GOVERNMENT OF WESTERN AUSTRALIA

GASCOYNE REGION WATER RESOURCES REVIEW AND DEVELOPMENT PLAN SUMMARY REPORT 1996

WATER RESOURCE ALLOCATION AND PLANNING SERIES

WATER AND RIVERS COMMISSION REPORT WRAP 3 1996

WATER AND RIVERS COMMISSION

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Aerial view of the Gascoyne River at Nine Mile Bridge

Gascoyne Region
Water Resources Review
and Development Plan
Summary Report
1996

A pamphlet designed to provide the community with an outline of the water resources in the Gascoyne Region and the probable future usage of that water in the Region.

Water and Rivers Commission
Policy and Planning

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Report No WRAP 3 1996

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Summary

Introduction

This booklet provides a concise outline of the existing and potential water resources as well as an insight into the possible future growth rates of population, industry and agriculture in the Gascoyne Region. More detail may be found in the main report entitled *Gascoyne Region Water Resources Review and Development Plan (1996).*

The Gascoyne Region is currently experiencing significant growth. Tourism is a relatively new industry in the region and is the fastest growing, contributing more than $70 million to the economy. Impressive features of the Gascoyne coast include the Ningaloo Reef, the World Heritage area at Shark Bay and world class game fishing and these provide a suitable backdrop for future development of tourism infrastructure. The Carnarvon Horticultural District, although relatively small is one of the most productive areas per hectare in Australia. Expansion proposals for tourism, horticultural and mining activities in the Gascoyne Region indicate potential dramatic changes in water consumption patterns. These, coupled with possible changes in the management of the Carnarvon Irrigation District, indicate that a strategic understanding of development and the resulting impacts on the region's water resources is imperative. This booklet is intended to improve that understanding.

The study area comprises three river basins (WAWRC, 1987). These are the Wooramel (703), Gascoyne (704) and Lyndon-Minilya (705) River Basins. The total area of these three basins is approximately 175,000 km^2. The Shires of Carnarvon and Exmouth are fully contained within the study area. The Shires of Shark Bay and Upper Gascoyne are partly contained in the study area.

The study area is essentially rural. Numerous stations and homesteads are scattered throughout the area and these occupy a vast proportion of the land. Four major population centres exist within the study area. These are Carnarvon, Exmouth, Denham and Gascoyne Junction. Other population centres include Coral Bay, Useless Loop, Burringurrah Aboriginal Community and Monkey Mia.

The primary industry activities of fishing, horticulture, pastoralism and mining, have provided a firm and diverse base for the Gascoyne economy. Although, a growing tourism sector has become a major element of the economy in recent years.

The study area of the *Gascoyne Region Water Resources Review and Development Plan* is shown in Figure 1.

Water Resources

Water resources in the region can be divided into two components; surface water and groundwater.

The surface water resources include the region's rivers, creeks, wetlands, pools and lakes. Numerous major and minor rivers flow from the east and these combine into a few major river channels which flow generally westward to the sea or to Lake MacLeod. These rivers flow intermittently, usually between January and August, as a direct result of rainfall runoff.

The Gascoyne River is the most significant river system in the region. Other major rivers are the Wooramel, Lyndon and Minilya Rivers. There is some potential for rivers in the region to be dammed. However, it should be noted that development of these surface water resources are subject to various constraints and these could outweigh the yield benefits which may be obtained. The surface water resources referred to in this booklet are shown in Figure 2.

The region does not conform to the groundwater area boundaries, however, it includes the Carnarvon Groundwater Area and portions of the Pilbara, Gascoyne and East Murchison Groundwater Areas. The region's groundwater resources exist primarily within the Carnarvon Basin, although some groundwater resources occur in the fractured rock province east of the basin. The hydrogeology of the region is controlled by the widespread occurrence of low permeability surficial formations and the general absence of thick and extensive aquifers. This, together with the climate, limits the potential of the major rivers to be large sources of recharge.

This very preliminary assessment has indicated that in some cases environmental values are likely to be significantly affected by water resource development, while other potential developments may remain relatively unconstrained.

Water Use Projections

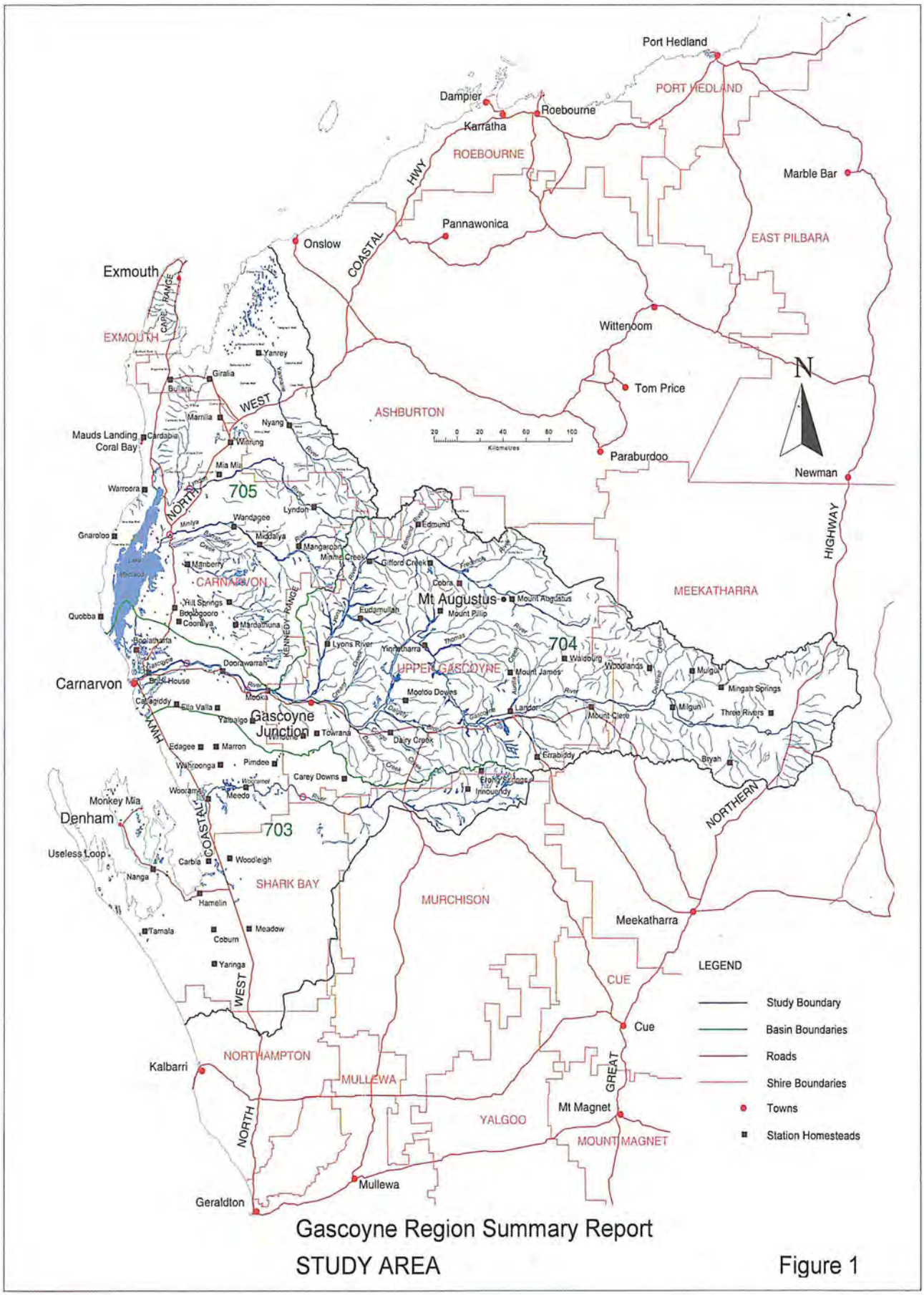
Population and water demand projections have been undertaken. Population projections for each town and significant settlement were undertaken to form the basis of the community water supply projections.

Total water demands from surface water and groundwater sources have been calculated separately for each drainage basin.

Conclusions

Essentially, potential exists for development of surface water sources to meet future demands within the region. However, development of these surface water resources are subject to constraints and these may outweigh the yield benefits which may be obtained.

At present, more than half the renewable groundwater resources in the region are utilised. By the year 2026, the amount of groundwater used in the region should decline, based on measures taken to curb the wastage from artesian bores in the pastoral areas. It is anticipated that usage from the artesian aquifer will be reduced to sustainable yield of the aquifer which would ensure its long term security. The potential groundwater supply and likely demand within the basins are presented in Figure 12.



Gascoyne Region Summary Report

STUDY AREA

Figure 1

Surface Water Resources

The surface water resources include the region's rivers, creeks, wetlands, pools and lakes. The Gascoyne River is the most significant river system in the region. Other major rivers are the Wooramel, Lyndon and Minilya Rivers. There is some potential for rivers in the region to be dammed.

Surplus available surface water will be foregone for development where the diversion development, such as a dam, would have an unacceptably adverse impact on environmental/social issues. Specific constraints will be determined for each development according to the downstream environmental/social needs and other issues through the environmental impact assessment process which is administered by the Department of Environmental Protection (DEP) and the Environmental Protection Authority (EPA). Development of any surface water resources must pass through this process before implementation.

The following is a summary of the surface water resources of each river basin.

Wooramel River Basin (703)

There are no potential dam sites or pipehead sites in the Wooramel River Basin. Any diversion of flows from the Wooramel River Basin must take into consideration any impacts on wetlands near Shark Bay and any impacts on the ecosystems of the Shark Bay world heritage area.

Gascoyne River Basin (704)

There are no existing surface water sources in the basin, however, there is some potential for dam sites or pipehead sites in the Gascoyne River Basin. These are listed in Table 1 and are shown in Figure 2. The surface water resources of the Gascoyne River Basin are likely to be turbid, due to the erosion of surface sediments by rainfall runoff from the sparsely vegetated landscape. Overgrazing by sheep and cattle may increase the risk of erosion.

Lyndon-Minilya Rivers Basin (705)

There are no existing surface water sources in the basin, however, there is some potential for dam sites or pipehead sites in the Lyndon-Minilya Rivers Basin. These are listed in Table 2 and are shown in Figure 2.

Table 1: Potential Dam Sites in the Gascoyne River Basin

Potential Dam Site	Average Streamflow (GL/year)	Potential Divertible Yield (GL/year)	Comments
Lockier Range (DS292)	248.6	50.7	constrained - due to distance
Kennedy Range (DS154)	805.4	235.7	constrained - due to high risk of salinity failure
Rocky Pool (DS55)	689.7	92.6	constrained - due to high risk of storage failure
Nine Mile Bridge (PHS15)	684.0	4.5*	constrained - due to high risk of storage failure
Mooka Creek (DS16)	0.11	0.04	small storage
Mungarra Creek (DS18)	0.18	0.07	small storage

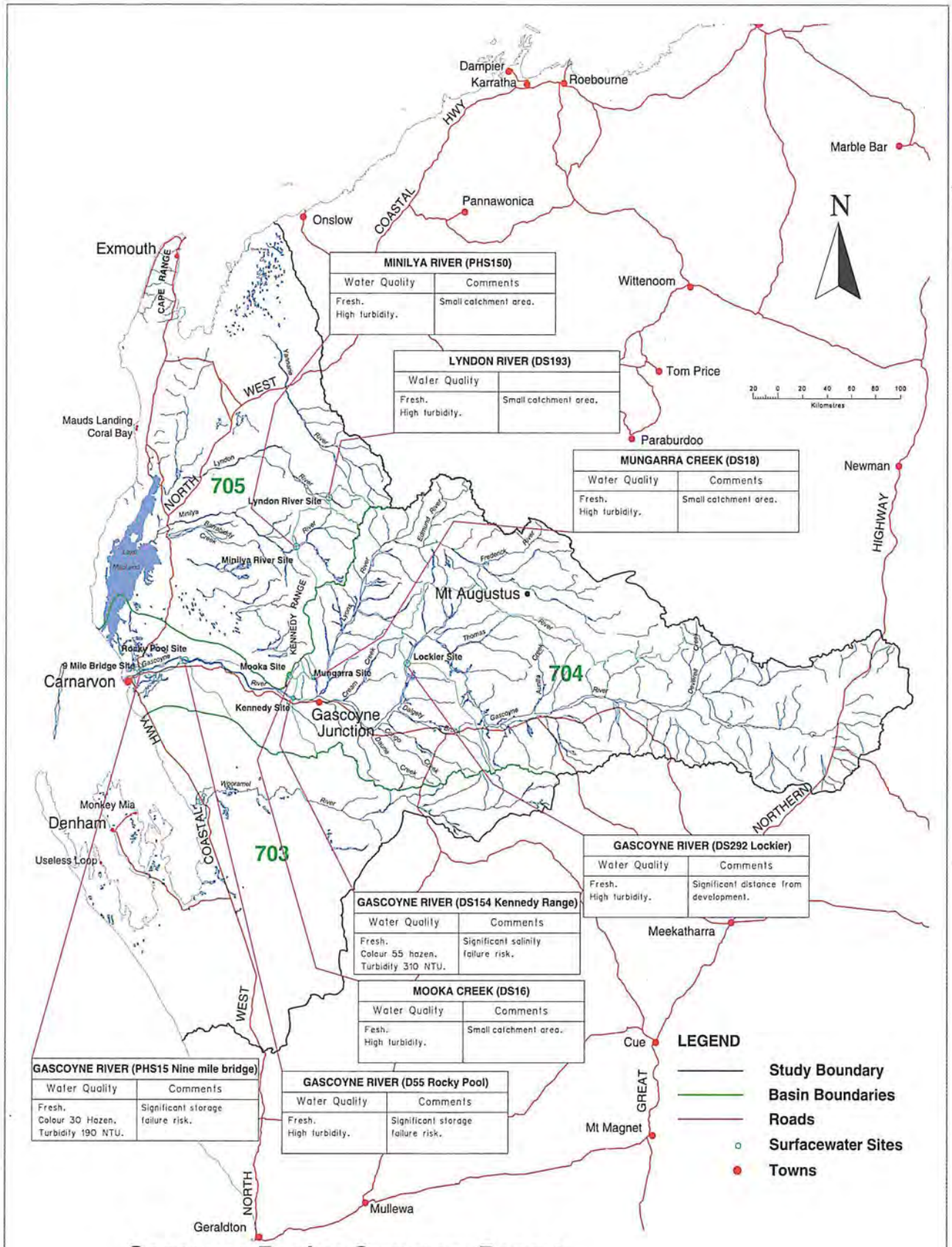
* *80% monthly reliability*

Table 2: Potential Dam Sites in the Lyndon-Minilya Rivers Basin

Potential Dam Site	Average Streamflow (GL/year)	Potential Divertible Yield (GL/year)	Comments
Lyndon River (PHS 193)	1.3	0.2	small storage
Minilya River (PHS 150)	20.2	4.7	small storage

Aerial view of Rocky Pool and surrounding landscape

Nine Mile Bridge Gauging Station



Gascoyne Region Summary Report

SURFACE WATER DEVELOPMENT SITES **Figure 2**

Groundwater Resources

The major groundwater resources in the region are contained in the sedimentary formations of the Carnarvon Basin. The basin contains up to 10,000 m of sedimentary rocks of predominantly marine origin. In the western Carnarvon Basin, the strata is generally flat-lying with some faulting and gentle folding, whereas in the eastern Carnarvon Basin, the strata is extensively faulted, locally folded and more steeply dipping. Extensive alluvial deposits associated with the major rivers occur in the western Carnarvon Basin, although, these are thin and poorly developed in the eastern Carnarvon Basin.

A regional water table extends throughout the basin and is recharged by rainfall infiltration or stream flow. It occurs at the surface in riverine pools and at depths of over 100 m in elevated areas. Perched water tables and springs may occur in the upland areas and extensive karst features occur in the Tertiary limestone underlying Cape Range. The regional flow systems are bounded by rivers, with flows occurring in the alluvium and Tertiary limestone.

Groundwater moves under gravity in the shallow, mainly catchment controlled regional flow systems towards the rivers in the interior plateau and upland areas and away from the rivers but towards the coast on the coastal lowland. Local groundwater mounds occur in some coastal areas (eg. Cape Range), along major drainage divides (eg. between Gascoyne and Lyons River) and possibly beneath some hills and ranges formed by outcropping strata. In areas of outcropping sandstone, some of the groundwater moves downward into deep confined flow systems in which the general direction of groundwater movement is towards the coast. Groundwater in the aquifer is generally brackish, although, fresh groundwater occurs beneath and adjacent to the major rivers and in some elevated areas.

The Birdrong Sandstone is the most extensive confined aquifer in the Carnarvon Basin. It occurs at considerable depth in the western Carnarvon Basin and varies up to 30 m in thickness. The aquifer probably contains several flow systems originating from different recharge areas. Artesian flows occur throughout most of the western part of the aquifer. Groundwater in the aquifer varies from fresh near the Wooramel River to hypersaline at Cape Range, however, it is generally brackish to saline.

Groundwater resources also occur in the fractured rock province to the east of the Carnarvon Basin. However, the groundwater is generally limited to the weathered profile or to fractures and joints in the granite bedrock. Alluvial sediments and calcrete overlie large areas along the main river channels. The groundwater resources occurring in the fractured rock province are generally brackish, although, fresh resources are present in some areas.

The hydrogeology of the region is controlled by the widespread occurrence of low permeability surficial formations and the general absence of thick and extensive aquifers. This, together with the climate, limits the potential of the major rivers to be large sources of recharge.

To facilitate long term management of the groundwater resources, much of the region has been proclaimed as *Groundwater Areas* (GWA's) under the provisions of the Rights in Water and Irrigation Act (1914) (RIWI). The study area does not conform to the groundwater area boundaries, although, it includes the Carnarvon Groundwater Area and portions of the Pilbara, Gascoyne and East Murchison Groundwater Areas.

The renewable and stored groundwater resources of the region are listed according to river basins in the tables overleaf. The renewable resources represent the water which is recharged to the aquifer on an annual basis and is a measure of the amount of water which may be abstracted from the aquifer on a sustainable (long-term) basis without depleting the stored resources. The stored groundwater resources represent the physical volume of water in the aquifer which may be subject to renewal or depletion from time to time. The location of the groundwater resources are illustrated in Figures 3 and 4.

Wooramel River Basin (703)

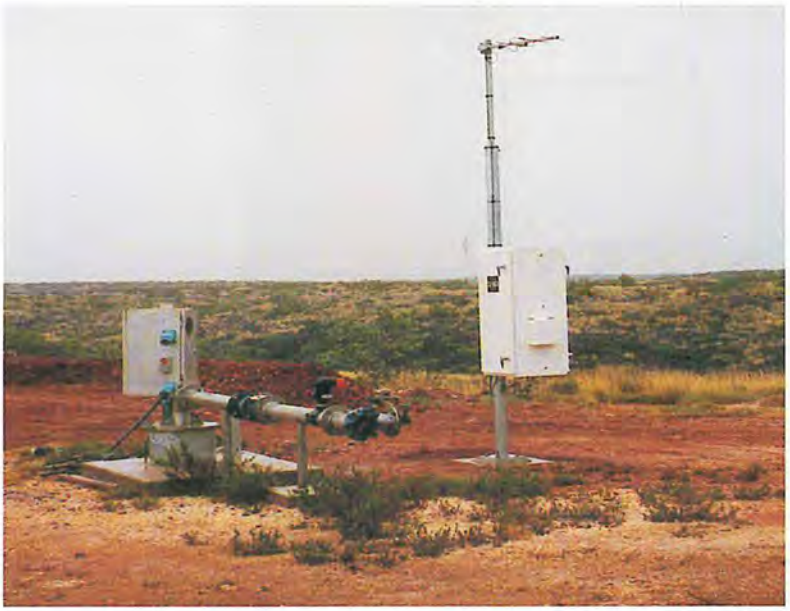
	Groundwater Resources with Salinity		
	< 1,000 mg/L TDS	1,000 - 3,000 mg/L TDS	> 3,000 mg/L TDS
Renewable Resources (GL)	2.2	36.0	6.4
Stored Resources (GL)	1,420	17,800	323,700

Gascoyne River Basin (704)

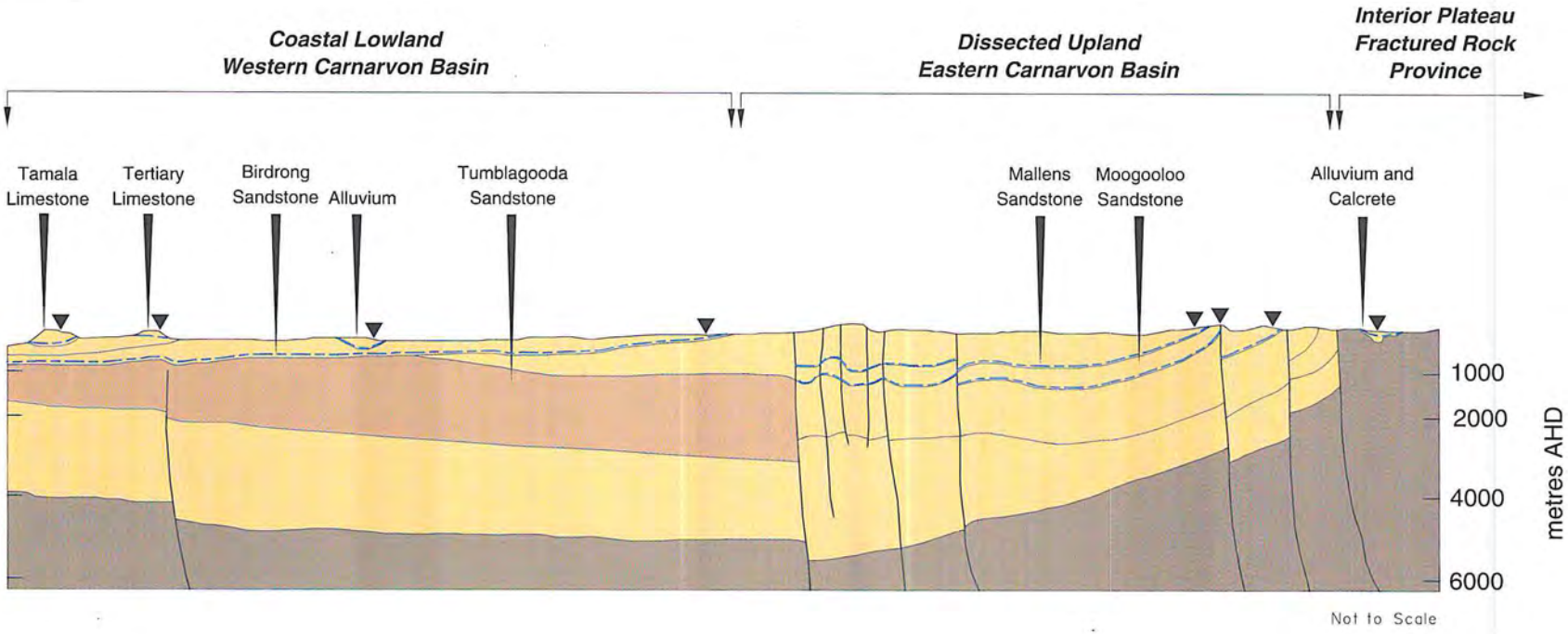
	Groundwater Resources with Salinity		
	< 1,000 mg/L TDS	1,000 - 3,000 mg/L TDS	> 3,000 mg/L TDS
Renewable Resources (GL)	66.7	18.3	10.2
Stored Resources (GL)	5,110	20,830	258,560

Lyndon-Minilya Rivers Basin (705)

	Groundwater Resources with Salinity		
	< 1,000 mg/L TDS	1,000 - 3,000 mg/L TDS	> 3,000 mg/L TDS
Renewable Resources (GL)	22.2	26.8	-
Stored Resources (GL)	1,035	14,355	14,700



Groundwater production bore at Exmouth

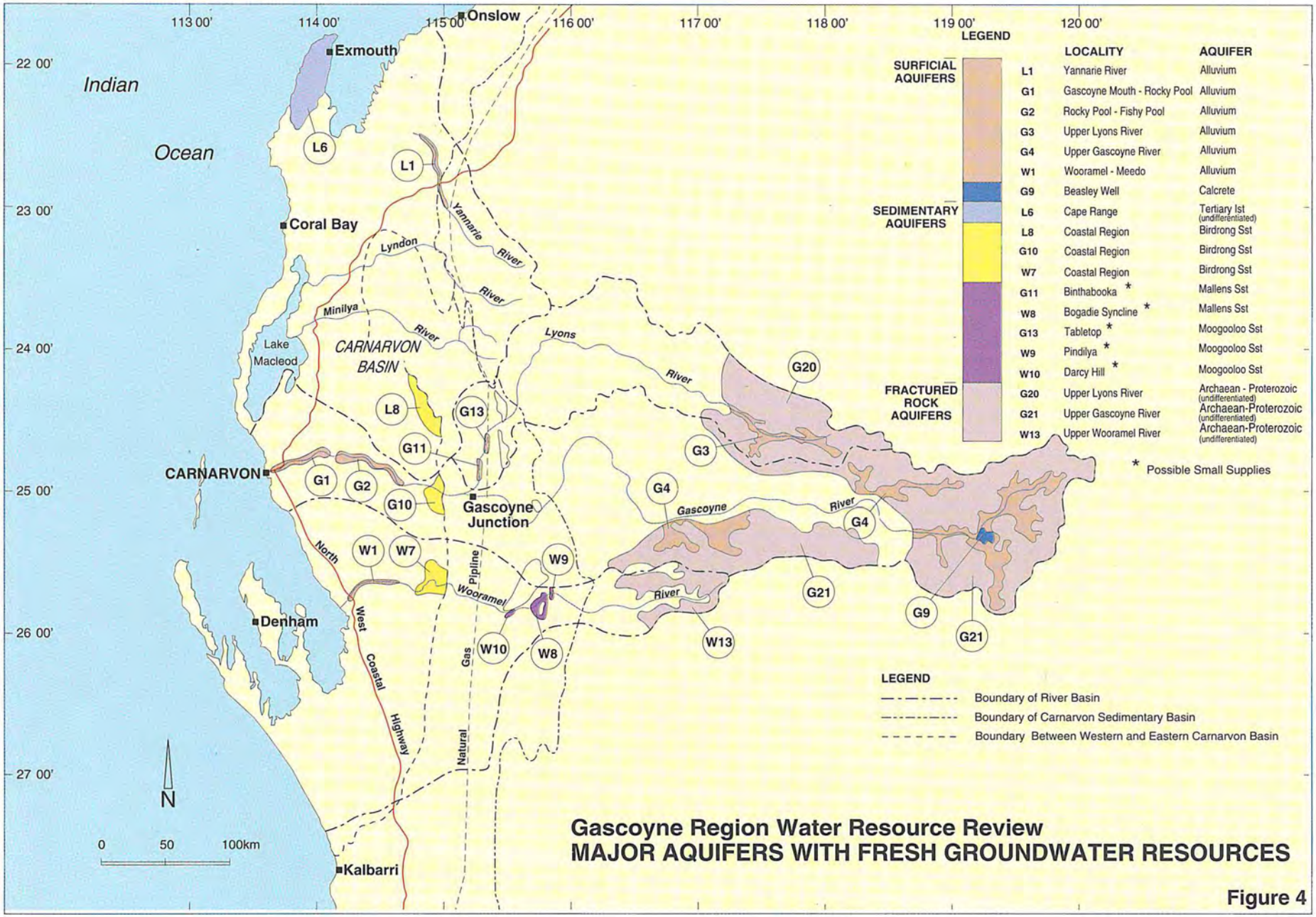


LEGEND

- ▼ Recharge area
- ---- Aquifer
- Siltstone and Shale
- Basement

Gascoyne Region Water Resource Review
DIAGRAMMATIC HYDROGEOLOGICAL CROSS SECTION

Figure 3



Gascoyne Region Water Resource Review
MAJOR AQUIFERS WITH FRESH GROUNDWATER RESOURCES

Figure 4

Alternative Water Source Options

There are limited fresh groundwater sources available in the Gascoyne Region. These resources are described in *Groundwater Resources*. The potential for traditional surface water sources such as dams and pipehead dams are also limited due to the poor topographical characteristics of the identified sites which may lead to salinity failure or storage failure. The potential dam sites and yields are described in *Surface Water Resources*. This chapter addresses the alternative water supply options which may be available for development in the Gascoyne Region.

Wooramel River Basin (703)

Desalination

Desalination is a technique currently used in the Wooramel River Basin to produce fresh water supplies for the town of Denham and other areas of Shark Bay. Groundwater drawn from the Birdrong Sandstone aquifer is generally brackish and has limited potential for use unless it is desalinated. Desalinated water is currently used for in-house purposes such as drinking and bathing. Current uses for the brackish groundwater include stock watering and irrigation of salt tolerant gardens.

The use of water is expected to increase and this is likely to be due to future increases in tourism and residential population in the Shark Bay area. It is expected that the demand for fresh water will increase in tune with increases in residential population and tourist numbers in the area. Fresh water is limited, therefore, it is considered that the potential for development and diversification in the basin will be largely dependent on the use of desalination practices.

Gascoyne River Basin (704)

The developed groundwater resources supplying the Carnarvon town and irrigation needs have been fully committed for years. Although, the granting of irrigation allocations has been pegged, the demand for water continues to increase. Positive steps are likely to be taken in the immediate future to address the water supply situation at Carnarvon. Augmentation options are currently being investigated which will improve the water availability to the Carnarvon area by approximately 4 GL.

Considerable investigation has been undertaken in the Gascoyne River Basin in past years to determine alternative sources to augment the water supplies to Carnarvon. The most up-to-date information is contained in a 1986 study by the Water Authority. However, despite results being based on streamflow data of poor quality, the 1986 study contains the only available information on the likely yields of some augmentation options. Augmentation options are described in Table 3.

Table 3: Gascoyne River Augmentation Options

Option	Description
Gated Weir across Gascoyne River	This proposal involves the building of a barrage or weir with gates which collapse when overtopped by a flood. Increases in yield benefit are small as once the surface storage has been used, the remaining groundwater storage is not much greater than if the supply had been from the groundwater alone. SMEC's preliminary findings are that this proposal is economically unviable.
Major Dams	Investigations indicate that major dams are not feasible as the sole water source because of the poor storage basin shape, irregular river flows and high evaporation. A dam would have to be operated conjunctively with the groundwater scheme to have most benefit. The risk of salinity failure increases if water is kept in storage to provide a drought reserve. Alternatively, the risk of supply failure increases if the water in storage is used first.
Major Off-Stream Storages	This system involves multiple tanks constructed of local earthen materials. These would be filled by pumping from the river during river flows. Evaporation losses could be controlled by building deep storages and covers could be advantageous. The system would be operated conjunctively with the groundwater scheme to provide the most benefit and water would be taken from the system having the greatest evaporation losses. Other offstream options include the Yandoo Creek Scheme and the Nichol Bay Flats Storage. These options are considered economically unviable due to the very small yields.
On-Farm Storages	The effectiveness of storages on individual properties is limited by operational efficiencies, method of construction and type of evaporation control.
Clay Barriers	This concept involves the installation of a clay barrier across the width of the river to act as an impediment to the downvalley flow of groundwater within the shallow river bed sand aquifers. The downvalley flow is considered to be extremely small. In addition, river flows may cause scour damage to the clay barriers. This option is considered unviable and should not be investigated further.
Upstream Extension beyond Rocky Pool	Groundwater in the alluvium aquifers of the Gascoyne River, upstream of Rocky Pool, has the potential to be used as a source of water. A recent assessment reveals that the maximum sustainable yield of the aquifer could be 8 GL/year, although further investigation should be carried out to verify the estimates. The establishment of new plantations in the Rocky Pool area would make better use of both land and water resources of the Rocky Pool area.
Artificial Recharge of Management Basin G	Artificial recharge to management Basin G may be possible because a major portion of this basin's storage is not located under the present river bed. The storage is located under the south bank, where a deposit of river sand up to 16 m deep exists. This basin does not recharge to the same extent as basins having the shallow storages below the river bed.
Increased Use of Deep Aquifer System	Groundwater available for abstraction from the older alluvium will depend on the management strategy adopted for the scheme. Potential problems from over-abstraction may include the loss of the existing level of supply security in the event of limited river flows.
Artificial Recharge of Prior Channels and Deeper 'Second' Aquifer	Artificial recharge by borehole injection was investigated in the past but was consideredunviable due to the relatively low permeability and limited areal extent of the aquifers. In their study, SMEC considers that artificial recharge by 'wick' drains, recharge wells and gravel trenches through the clay layer are the most likely augmentation options. SMEC indicates that these groundwater recharge options are the only ones which are justifiable on economic grounds.
Desalination	Desalination techniques may be used to provide fresh water resources for the Gascoyne River Basin. Desalination techniques, including Reverse Osmosis and Electrodialysis Reverse Cycle, have been used with success in the Wooramel and Lyndon-Minilya River Basins.

Lyndon-Minilya Rivers Basin (705)

Exmouth obtains its water from a wellfield located to the west and south of the town. The capacity of the existing wellfield is limited due to the geology of the area and the upconing effects of saline water from below the fresh water lens. Future augmentation options for Exmouth and other parts of the Lyndon-Minilya Rivers Basin are indicated below.

Extend Existing Wellfield

The Exmouth wellfield extends southwards to Mowbowra Creek, a significant physical barrier. To extend the wellfield further south, access, collector mains and power must be extended across Mowbowra Creek. The preferred way to achieve this is to extend the existing collector main and access road along the edge of the coastal flat with westerly 'legs' stretching into the foothills. The wellfield could be extended as far south as Learmonth or beyond, if necessary or economically feasible.

Purchase Desalinated Water from Naval Base

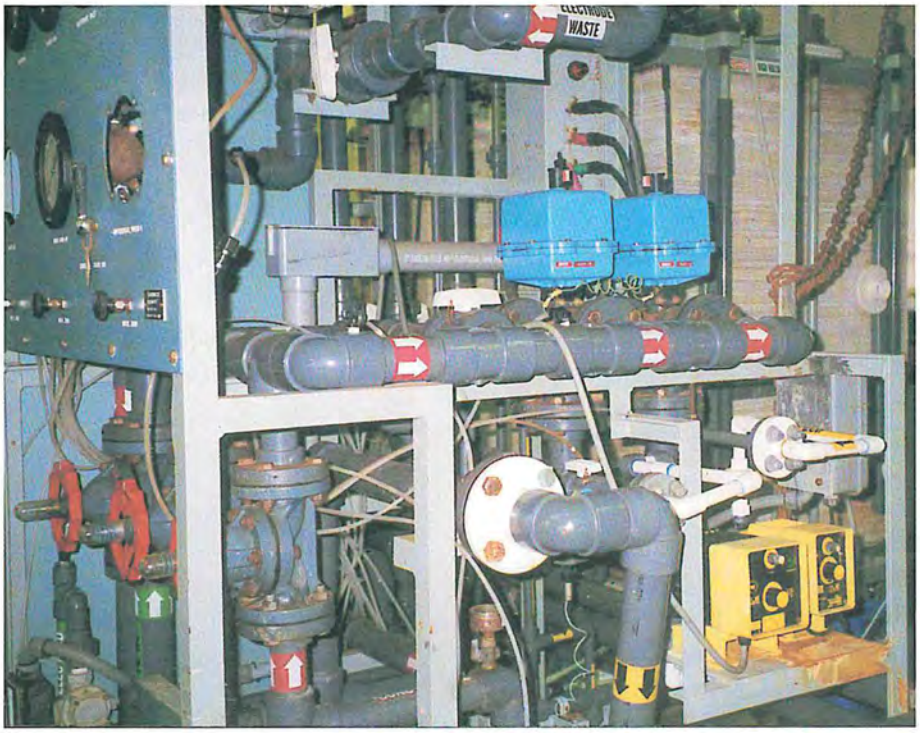
The Naval Base draws water from a wellfield located to the west of the Base and to the north of the Exmouth Town Water Supply Scheme. Water in this part of the aquifer is brackish and is desalinated to supply the Base's needs. It would be relatively simple to augment the existing TWS by about 400 kL/day, however, the sustainable yield of the aquifer should not be exceeded to achieve this objective. Desalinated water could be available immediately and this would provide an infusion of excellent quality water into the northern end of the town water supply scheme.

Desalination

Two desalination options could be used to provide water in the area. These are:

- Desalination of brackish water from wells in the northern part of the Exmouth wellfield,
- Desalination of sea water from wells near the coast.

In both cases, water could be pumped to desalination plants. The plants could be designed for easy transport so they may be used elsewhere, if required. Desalination will become increasingly viable when the cost of extending wellfields exceeds the cost of desalination.



Desalination Plant (Electrodialysis Reverse Cycle Process)

Environmental/Social and Cultural Issues

This very preliminary assessment has indicated that in some cases environmental values are likely to be significantly affected by water resource development, while other potential developments may remain relatively unconstrained. The environmental, social and cultural values of each river basin are outlined below.

Wooramel River Basin (703)

Environmental Values

- The Shark Bay World Heritage Area has international significance. It features outstanding examples of geological and biological evolution.
- Dam sites on the Wooramel River would significantly alter the river flow regime which could impact on the ecosystems of the Shark Bay heritage area.

Cultural Values

- Aboriginal sites / values

- Currently, one native title claim (Nanda) exists in the Wooramel River Basin. The area subject to claim has Aboriginal cultural significance.

- European sites / values

- There are numerous sites of European cultural significance. These include sites of early discovery and settlement, such as Dirk Hartog's landing.

Social Values

- Recreational values

- The Shark Bay area provides regionally significant opportunities for water dependent and water orientated recreational activities. Monkey Mia is a well recognised recreational area.

Gascoyne River Basin (704)

Environmental Values

- Dam sites on the Gascoyne River would significantly alter the river flow regime which could impact on ecosystems of the area. Environmental impacts associated with the development of the identified potential surface water resources (at Lockier Range, Kennedy Range, Rocky Pool, Nine Mile Bridge, Mooka Creek and Mungarra Creek) may include increased water salinity due to high evaporation and increased flood risk caused by the obstruction of river flows by dam walls. These impacts may outweigh the possible yield benefits obtained.

Cultural Values

- Aboriginal sites / values

- Currently, five native title claims (Crowe, Burringurrah Wadjari, Nganawongka, Nganawongka 3 and Nganawongka Wandjari) exist in the Gascoyne River Basin. Areas subject to claim have Aboriginal cultural significance.

- European sites / values

- There are numerous sites of European cultural significance. These include sites of early discovery and settlement, such as Carnarvon town and Brickhouse Station.

Social Values

- Community values

- Gascoyne Junction may be subject to permanent inundation if a potential dam site (Kennedy Range) is implemented. The risk of flooding at Rocky Pool and Carnarvon may also be heightened if potential barrages are implemented in these areas.

- Recreational values

- The Fascine area near Carnarvon provides significant opportunities for water dependent and water orientated recreational activities.

Lyndon-Minilya Rivers Basin (705)

Environmental Values

- Subterranean fauna occupying the underground caves and fissures of the Cape Range landscape represent rare and unique species of worldwide scientific significance. These fauna are sensitive to hydrological changes and may be impacted by groundwater abstraction, limestone excavation and other activities which may potentially disrupt the existing hydrological regime.
- Dam sites on the Lyndon and Minilya Rivers would significantly alter the river flow regime which could impact on ecosystems of the area.

Cultural Values

- Aboriginal sites / values

- Currently, two native title claims (Thalanyji and Thalanyji 2) exist in the Lyndon-Minilya Rivers Basin. Areas subject to claim have Aboriginal cultural significance.

- European sites / values

- There are numerous sites of European cultural significance. These include sites of early discovery and settlement, such as Point Maud.

Social Values

- Recreational values

- The North West Cape area provides regionally significant opportunities for water dependent and water orientated recreational activities. Other significant recreational areas include Coral Bay and the Ningaloo Reef.

Town/Settlement Water Supply Projections and Water Source Development Options

The Gascoyne Region's population has fluctuated in past years. However, the population is expected to increase in future due to the prospect of increased economic activity in the region.

Potential residential development projects are proposed in Carnarvon, Denham, Exmouth and Gascoyne Junction and a tourism/residential development has also been proposed at Maud's Landing. These developments are likely to boost population further.

To cater for future water demand, population increases have been projected to the year 2026 for municipal centres, along with the corresponding increases in water consumption.

Two population growth scenarios have been developed; 'medium' and 'high'. The 'medium' scenario is referred to as 'projected population'. The 'high' scenario is referred to as the 'feasible population' and is used to demonstrate the likely maximum needs in the respective areas.

Growth scenario projections of water demand to the year 2026 for each municipal centre are summarised in Figures 5 to 8.

Future increases in water demand from town/settlement water supplies will place further pressure on the existing water sources. Based on the expected water demand in the year 2026, as well as the current availability of water from the sources, water source development options have been offered. These development options range from extension of the existing borefields (groundwater) to the development of new water sources and are shown in Table 4.

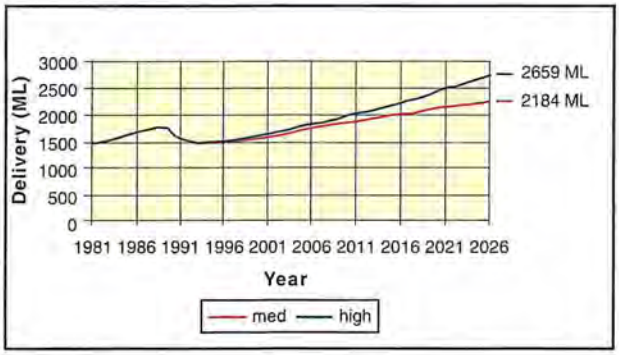


Figure 5: Water Demand Projections Carnarvon Town

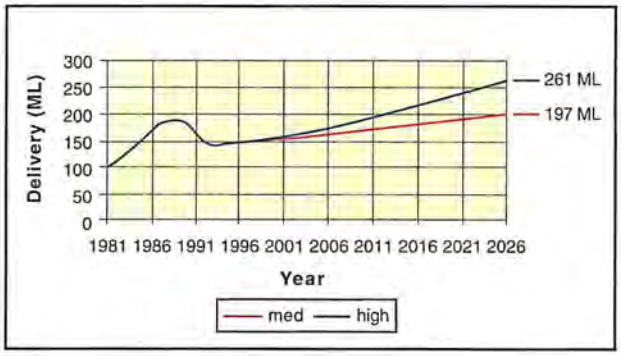


Figure 7: Water Demand Projections Denham

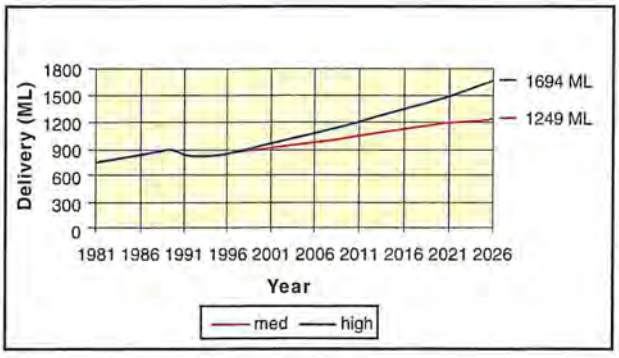


Figure 6: Water Demand Projections Exmouth Town

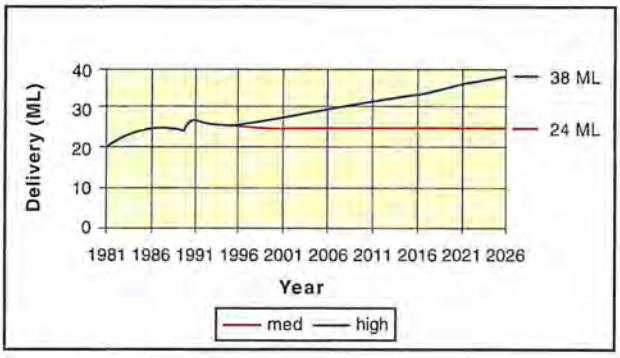


Figure 8: Water Demand Projections Gascoyne Junction

Table 4: Town/Settlement Water Supply Development Options

Town/Settlement Water Supply Scheme	Current Source	Current Licence (ML)	Estimated Water Requirements in 2026 (ML)	Future Development Options
Denham Town	Birdrong Sandstone Aquifer	200	261	- expansion of existing borefield (desalination for potable supplies)
Monkey Mia	Birdrong Sandstone Aquifer	100	106	- expansion of existing borefield (desalination for potable supplies)
Useless Loop	Birdrong Sandstone Aquifer	200	167	- expansion of existing borefield (desalination for potable supplies)
Carnarvon Irrigation and Town	Gascoyne River Alluvium Aquifer	6,800	6,909	- Carnarvon irrigation augmentation scheme - possible expansion of existing borefield
Proposed Rocky Pool Horticultural Area	—		8,000	- groundwater abstraction from Gascoyne River alluvium aquifer
Gascoyne Junction Town	Gascoyne River Alluvium Aquifer	40	38	- expansion of existing borefield
Burringurrah Aboriginal Community	Fractured Rock Aquifer	?	100?	- expansion of existing borefield
Exmouth Town	Tulki and Trealla Limestone Aquifer	800	1,694	- expansion of existing borefield - purchase water from Naval Base - desalination of sea water
Coral Bay	Birdrong Sandstone Aquifer	?	450	- expansion of existing borefield (desalination for potable supplies) - desalination of sea water
Proposed Maud's Landing	—		690	- groundwater abstraction from Birdrong Sandstone Aquifer (desalination for potable supplies) - desalination of sea water
Harold E Holt Naval Base	Tulki and Trealla Limestone Aquifer	217	221	- expansion of existing borefield (desalination, if necessary) - desalination of sea water

Agricultural Development and Growth Potential

The rural (primary) industries have historically been the mainstay of the regional economy and agriculture has significance to the future of the region. The region contributes significantly to the State's agricultural production. The relationship between agriculture, the natural environment and other land uses in the region are changing and values placed on agriculture and its location are being redefined.

Horticulture and pastoral activity are industries which already contribute significantly to the Gascoyne Region. Horticulture primarily takes place along the banks of the Gascoyne River, near Carnarvon and pastoral activity occurs extensively throughout the region. Although, development may be constrained in certain locations, potential exists for further development of agriculture in the region.

Future developments in the agricultural industry may include:

- establishment of the proposed Rocky Pool Horticultural area; and
- possible diversification of production in the pastoral industry.

Demand for water supplies will increase with the growth of agricultural activities in the region. The implementation of the proposed Rocky Pool Horticultural area is expected to have a significant effect on the water resources in the area. While there may be suitable surplus land in the Rocky Pool area with respect to water resources, the extent of horticultural development in the area will be limited by the availability of suitable water resources in the area. The maximum annual water availability is expected to be approximately 8 GL per year. Efficiencies in water usage and irrigation techniques may be possible and this would optimise the water availability.

Growth of the existing Carnarvon horticultural area is limited as the existing groundwater supplies are already fully committed. However, investigations on the future management and augmentation of the Carnarvon Irrigation area are currently being undertaken. It is anticipated that up to 4 GL of additional water per year may be available to the Carnarvon irrigation area.

Water demand projections relating to horticultural activity are presented graphically in Figures 9 and 10.

The pastoral industry is a major user of groundwater in the artesian aquifers. Groundwater usage from artesian bores is estimated to be approximately 45 GL per year. This groundwater usage still exceeds the total recharge to the aquifer of about 28 GL per year of which only 17 GL per year is recharged to the most heavily exploited part of the aquifer.

The Gascoyne Region supports an estimated 725,000 sheep and 33,000 cattle. In this region, one dry sheep equivalent is expected to consume 1.5 kL per year which equates to a total demand of about 2 GL per year. The current usage of 45 GL per year (mostly from uncontrolled artesian bores) would appear to be a substantial overuse of a regionally valuable resource.

The main effect of controlling the artesian flows would be to maintain artesian pressures in the aquifer for an indefinite period. Another effect of controlling the artesian flows is to conserve groundwater resources. By the year 2026, it is anticipated that groundwater usage from the artesian pastoral bores will be reduced to the sustainable yield of the aquifer (approximately 20 GL per year), based on measures taken to curb the wastage of water from uncontrolled flowing bores.

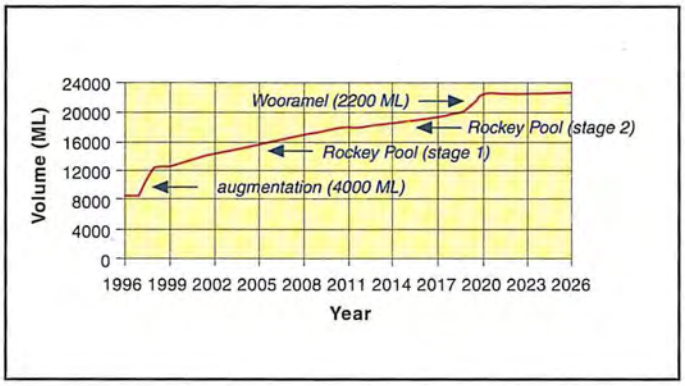


Figure 9: Horticultural Projection High Growth Scenario

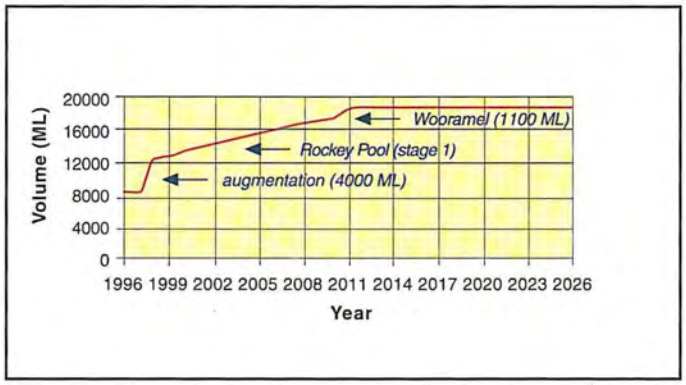


Figure 10: Horticultural Projection Medium Growth Scenario

Irrigated Horticulture at Carnarvon

Tourism Development and Growth Potential

The growth of the tourism industry will have an impact on the natural resources, existing infrastructure and utilities, such as power and water supply. Increased tourist numbers and a general increase in the number of permanent residents will lead to an increased demand on water resources. Periods of high water consumption during peak holiday seasons may place pressure on existing water sources and promote the need for development of new sources.

The development of new sources is restricted by the climate and geology of the region. Despite the presence of large rivers, surface water resources are unreliable and difficult to develop because of the large variation in rainfall and high evaporation rates. Groundwater occurs throughout the region. However, in response to the varied geology and climatic factors, the groundwater varies widely in the amount available and in its salinity.

Consideration to the availability and quality of water resources must be made in planning for future development of the tourism industry. Planning of developments related to the tourism industry should consider the impacts they may have on existing and future water resources in the Gascoyne Region and should give due consideration to the sustainable allocation of resources as well as the effect of potential pollutants on the water resources.

Competition for water resources may arise when the existing sources can no longer sustain demand. The tourism industry is only one growing industry in the Gascoyne Region in which the future water requirement is an important issue related to its development. Therefore, if future usage is not allocated sustainably, the water resources may become exhausted under the pressure of competition.

Major potential tourism developments in the region are shown below. The developments should give regard to the potential for the available water resources to sustainably meet the projected water demands.

- proposed Monkey Mia resort expansion,
- proposed Maud's Landing tourism and residential development,
- additional tourism developments in Coral Bay arising from proposed infrastructure improvements.

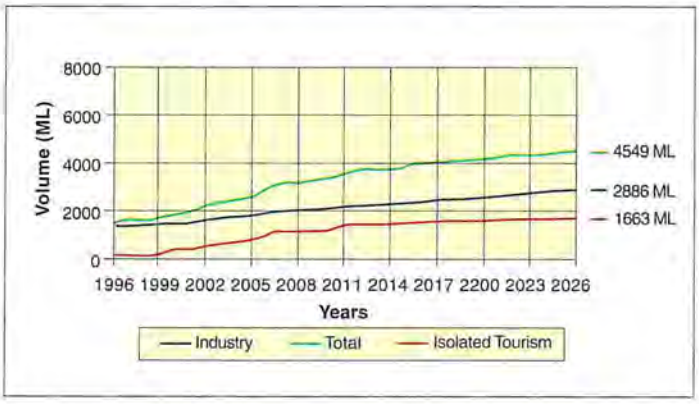


Figure 11: Tourism and Industrial Growth Projection

Industrial Development and Growth Potential

The Gascoyne Region's economic activity is diverse and relatively well balanced. Much of the product from the region is directed either to the Perth metropolitan domestic market or to export markets. While the region has a small economy, it has one of the broadest with important contributions being made to economic activity and employment by a variety of sectors.

The economic return from tourism and mining are likely to expand in the medium term. In the longer term, growth may also be expected from the fishing, aquaculture and horticultural industries. The prospect of strategic industrial development is also strong, particularly in the North West Cape, where development associated with quality limestone resources are proposed.

The region's fishing sector provides a rich variety of seafood to the domestic and international market. Fishing in the region is based primarily on prawns, scallops and finfish. The catch is processed in the region and is the region's principal manufacturing activity. The region's mining sector makes an important contribution to the region in both economic and employment terms Production from the region is almost entirely attributable to salt mining, although, significant contributions have been made from gypsum mining recently.

Potential exists for further industrial development in the region, although, it may be constrained in certain locations. Future developments which may impact on the growth of industry in the region include:

- establishment of a new boat harbour at Exmouth,
- proposed upgrading of the airport terminal at Learmonth,
- gypsum processing at Lake MacLeod,
- proposed limestone mining project near Exmouth,
- potential aquaculture initiatives.

Demand for water supplies will increase with the growth of industrial activities in the region. Currently, 1.5 GL of water is used in the region for industrial purposes and includes the mining, fishing and manufacturing sectors. The future water demand has been projected and considers only the known large scale developments which are expected to require water within the next five to ten years. This assessment includes the water requirements associated with the expansion of the salt, gypsum, limestone and fishing/fish processing industries. Water usage from the naval base may also increase as industries take advantage of the water and infrastructure available at the base. Projections indicate that the industrial water requirements in 2026 are likely to be approximately 2.9 GL.

Approximately, 0.2 GL is believed to be used by the tourism industry in areas remote from major towns in the region. Tourism developments in the major towns are expected to use water obtained from the town reticulated supplies and are accounted for in the town water supply projections. The future water demand for the tourism industry remote from towns has been projected and includes the known large scale developments which are expected to require water within the next five to ten years. The assessment includes the water requirements associated with the expansion of the tourism industry at Monkey Mia, Coral Bay, Maud's Landing, Nanga and the North West Cape. Projections indicate that the tourism water requirements in 2026 could be approximately 1.6 GL.

Water demand projections relating to tourism and industrial activity are shown graphically in Figure 11.

Significant development pressure is likely to occur at the existing development nodes of Carnarvon, Shark Bay and the North West Cape. Competition for water resources is likely to arise when the existing sources cannot sustain demand. If future usage is not allocated sustainably, these water resources may become exhausted under the pressure of competition.

Conclusion

Currently, groundwater resources are largely used by the agricultural sector in the Gascoyne Region. Demands for groundwater resources are relatively small from the town water supplies and tourism/industrial sector. Groundwater is allocated to sustain the environmental value of the region. Groundwater allocations are based on sustainable yield. Currently, the surplus groundwater available is almost half of the total groundwater resources of the Gascoyne Region.

The Gascoyne Region is prone to drought. The effects of drought on groundwater availability varies according to the hydrogeological characteristics of the resource, particularly storage. A small superficial aquifer will be largely affected by short term climatic variations. Management of groundwater during drought should be tailored to reflect the characteristics of the aquifer, with the impacts on water users and the long term sustainability of the resource being the primary objectives.

In Carnarvon, the water supply for irrigation relies on the resources available from the Gascoyne River and its aquifers. These limited resources are allocated to ensure that the horticultural industry can be sustained through all but extended drought periods. The process for setting allocations is based on the aquifer storage position and the time since the river flowed.

Demands for groundwater from the town water supplies and the tourism/industrial sector are expected to increase marginally by the year 2026. Demands for groundwater from the agricultural sector may decrease marginally by the year 2026 and this is due to anticipated reductions in the amount of water being wasted from uncontrolled flowing artesian bores.

Groundwater allocations will continue to be based on sustainability, which will allow for environmental requirements. It is expected that there will be considerable groundwater resources available in the Gascoyne Region in the year 2026 and this is likely to occur in remote areas where demand and development potential is low. Nevertheless, strong competition for the available groundwater resources is expected to occur in key populated areas and in locations where there is favourable (perhaps multi-sector) development potential.

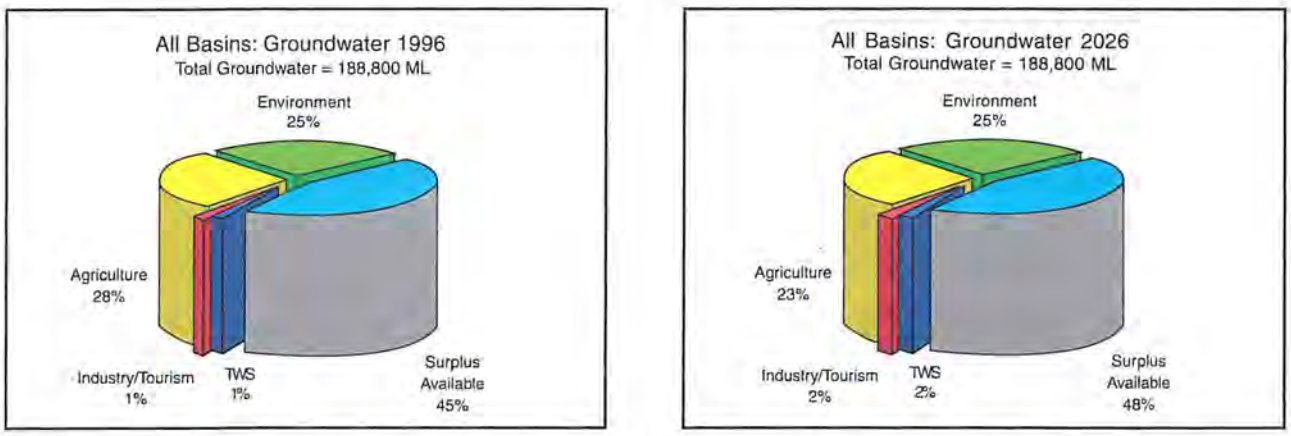


Figure 12: Potential Groundwater Supply and Likely Demand Within the Study Region 1996 and 2026

Glossary

Aquifer	A geological formation or group of formations capable of receiving, storing and transmitting significant quantities of water.
Brackish water	Water of salinity 1000 - 3000 mg/L TDS.
Dam	A structure constructed across a river valley to store stream flow and allow it to be diverted for water supply use and for release in a controlled manner for downstream use.
Demand	The amount of water required from the water supply system.
Divertible water	The average annual volume of water which could be removed from developed or potential sources on a sustainable basis.
Diversion	Development of a water resource to harvest some or all of its divertible water.
Fresh water	Water of salinity less than 500 mg/L TDS.
Gigalitre	1000 Megalitres.
Groundwater	Water which occupies the pores and crevices or rock or soil.
Groundwater area	An area proclaimed under the Rights in Water and Irrigation Act (1914) in which private groundwater abstraction is licensed.
Kilolitre	1000 litres.
Marginal water	Water of salinity 500 - 1000 mg/L TDS.
Megalitre	1000 Kilolitres.
Pipehead	A small dam allowing some of the water flowing in a stream to be diverted into a pipe for water supply use.
River basin	The catchment of river(s) as defined by the Australian Water Resources Council for presenting hydrological data.
Saline water	Water resources of salinity greater than 3000 mg/L TDS.
Salinity	The measure of the total soluble (or dissolved) salt, ie. mineral constituents in water. Water resources are classified on the basis of that salinity in terms of milligrams per litre Total Dissolved Salts (mg/L TDS).
Scheme supply	Water diverted from a source (or sources) by a water authority or private company and supplied via a distribution network to customers for urban, industrial or irrigation use.
Self supply	Water diverted from a source by a private individual, company or public body for their own individual requirements.
Strategy	A set of policies or means aimed at a set of objectives designed to bring various actions under unified direction in order that the organisation's or community's objectives may be effectively served. It may consist of one or more source options, water efficiency policies, as well as a commitment to research and develop "environmentally friendly" options.
Superficial Formation	An unconfined aquifer at depth 0-15m.
Surface water	Water flowing or held in streams, rivers and other wetlands in the landscape.
Sustainable	The rate of water extraction from a source that can be sustained on a long-term basis without exceeding the rate of replenishment. Sustainable groundwater use limits extraction to no more than the recharge rate and requires sufficient throughflow to prevent significant ocean water intrusion into aquifers.

System yield	The maximum demand that the water supply system can sustain under specified expectation of restrictions (currently restrictions are expected in 10% of years).
Treatment	Application of techniques such as settlement, filtration, chlorination, to render water suitable for drinking purposes.
Turbidity	Clouding of water due to suspended material in the water causing a reduction in the transmission of light.
Water Reserve	An area proclaimed under the metropolitan water Supply Sewerage and Drainage Act or Country Areas water Supply Act to allow the use of water on or under land for public water supplies.
Water Resources	Water in the landscape (above and below ground) with current or potential value to the community and the environment.
Water Table	The surface of the unconfined groundwater, which may be above ground as swamps or lakes in low-lying areas. Measured as the level to which water rises in a well tapping an unconfined aquifer.
Well	A hole dug or drilled (bore) from the ground surface into a groundwater aquifer to monitor or to withdraw water. Household wells are commonly termed bores.
Wellfield	A grouping of wells to extract large volumes of groundwater, generally for scheme supply.
Wetland	Area of seasonally, intermittently or permanently waterlogged soils or inundated land, whether natural or otherwise, fresh or saline.
Yield benefit	The increase in system yield which occurs when source is added to the water supply system.