Canning Basin is an extensive and largely undeveloped resource that could provide fresh and fit-for-purpose water for a variety of important uses.
- We have a groundwater model to assess the potential effects of abstraction from the Wallal aquifer.
- Connectivity between the Wallal aquifer and potential groundwater-dependent ecosystems (Mandora Marsh, 80 Mile Beach wetlands and coastal springs in the Pardoo area) is unclear.

- Current use from the Wallal aquifer is approximately 1.8 GL/yr and there is no licensed use from the Broome Sandstone.
- The highest projected demand for water in Port Hedland is 33 GL/yr by 2021, well above the volume of water available from the De Grey and Yule bore fields.

3 Setting objectives and allocation limits

In part B of the allocation planning process we:

- set objectives
- assess allocation options
- decide allocation limits.

3.1 Setting objectives

In administering the *Rights in Water and Irrigation Act 1914*, the Department of Water provides for both the sustainable use and development of water resources and the protection of ecosystems associated with water resources.

Outcomes

We manage water resources in the West Canning Basin so that the following outcomes are achieved:

- the availability of water within legislative objectives is maximised, given the particularly high economic value of these water supplies to the state
- the development of the resources as a major regional water supply is supported
- groundwater is maintained as a useable resource into the future
- the valuable environments and ecosystems dependent on groundwater are managed
- Indigenous values dependent on groundwater are managed
- the guidance for regulatory assessment of mining is clarified and improved
- the understanding of groundwater resources is continually improved.

Resource objectives

Water resource objectives are designed to ensure we achieve the outcomes above. They relate to maintaining, increasing, improving, restoring, reducing or decreasing surface water flow, groundwater levels or water quality. The water resource objectives are measurable. We monitor the resource against the objectives over the life of the plan, allowing us to evaluate and adapt our resource management.

The water resource objectives for the West Canning Basin are to:

- prevent seawater intrusion into the Broome Sandstone aquifer caused by abstraction
- prevent seawater intrusion into the onshore area of the Wallal aquifer caused by abstraction
- maintain groundwater levels in the Broome Sandstone aquifer to avoid adverse effects on coastal wetlands
- maintain pressure heads in the Wallal Sandstone aquifer above the top of the aquifer so that it remains confined.

3.2 Setting allocation limits

In setting allocation limits for water resources in the West Canning Basin we considered the available information (Chapter 2) and the outcomes and objectives for the resources (Section 3.1). We developed and modelled a number of allocation options, assessed the model results and selected the best option as the basis for deciding how much water will be made available for abstraction – the allocation limit (Figure 11). The final allocation limit decision included verification of model results using a 'first principles' recharge calculation.

Figure 11 Setting allocation limits

Allocation options

The West Canning Basin groundwater model described in Section 2.1 was used to assess a range of allocation options for the Wallal aquifer. Six options were modelled to understand the potential effects of current and future abstraction from the resource. Direct abstraction from the Broome Sandstone was not modelled. However, because there is some connection between the Wallal and Broome Sandstone aquifers, drawdown in the Wallal aquifer could cause drawdown in the Broome Sandstone aquifer.

The options represented different likely combinations of current and future abstraction volumes and bore field distributions (Table 2 and Figure 12).

For all options, except Option 2 we applied the same climate conditions. This was based on long-term, average monthly rainfall (315 mm) from three sites across the West Canning Basin (Pardoo, Mandora and Yarrie rainfall stations). Option 2 was modelled with no rainfall as a test for the sensitivity of the aquifer to changes in recharge.

Table 2 Allocation options modelled for the West Canning Basin aquifers

Option	Demand	Use and location	Volume GL/yr
1	Current	Pardoo and Wallal stations stock bores (estimated)	0.2
	Current	Shay Gap bore field	1.2
	Current	Pardoo Roadhouse	0.025
	Current	Pardoo Station irrigation	1.3
	Future	Pardoo Station irrigation expansion	Up to a total of 10
Total use			**11.4**
2		Same as Option 1	11.4
		with no recharge	
Total use			**11.4**
3		Same as Option 1	11.4
	Future	with addition of bore field (mining) south-west of Pardoo irrigation expansion	16
Total use			**27.4**
4		Same as Option 1	11.4
	Future	with additional bore field (public water supply) in east of model domain	16
Total use			**27.4**
5		Same as Option 3	27.4
	Future	with additional bore field (mining) east of Shay Gap	5
Total use			**32.4**
6	Current	Pardoo and Wallal stations stock bores (estimated)	0.2
	Current	Pardoo Roadhouse	0.025
	Future	with additional large bore field (public water supply) on eastern side of West Canning Basin	Up to a total of 32.4
Total use			**32.4**

Allocation options included annual abstraction of 11.4, 27.4 or 32.4 GL/yr based on current use and/or future demand by pastoral and mine operations and potential public water supply (PWS).

All options except Option 6 included current stock and domestic use by the Pardoo and Wallal stations, current use by Pardoo Station for irrigation, and use by the Pardoo Roadhouse and Shay Gap borefield. Options 1 to 5 also modelled future use to expand irrigation at Pardoo Station.

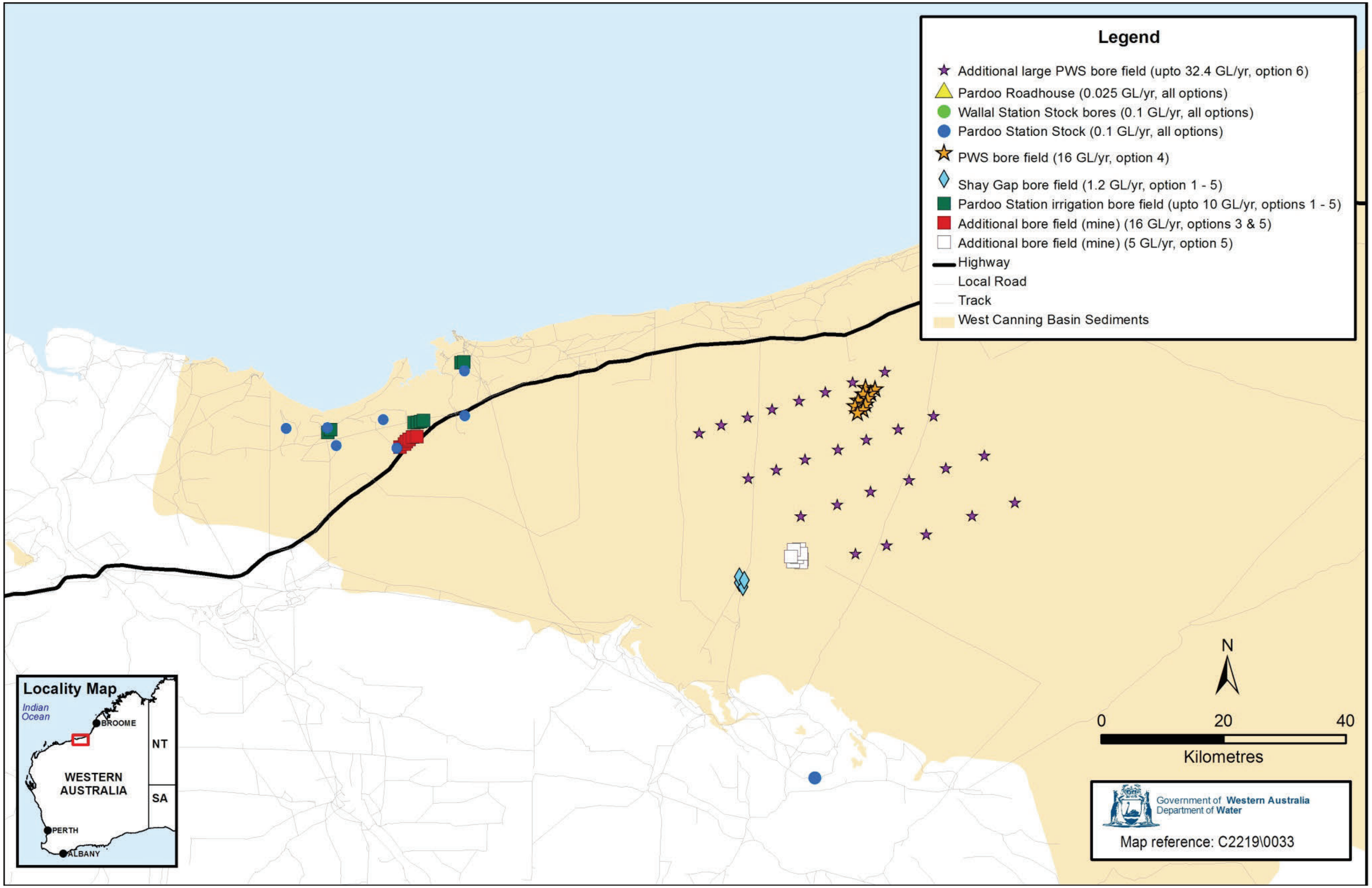

Figure 12 Location of modelled bore fields

The greatest differences between options were the volumes modelled for future use and the distribution of future bore fields (Figure 12). Bore fields and abstraction were, most concentrated under options 3 and 5. See Appendix C for more information.

Assess model results

The six allocation options were assessed to select an abstraction volume that will meet the resource objectives (Section 3.1) as well as provide for the predicted level of demand.

The maximum predicted drawdown from each modelled allocation option is shown in Table 3 (Wallal aquifer) and Table 4 (Broome Sandstone aquifer). See Appendix C for more information.

Drawdown in both aquifers was sensitive to bore field distribution and the volume of abstraction. The greatest drawdowns were under options 3 (27.4 GL/yr) and 5 (32.4 GL/yr).

Table 3 Wallal allocation option results: drawdown in the Wallal aquifer

Option	Volume GL/yr	Maximum drawdown at 20 years	Maximum drawdown at 50 years
1	11.4	3 m (around Pardoo Irrigation bore field)	3 m (around Pardoo Irrigation bore field)
2	11.4	4 m (around Pardoo Irrigation bore field)	5 m (around Pardoo Irrigation bore field)
3	27.4	7 m (around mine bore field)	9 m (around mine bore field)
4	27.4	3 m (around Pardoo area and eastern PWS bore field)	4 m (around Pardoo area and eastern PWS bore field)
5	32.4	8 m (around mine bore field)	10 m (around mine bore field)
6	32.4	3 m (around large PWS bore field)	3 m (around large PWS bore field)

Table 4 Wallal allocation option results: drawdown in the Broome Sandstone aquifer

Option	Volume GL/yr	Maximum drawdown at 20 years	Maximum drawdown at 50 years
1	11.4	1 m (around Pardoo Irrigation bore field)	2 m (around Pardoo Irrigation bore field)
2	11.4	2 m (S-W of Pardoo and along coast)	4 m (S-W of Pardoo and along coast)
3	27.4	5 m (S-W of Pardoo and to west and east)	7 m (S-W of Pardoo and to west and east)
4	27.4	1 m (S-W of Pardoo bore field)	1 m (S-W of Pardoo bore field)
5	32.4	5 m (S-W of Pardoo bore field)	7 m (S-W of Pardoo bore field)
6	32.4	0.5 m (S-W of Pardoo bore field)	1.5 m (S-W of Pardoo bore field)

Not surprisingly, the model predicted that abstraction that is concentrated in one area, such as that modelled around Pardoo under options 3 (27.4 GL/yr) and 5 (32.4 GL/yr), would have the biggest effect on the potentiometric head of the Wallal aquifer and on groundwater levels in the Broome Sandstone aquifer. Options 4 (27.4 GL/yr) and 6 (32.4 GL/yr), simulating broader distributions of abstraction, showed that drawdown effects can be significantly reduced if abstraction points are more widely distributed

Under options 1 (11.4 GL/yr) and 5 (32.4 GL/yr) the model predicted drawdowns of up to 2.5 m and 10 m respectively, which could cause loss of artesian heads in some of the Wallal aquifer bores.

The model predicted a low risk of seawater intrusion in the Wallal aquifer as most options maintained pressure heads above the top of the aquifer near the coast. Some options, particularly those with concentrated, high abstraction near the coast (e.g. options 3 and 5), indicated there may be some risk of seawater intrusion in the unconfined Broome Sandstone aquifer.

The maximum predicted drawdown in the Broome Sandstone aquifer near the coast is 0.5 m after 50 years under options 2 to 6. The extent of drawdown varies and is greatest under option 2 (11.4 GL/yr), extending along the shoreline for 215 km. This is likely to be caused by the absence of recharge under this option. Drawdown is smallest and least extensive under option 6 (32.4 GL/yr), which represents the largest abstraction volume distributed over the greatest area. If the coastal wetlands are supported by the Broome Sandstone aquifer, they also are at greatest risk of being adversely affected under options that abstract water from a concentrated area near the coast than under options that spread abstraction over a greater area.

There has been on-going discussion with stakeholders in the West Canning Basin to identify current and future demand for water from the Wallal aquifer. An allocation limit of between 27 and 32 GL/yr, if not taken from a concentrated area, meets this demand in the short to medium term. It also meets the resource objectives for maintaining pressure heads and therefore the confined nature of the Wallal aquifer, to prevent seawater intrusion and to reduce adverse effects on coastal wetlands from drawdown in the Broome Sandstone aquifer.

Decide allocation limits

Broome Sandstone aquifer

Because of the lack of information on the Broome Sandstone aquifer, we retained the current allocation limit of 10 GL/yr. This is available for general licensing. This allocation will maintain aquifer water quality and productivity and any groundwater-dependent ecosystems and is an adequate response to the low demand.

Wallal aquifer

To test an allocation limit of between 27 and 32 GL/yr for the Wallal we ran a series of 'first principles' recharge calculations using conservative figures and basic assumptions.

The recharge calculation used a potential direct recharge area of 2800 km^2, and recharge rates of 2.7%, 6.0% and 15.0%, representing different proportions of rainfall infiltrating the aquifer. Results suggest that the potential direct rainfall recharge volumes are 26, 58 and 144 GL/yr respectively. See Appendix A for further detail.

Because rainfall is highly variable, and there is only limited on-ground information regarding recharge of the Wallal aquifer we decided to use a precautionary recharge rate of 2.7%. This was the recharge rate in the West Canning Basin groundwater model that best calibrated predicted and observed groundwater levels (average root mean square error, which measures the scattering of data was, 5.23%). It is likely that the actual recharge rate is higher as the recharge area is mostly sand, has a deep watertable and there is limited surface water flow. This means that what rainfall does occur (and does not evaporate) will percolate though the sands into the aquifer rather than move away along a river or creek.

A recharge rate of 2.7 % equates to approximately 26 GL/yr recharge to the Wallal aquifer. As the model results showed little difference in drawdown effects between 26.4 GL/yr and 32.4 GL/yr options (if abstraction is broadly distributed), we decided that 32 GL/yr was a possible allocation limit. We then considered a number of other factors including the predicted short to medium term demand and the level of knowledge we have of the system.

The final decision was therefore based on:

- meeting resource objectives
- the use of a conservative recharge rate in the model (2.7%)
- the variability in recharge
- the reductions in pressure heads seen in modelling results
- the predicted short to medium term demand
- the low level of knowledge of the system.

Based on these considerations and the assessment of the modelling results, we set the allocation limit for the Wallal aquifer in the West Canning Basin subarea at 30 GL/yr (Table 5).

This is three times the previous allocation limit which may seem a particularly large increase, However, we now have more information available than was the case when the original limit was set.

A volume of 10 GL/yr has been reserved from the Wallal aquifer for public water supply, the remaining 20 GL/yr is for general licensing. There is also 1 GL/yr available for general licensing from the Wallal aquifer in the East Pilbara subarea (Table 5).

The allocation limit will remain at this level until we have more information and can recalibrate and re-run the groundwater model. In addition, if groundwater levels in the Wallal aquifer fall by more than that predicted under an abstraction of 30 GL/yr and still meet the objectives for the resource, the allocation limit may be reviewed.

Table 5 Allocation limit and components for the Wallal and Broome Sandstone aquifers of the West Canning Basin

Aquifer	Subarea	Allocation limit GL/ yr	Licensable components GL/ yr		Un-licensable component GL/yr
			General licensing	Public water supply	Unlicensed use
Wallal	West Canning Basin	30	20	10	n/a
	East Pilbara	1	1	n/a	n/a
Broome	West Canning Basin–Pardoo	10	10	n/a	n/a

3.3 Managing risk

The department will manage risk to other users and in-situ values through the allocation limit and by using the management strategies in the *Pilbara groundwater allocation plan.* We will also conduct further work to improve our knowledge of the aquifers as lack of information was a major factor in setting the allocation limit.

At the aquifer scale the allocation limit helps us meet the resource objectives to prevent seawater intrusion and maintain pressure heads and to address risks to any groundwater-dependent ecosystems.

At the local scale, licensing rules will help us assess each groundwater licence application and manage licences on a case-by-case basis. This will include assessing the issues and/or risks to existing users from new licences.

Licensing policies and rules, similar to those applied to the La Grange groundwater area, will be included in the plan to protect groundwater-dependent ecological values associated with the Broome Sandstone aquifer. These will include policy and rules specific to a coastal management zone covering the coastal wetlands.

3.4 Further work

The allocation limits for the Wallal and Broome Sandstone aquifers are based on limited information. The actual volume of water available may be higher and as more information becomes available allocation limits will be reviewed. We will also work with proponents who wish to investigate the availability of water above 30 GL/yr from the Wallal aquifer and 10 GL/yr from the Broome Sandstone aquifer.

The work that is needed to review the allocation limits includes:

- Hydrogeological investigations in the eastern half of the West Canning Basin to realise the full potential of the Wallal aquifer as a major water source in the East Pilbara area.
- Confirming the Wallal aquifer recharge rate estimates, as the recharge area is mostly sand, has a deep watertable and has relatively flat topography (i.e. limited surface water runoff).
- Identifying the sources of water feeding springs
- Determining whether groundwater is supporting coastal wetlands.
- The department has recently begun a three-year investigative program in the eastern half of the West Canning Basin (referred to as the Sandfire area). This work is being funded through the Royalties for Regions program and follows on from work completed as part of the Pilbara *Water For the Future* project.

Appendices

Appendix A — West Canning Basin rainfall recharge calculations and geology

The West Canning Basin lies between two pastoral stations – Pardoo and Mandora. Average annual rainfall is 314 mm at Pardoo Station and 371 mm at Mandora Station. The department has used the average of the two (343 mm) to calculate recharge (Table A 1).

Table A 1 Rudimentary direct rainfall recharge calculations

Recharge rate %	Potential direct recharge area m^2	Rainfall m	Recharge		
			m^3	ML	GL
2.7	2 800 000 000	0.343	25 923 240	25 923	26
6	2 800 000 000	0.343	57 607 200	57 607	58
15	2 800 000 000	0.343	144 018 000	144 018	144

Wallal Embayment (Hocking 1994)

The Wallal Embayment is a north-westward-plunging, complex half-graben infilled by the Carboniferous–Permian Paterson Formation and fault bounded on the north-east against the Wallal Platform. The south-western boundary against the Lambert Shelf is taken at the edge of significant preservation of the Grant Group. The embayment is here extended southwards into the Oakover valley, which is a Carboniferous–Permian, glacially eroded valley infilled by the Paterson Formation.

Wallal Platform (Hocking 1994)

The Wallal Platform is an elongate, north-west-trending horst between the Samphire Graben and Wallal Embayment. A basement ridge underlies the platform. The Grant Group and Paterson Formation are not preserved except at the south-east end of the platform, and its south-west and north-east margins are defined by faults. The platform extends southwards to steeply dipping, highly faulted Precambrian rocks of the Paterson Orogen.

Appendix B — Springs of the West Canning Basin

Myadee Spring is located close to the Great Northern Highway. It has been known since 1890 and was used as a watering point on a stock route from the Kimberley to the shipping settlement of Condon, close to the De Grey River estuary (Leech 1979). Despite the pool being dry for some years, Myadee Spring supports relatively dense *Melaleuca argentea* (cadjeput) and introduced palm trees, *Phoenix dactylifera* (Figure B 1).

Figure B 1 Myadee Spring

Two springs occur on the bank of Pardoo Creek, 3 km to the west of the Pardoo Station homestead. The pools associated with both springs are highly degraded. The pool at the Pardoo Creek Spring is about 150 m^2 in area (Figure B 2). *Typha domingensis* occur within the pool itself and a small but dense stand of *M. argentea* occurs along one edge. Grazing has removed the understorey.

Figure B 2 Pardoo Creek Spring

Pardoo Creek Palm Spring forms a soak which flows down gradient into a 200 m^2 pool on the very edge of the bed of the Pardoo Creek. *T. domingensis* occur within the soak with a small number of *M. argentea* and *P. dactylifera* on one edge of the pool (Figure B 3).

Figure B 3 Pardoo Creek Palm Spring

Three springs occur approximately 15 km to the north-east of the Pardoo Station homestead. The pool associated with Baningarra Spring is the largest in the West Canning Basin, at approximately 140 m long and 50 m wide at its widest point. Although highly degraded by stock access, the spring supports *T. domingensis* with *Acacia* sp. in drier areas (Figure B 4). Department staff noted numerous waterbirds at the site in November 2011.

Figure B 4 Baningarra Spring

Tiny Spring and Clear Spring occur on salt flats. Tiny Spring, so named as it is less than 50 m^2 in area, does not appear to have open water and is marked by a small stand of *T. domingensis* (Figure B 5). A very small, totally unvegetated freshwater pool is formed by Clear Spring (Figure B 6). This spring sits on the shoreline within 500 m of the sea.

Figure B 5 Tiny Spring

Figure B 6 Clear Spring

Appendix C - Modelling options and results

The details of the options run through the West Canning Basin groundwater model, and the results, are shown in Table C 1.

Table C 1 Modelling options and results (Aquaterra 2010)

Option	**Results**
Option 1	
• Pardoo and Wallal Station stock bores pumping at a maximum total rate of 0.2 GL/yr. • Shay Gap bore field (BHP Billiton) pumping at a total rate of 1.2 GL/yr. • Pardoo Roadhouse pumping at a total rate of 0.025 GL/yr. • Pardoo Station irrigation bore fields pumping with the following incremental abstraction regime: – Year 1 = 1.3 GL/yr (1 operational production bore) – Year 2 = 2.5 GL/yr (2 operational production bores) – Year 3 = 4 GL/yr (4 operational production bores) – Year 4 = 6 GL/yr (4 operational production bores) – Year 5 = 8 GL/yr (6 operational production bores) – Year 6 to 50 = 10 GL/yr (8 operational production bores) • Total maximum pumping rate of up to 11.4 GL/yr (from Year 6 onwards).	Wallal aquifer • After 20 years, the predicted maximum aquifer drawdown is 3 m in the immediate area around Pardoo and 0.5 m near the Shay Gap. • After 50 years, the predicted maximum aquifer drawdown is 3 m extending around the Pardoo area, with the 0.5 m drawdown contour extending up to about 70 km from the Pardoo area. • After 50 years, the Wallal aquifer remains confined as well as mostly artesian, with maximum drawdown at the coast of about 3 m. • The potential for saline intrusion is limited. Broome aquifer • After 20 years, the predicted maximum aquifer drawdown is 1 m S-W of Pardoo. • After 50 years, predicted maximum aquifer drawdown is 2 m with 0.5 contour extending towards Pardoo Station.

Option	Results
Option 2	
• As per Option 1, except that the prediction included dry climatic conditions, that is, no recharge was applied for the simulation period (worst case option). Groundwater inflow to the West Canning Basin from the east (via the fixed head inflow boundary) was unchanged. • Total maximum pumping rate of up to 11.4 GL/yr (from Year 6 onwards).	Wallal aquifer • After 20 years, the predicted maximum aquifer drawdown is 4 m in the proposed Pardoo irrigation bore field area, with the 0.5 m drawdown contour extending up about 90 km from the Pardoo area. • After 50 years, the predicted maximum aquifer drawdown is more than 5 m around the Pardoo area. • After 50 years, the Wallal aquifer remains confined as well as mostly artesian, with maximum drawdown at the coast of about 5 m. • The potential for saline intrusion is limited. Broome aquifer • After 20 years, the predicted maximum aquifer drawdown is 2 m S-W of Pardoo, with the 0.5 m and 1 m drawdown contours extending the length of the shoreline • After 50 years, the predicted maximum aquifer drawdown is 4 m S-W of Pardoo, the 0.5, 1 and 2 m contours extends the length of the shoreline.
Option 3	
• As per Option 1, with the addition of the proposed Atlas Iron bore field, which includes eight production bores pumping at a total maximum rate of 16 GL/yr. • Total maximum pumping rate of up to 27.4 GL/yr (from Year 6 onwards).	Wallal aquifer • After 20 years, the predicted maximum aquifer drawdown is 7 m in the area around the proposed Pardoo irrigation and Atlas Iron bore fields, with the 0.5 m drawdown contour extending up to about 80 km from the Pardoo bore fields. • After 50 years, the predicted maximum aquifer drawdown is 9 m in the area around the proposed Pardoo irrigation and Atlas Iron bore fields. However, the 1 m drawdown contour extends up to about 70 km from the Pardoo bore fields. • After 50 years, the Wallal aquifer remains confined as well as mostly artesian, with maximum drawdown at the coast of about 8 m. • The potential for saline intrusion is limited. Broome aquifer • After 20 years, the predicted maximum aquifer drawdown is 5 m S-W of the Pardoo area, with the 0.5 m contour extending 50-60 km west towards the De Grey River and east towards Pardoo Roadhouse. • After 50 years, the predicted maximum aquifer drawdown is 7 m S-W of the Pardoo area, with the 0.5 m contour extending 90–100 km west and east.

Option	Results
Option 4	
• As per Option 1, with the addition of a theoretical bore field located east of GSWA22 and GSWA24, which includes eight production bores pumping at a total maximum rate of 16 GL/yr. • Total maximum pumping rate of up to 27.4 GL/yr (from Year 6 onwards).	Wallal aquifer • After 20 years, the predicted maximum aquifer drawdown is 3 m in the area around the Pardoo bore fields and the ‘eastern’ bore field area. The 1 m drawdown contour extends about 130 km across the West Canning Basin. • After 50 years the predicted maximum aquifer drawdown is about 4 m in the area around the Pardoo bores, whilst a drawdown of up to 3 m is predicted around the ‘eastern’ bore field area and over a larger area around the Pardoo station and irrigation bores. The 1 m drawdown contour extends up to about 115 km across the West Canning Basin. • After 50 years, the Wallal aquifer remains confined as well as mostly artesian, with maximum drawdown at the coast of about 3.5 m. • The potential for saline intrusion is limited. Broome aquifer • After 20 years, the predicted maximum aquifer drawdown is 1 m S-W of the Pardoo borefield. • After 50 years, the predicted maximum aquifer drawdown is 1 m S-W of Pardoo and around the proposed borefield.

Option	Results
Option 5	
• As per Option 3, with the addition of the proposed Moly Mines bore field (east of Shay Gap), which includes seven production bored pumping at a rate of 5 GL/yr. • Total maximum pumping rate of up to 32.4 GL/yr (from Year 6 onwards).	Wallal aquifer • After 20 years, the predicted maximum aquifer drawdown is 8 m in the area around the proposed Pardoo irrigation and Atlas Iron bore fields and 2 m near the Moly Mines Spinifex Ridge bores. The 0.5 m and 1 m drawdown contours extend up to about 85 km and 70 km radially from Pardoo, respectively. • After 50 years, the predicted maximum aquifer drawdown is 10 m in the area around the proposed Pardoo irrigation and Atlas Iron bore fields. The 0.5 m and 1 m drawdown contours extend between 95 km and 80 km in a radial direction from Pardoo, respectively. • After 50 years, the Wallal aquifer remains confined as well as mostly artesian, with maximum drawdown at the coast of about 8.5 m. • The potential for saline intrusion is limited. Broome aquifer • After 20 years, the predicted maximum aquifer drawdown is 5 m S-W of the Pardoo area, with the 0.5 m contour extending west towards the De Grey River and east towards Pardoo Roadhouse. • After 50 years, the predicted maximum aquifer drawdown is 7 m S-W of the Pardoo area, with the 0.5 m contour extending west beyond the De Grey River and east beyond Pardoo Roadhouse.

Option	Results
Option 6	
• Pardoo Roadhouse, Pardoo Station and Wallal Station stock bores pumping at the same rates as those specified in Option 1. • A proposed regional bore field on the eastern side of the West Canning Basin, with a total abstraction to equal the same total abstraction as in Option 5 (up to 32.4 GL/yr) but spread over a greater area. • Total maximum pumping rate of up to 32.4 GL/yr (from Year 6 onwards).	Wallal aquifer • After 20 years, the predicted maximum aquifer drawdown is 3 m in the vicinity of pumping locations, with the 2 m drawdown contour extending up to 25 km toward the coast. The 0.5 m drawdown contour is predicted to extend up to about 115 km across the West Canning Basin. • After 50 years, the predicted maximum aquifer drawdown is 3 m extending up to 25 km in a radial direction from the centre of the bore field. The 0.5 m drawdown contour is predicted to extend up to about 125 km across the West Canning Basin. • After 50 years, the Wallal aquifer remains confined as well as mostly artesian, with maximum drawdown at the coast of about 2.5 m. • The potential for saline intrusion is limited. Broome aquifer • After 20 years, the predicted maximum aquifer drawdown is 0.5 m around the Pardoo bores and S/W of the Pardoo area. • After 50 years, the predicted maximum aquifer drawdown is 1.5 m around the Pardoo bores and S/W of the Pardoo area.

Appendix D— Map information and disclaimer

Datum and projection information

Vertical datum: Australian Height Datum (AHD)

Horizontal datum: Geocentric Datum of Australia 94

Projection: MGA 94 Zone 50

Spheroid: Australian National Spheroid

Project information

Client: Emily Harrington

Map author: Chelsea. Samuel

Filepath: J:\gisprojects\Project\C_series\C2219\033_West_Canning

Completion Date: May 2012

Disclaimer

These maps are a product of the Department of Water, Water Resource Use Division and were printed as shown.

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While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.

Sources

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Hydrography, Linear (Hierarchy) – DoW – 2007

DWAID Aquifers – DoW – 2012

DWAID Subareas – DoW – 2012

DWAID Groundwater Areas – DoW – 2012

Wallal Recharge Area – DoW – 2012

Wetlands, DIWA – DEC - 2001

RAMSAR, Wetlands – DEC– 2006

Coastal Management Zones – DoW – 2012

Inland Management Zones – DoW – 2012

WA Coastline – DoW – 2009

Bores WAWRC 2006 – DoW – 2012 updated

Bores GSWA 1979 – DoW – 2012 updated

Faults – DoW – 2012 updated

Salinity – DoW – 2012 updated

Drainage – DoW – 2006

Roads Centrelines – DLI – 2010

Surveyed Springs – DoW – 2012

Geographic Names – DLI – 2002

Model Limits Boundary – DoW – 2012

Shortened forms

ANSTO	Australian Nuclear Science and Technology Organisation
BoM	Bureau of Meteorology
DEC	Department of Environment and Conservation
DIWA	Directory of important wetlands in Australia
DoW	Department of Water
DWAID	Divertible water allocation information database
GSWA	Geological Survey of Western Australia
mbgl	Metres below ground level
NHMRC & NRMMC	National Health and Medical Research Council and Natural Resource Management Ministerial Council
PWS	Public water supply
WAWRC	Water Resources Commission, Western Australia
WCB	West Canning Basin
WRC	Water and Rivers Commission

Volumes of water

One litre	1 litre	1 litre	(L)
One thousand litres	1000 litres	1 kilolitre	(kL)
One million litres	1 000 000 litres	1 megalitre	(ML)
One thousand million litres	1 000 000 000 litres	1 gigalitre	(GL)

Glossary

Abstraction	The permanent or temporary withdrawal of water from any source of supply, so that it is no longer part of the resources of the locality.
Allocation limit	Annual volume of water set aside for consumptive use from a water resource.
Aquifer	A geological formation or group of formations capable of receiving, storing and transmitting significant quantities of water. Usually described by whether they consist of sedimentary deposits (sand and gravel) or fractured rock. Aquifer types include unconfined, confined and artesian.
Artesian aquifer	A confined aquifer in which the hydraulic pressure will cause water to rise in a bore or spring above the land surface. If the pressure is insufficient to cause the well to flow at the surface, it is called a sub-artesian aquifer.
Artesian head	The pressure head of artesian water.
Artesian well	A well, including all associated works, from which water flows, or has flowed, naturally to the surface.
Australian Height Datum	The datum used for the determination of elevations in Australia. The determination used a national network of bench marks and tide gauges, and set mean sea level as zero elevation.
Bore	A narrow, normally vertical hole drilled in soil or rock to monitor or withdraw groundwater from an aquifer.
Borefield	A group of bores to monitor or withdraw groundwater.
Confined aquifer	An aquifer lying between confining layers of low permeability strata (such as clay, coal or rock) so that the water in the aquifer cannot easily flow vertically. see artesian aquifer.
Consumptive use	The use of water for private benefit consumptive purposes including irrigation, industry, urban and stock and domestic use.
Dewatering	Removing underground water to facilitate construction or other activity. It is often used as a safety measure in mining below the watertable or as a preliminary step to development in an area.

Discharge	The water that moves from the groundwater to the ground surface or above, such as a spring. This includes water that seeps onto the ground surface, evaporation from unsaturated soil, and water extracted from groundwater by plants or engineering works.
Drawdown	The lowering of a watertable resulting from the removal of water from an aquifer or reduction in hydraulic pressure.
Ecological water requirement	The water regime needed to maintain ecological values of water-dependent ecosystems at a low level of risk.
Fit-for-purpose water	Water whose quality is suitable for the purpose for which it is intended. It implies that the quality is not higher than needed.
Groundwater	Water which occupies the pores and crevices of rock or soil beneath the land surface.
Hydrogeology	The hydrological and geological science concerned with the occurrence, distribution, quality and movement of groundwater, especially relating to the distribution of aquifers, groundwater flow and groundwater quality.
Licence	A formal permit which entitles the licence holder to ‘take’ water from a watercourse, wetland or underground source.
Public water supply reserve	Reservation of a volume of water to supply drinking water for human consumption.
Ramsar	Convention on wetlands, Ramsar, Iran, 1971.
Recharge	Water that infiltrates into the soil to replenish an aquifer.
Spring	A spring is where water naturally rises to and flows over the surface of land.
Stock and domestic water use	Water that is used for ordinary domestic purposes associated with a dwelling, such as: water for cattle or stock other than those being raised under intensive conditions; water for up to 0.2 hectares (if groundwater) or 2 hectares (if surface water) of garden from which no produce is sold. This take is generally considered a basic right.
Subarea	A sub-division within a surface or groundwater area, defined for the purpose of managing the allocation of groundwater resources. Subareas are not proclaimed and can therefore be changed internally without being gazetted.

Yield The yield is the calculated volume of water that can be taken from a system renewably, subject to the effects of climate variability, water quality and in situ water requirements.

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