



GASCOYNE REGION  
WATER RESOURCES REVIEW  
AND DEVELOPMENT PLAN  
1996

APPENDICES  
VOLUME II OF II



WATER RESOURCE ALLOCATION AND PLANNING SERIES

WATER & RIVERS COMMISSION REPORT WRAP 3 1996



WATER AND RIVERS  
COMMISSION

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GASCOYNE REGION  
WATER RESOURCES REVIEW AND DEVELOPMENT PLAN  
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APPENDICES  
VOLUME II OF II

by

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Water and Rivers Commission  
Policy and Planning

WATER AND RIVERS COMMISSION  
WATER RESOURCE ALLOCATION & PLANNING SERIES  
REPORT NO WRAP 3 1996

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## **Appendix A : Rainfall Information**

Figure A.1 : Rainfall Histogram for Carnarvon

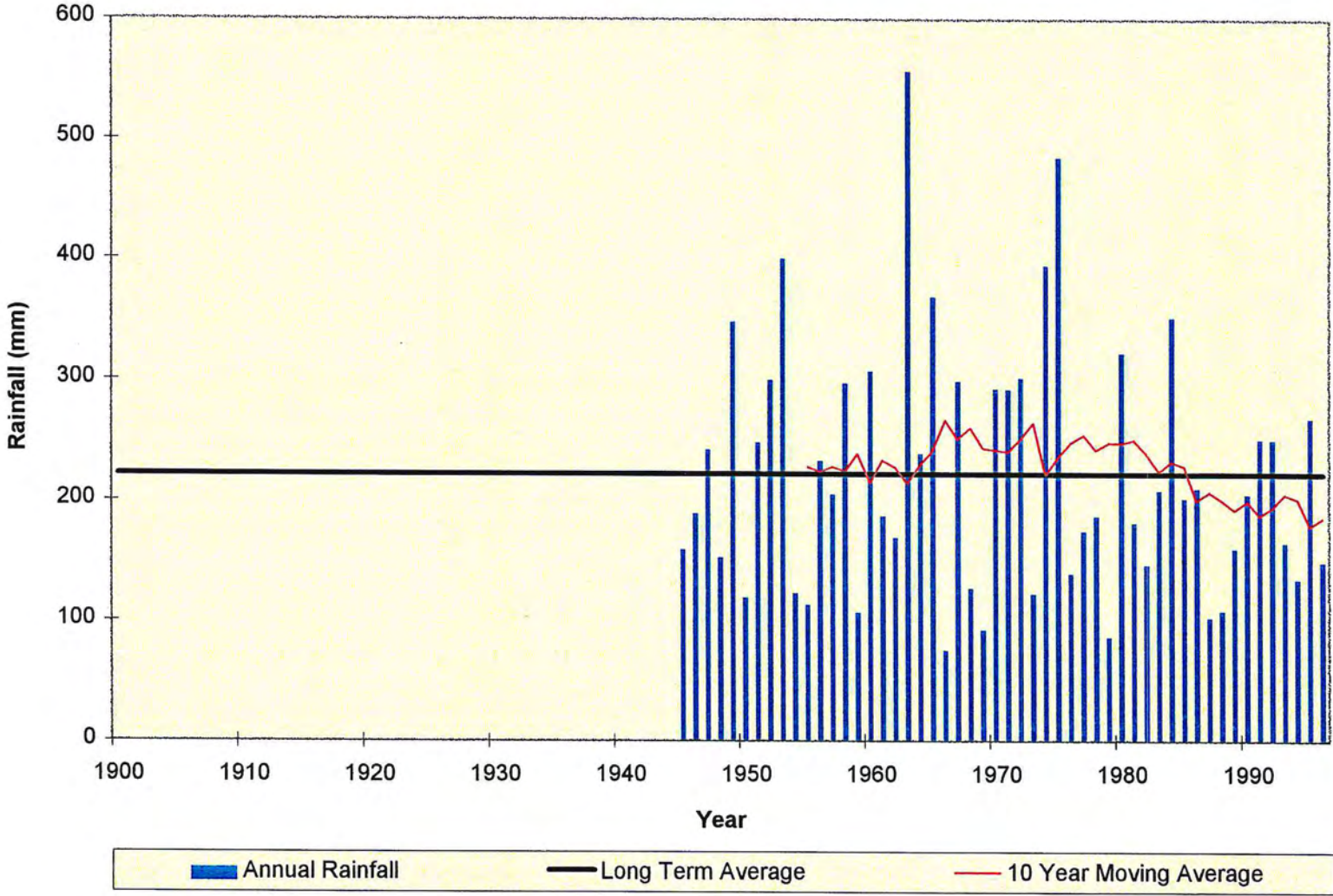
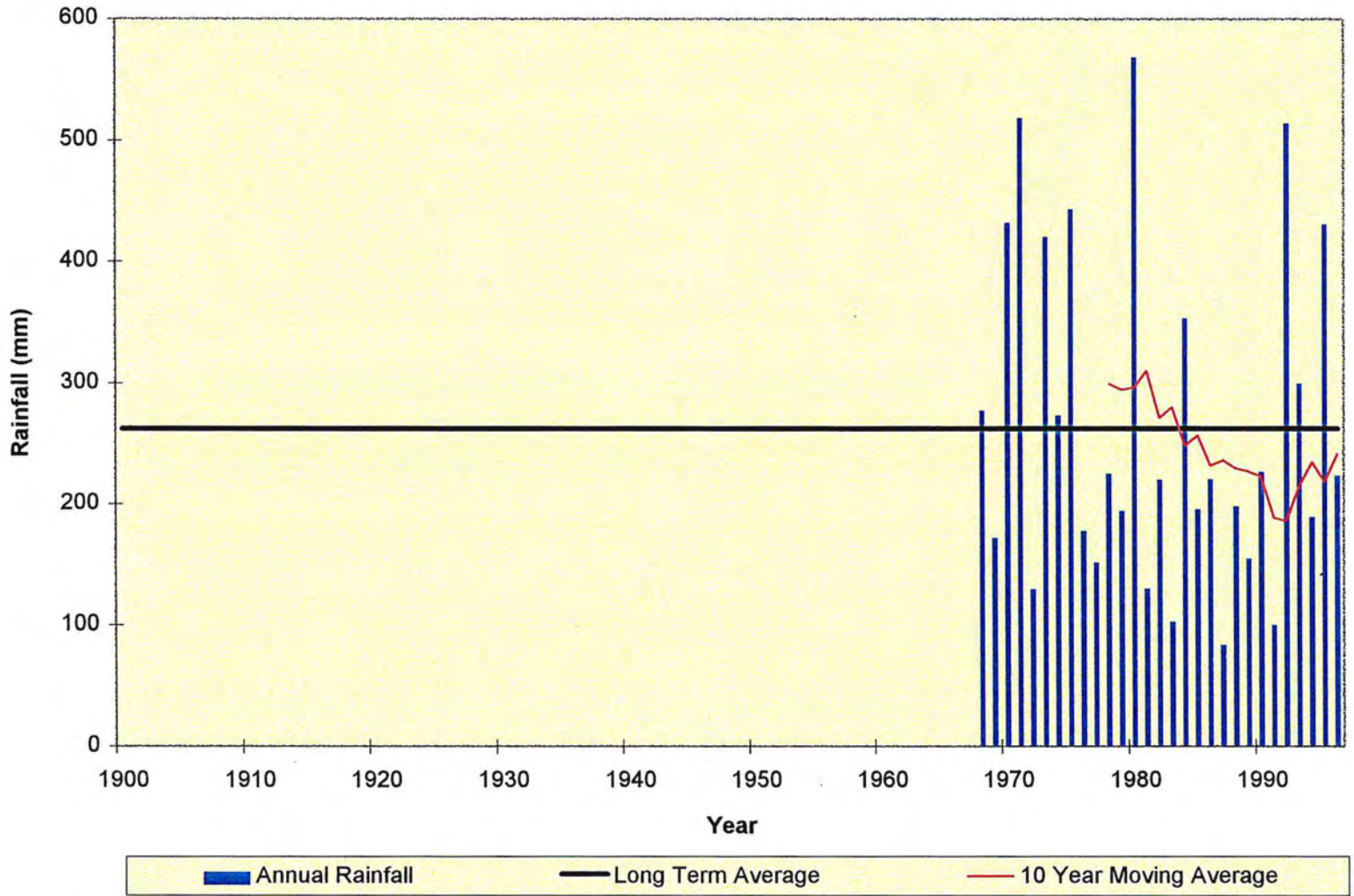


Figure A.2 : Rainfall Histogram for Exmouth





**Figure A.3 : Rainfall Histogram for Gascoyne Junction**

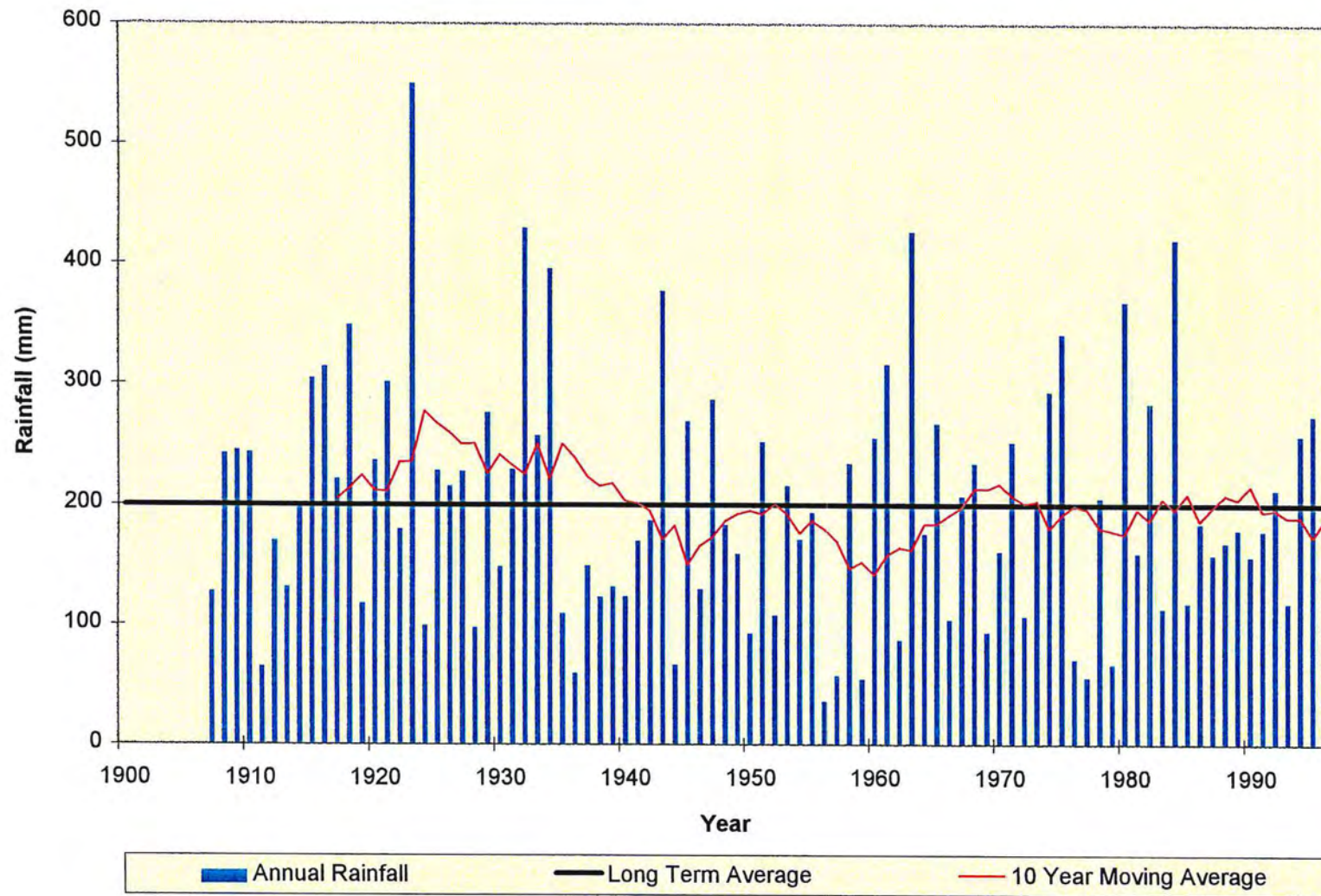
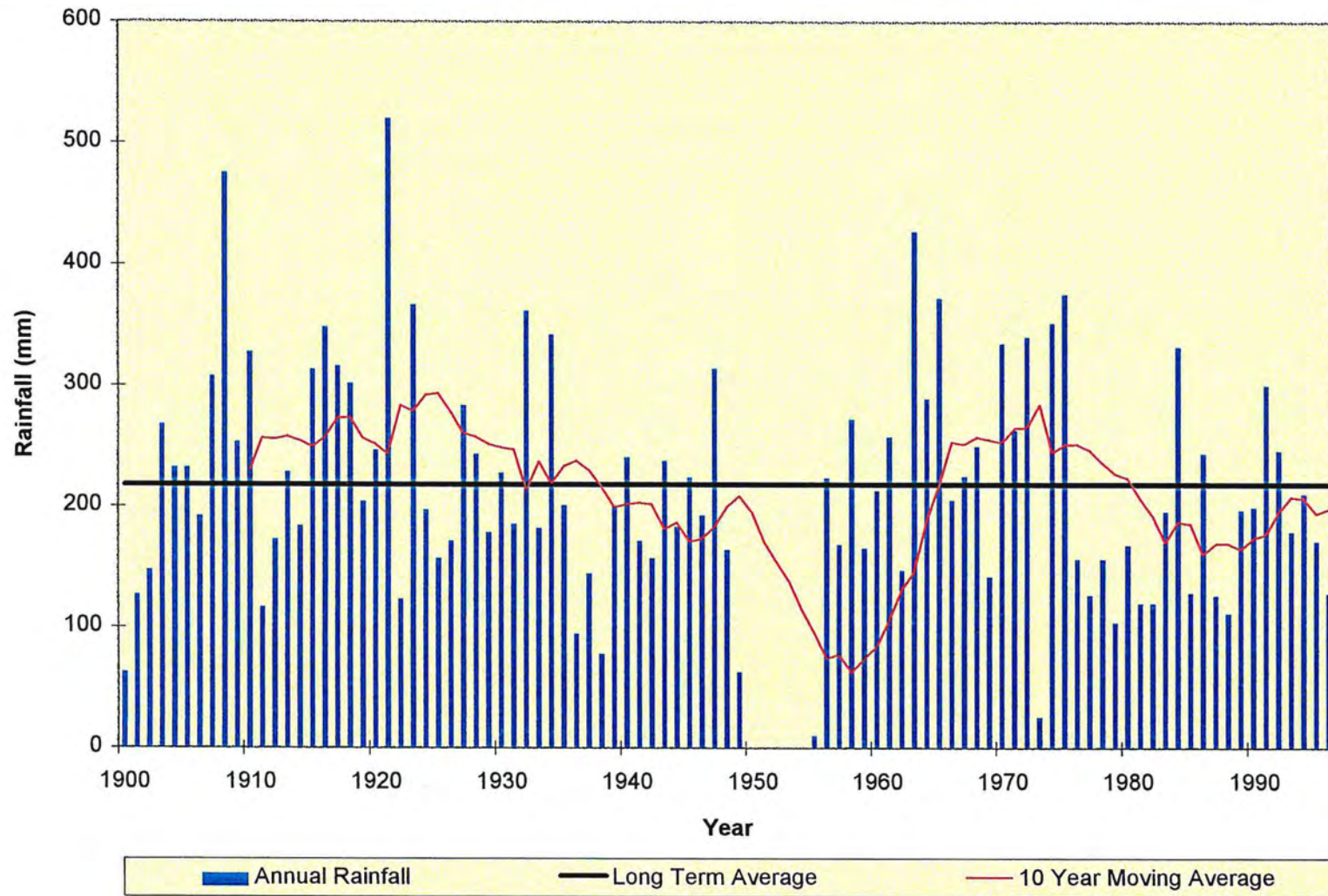


Figure A.4 : Rainfall Histogram for Shark Bay (Denham)



## **Appendix B : Regional Population Trends**

**Table B.1 : Population Growth 1976 and Medium Growth Population Projection 1994-2026**

<b>LOCAL AUTHORITY</b>	<b>1976</b>	<b>1981</b>	<b>1986</b>	<b>1991</b>	<b>1996</b>	<b>2001</b>	<b>2006</b>	<b>2011</b>	<b>2016</b>	<b>2021</b>	<b>2026</b>
Carnavon (S)	9725	7215	7286	6807	6779	7195	7751	8329	8863	9408	9888
Exmouth (S)	2821	2287	2440	2437	2492	2645	2849	3062	3258	3459	3635
Shark Bay (S)	696	842	1008	1038	886	932	979	1029	1082	1137	1195
Upper Gascoyne (S)	246	236	247	278	259	253	253	253	253	253	253
<b>REGION</b>	<b>13488</b>	<b>10580</b>	<b>10980</b>	<b>10560</b>	<b>10417</b>	<b>11025</b>	<b>11833</b>	<b>12674</b>	<b>13456</b>	<b>14256</b>	<b>14970</b>
Carnavon (T)		5885	6417	6962	6011	6380	6873	7404	7878	8383	8811
Exmouth (T)		2104	2185	2405	2259	2397	2583	2782	2961	3150	3311
Denham (T)		800	872	1073	834	876	921	968	1017	1069	1124
Gascoyne Junction (T)		118	119	125	130	127	126	126	126	126	126

**Table B.2 : Population Growth 1976 and High Growth Population Projection 1994-2026**

<b>LOCAL AUTHORITY</b>	<b>1976</b>	<b>1981</b>	<b>1986</b>	<b>1991</b>	<b>1996</b>	<b>2001</b>	<b>2006</b>	<b>2011</b>	<b>2016</b>	<b>2021</b>	<b>2026</b>
Carnavon (S)	9725	7215	7286	6807	6879	7337	8101	8944	9875	10903	12037
Exmouth (S)	2821	2287	2440	2437	2517	2779	3144	3557	3946	4357	4930
Shark Bay (S)	696	842	1008	1038	895	964	1065	1176	1298	1433	1582
Upper Gascoyne (S)	246	236	247	278	269	287	307	328	350	374	400
<b>REGION</b>	<b>13488</b>	<b>10580</b>	<b>10980</b>	<b>10560</b>	<b>10560</b>	<b>11368</b>	<b>12616</b>	<b>14005</b>	<b>15470</b>	<b>17067</b>	<b>18949</b>
Carnavon (T)		5053	6417	6962	6100	6474	7148	7892	8713	9620	10621
Exmouth (T)		2104	2185	2405	2270	2506	2822	3193	3559	3930	4425
Denham (T)		800	872	1073	838	903	992	1095	1209	1335	1474
Gascoyne Junction (T)		118	119	125	133	142	151	162	173	185	197

## **Appendix C : Surface Water Resource Information**

River Basin: Gascoyne River

AWRC Basin No: 704

**Catchment Details:**

**Site location:** Lockier Range; 7256000 m N; 388200 m E, - Zone 50  
**Area:** 37,000 km<sup>2</sup>  
**Rainfall Range:** 200 - 250 mm/annum  
**Pan evaporation:** 3500 mm/annum (at dam site)  
**Cleared:** No significant clearing.  
**Landuse:** Open range grazing of sheep and cattle on pastoral leases.

**Mean Annual Flow** (x 10<sup>6</sup> m<sup>3</sup>/ year): 248.6

**Estimated Divertible Yield** (x 10<sup>6</sup> m<sup>3</sup>/ year): 50.7

**Water Quality:**

**Salinity:** Fresh

**Other significant parameters:**

**Existing Developments:**

**Water Corporation:** None

**Other:** None

**Current uses:** None

**Possible Future Uses:**

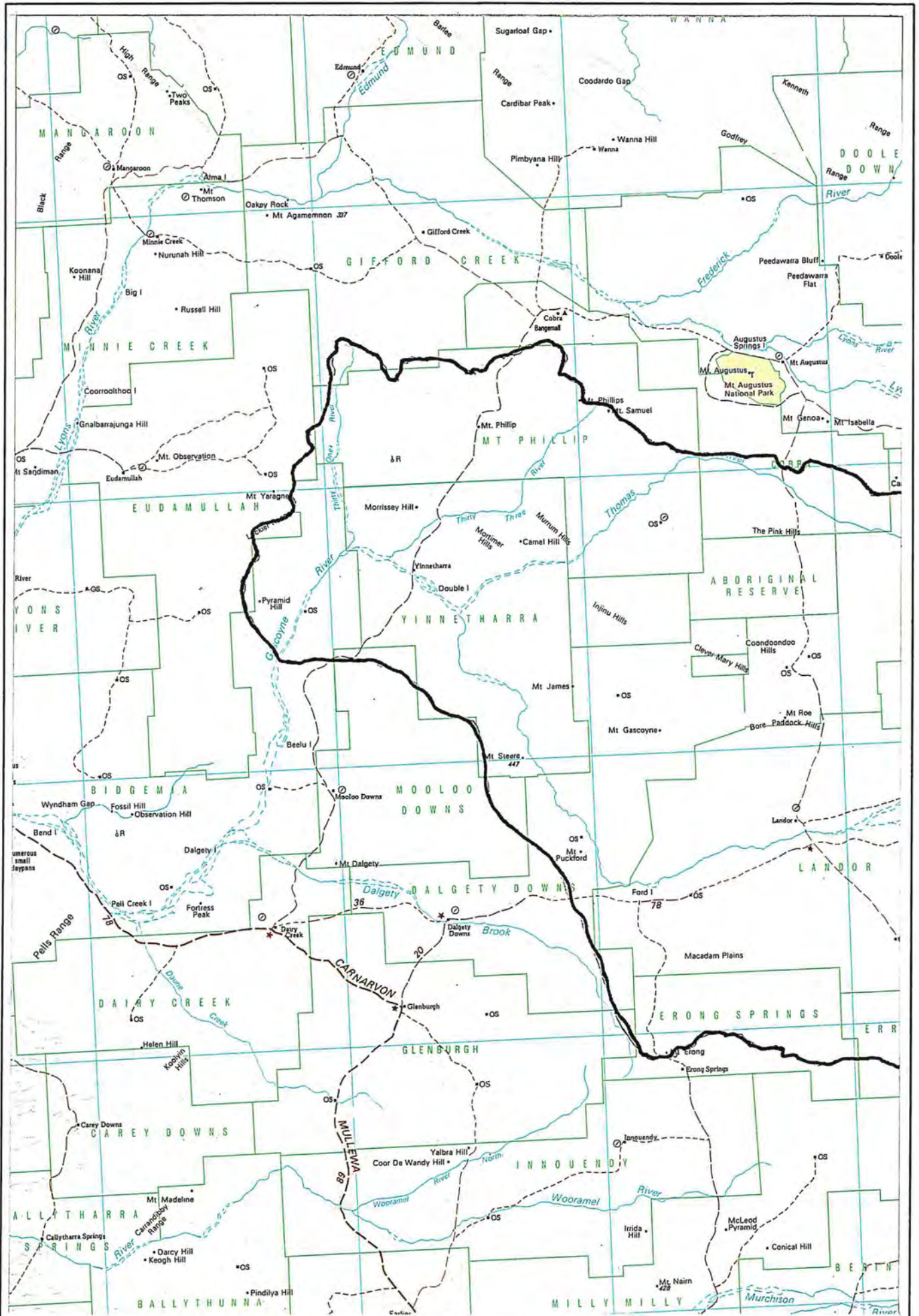
Supplement town water supplies to Carnarvon and Gascoyne Junction. Supplement water supplies to Carnarvon irrigation area and future developments at Rocky Pool.

**Factors (environmental, social and economic) which may affect future development:**

The distance of this site from any developments is likely to be a major constraint to the implementation of this water source.

**Comments:**

Reliability of estimate is reasonable. Mean annual flow is based on regional estimates.



Gascoyne River



River Basin: Gascoyne River

AWRC Basin No: 704

**Catchment Details:**

**Site location:** Kennedy Range; 7231000 m N; 296100 m E, - Zone 50  
**Area:** 69,792 km<sup>2</sup>  
**Rainfall Range:** 200 - 250 mm/annum  
**Pan evaporation:** 3250 mm/annum (at dam site)  
**Cleared:** No significant clearing.  
**Landuse:** Open range grazing of sheep and cattle on pastoral leases.

Mean Annual Flow (x 10<sup>6</sup> m<sup>3</sup>/ year): 805.4

Estimated Divertible Yield (x 10<sup>6</sup> m<sup>3</sup>/ year): 235.7

**Water Quality:**

**Salinity:** Fresh

**Other significant parameters:** Colour 55 Hazen, Turbidity - 310 NTU.

**Existing Developments:**

**Water Corporation:** None

**Other:** None

**Current uses:** None

**Possible Future Uses:**

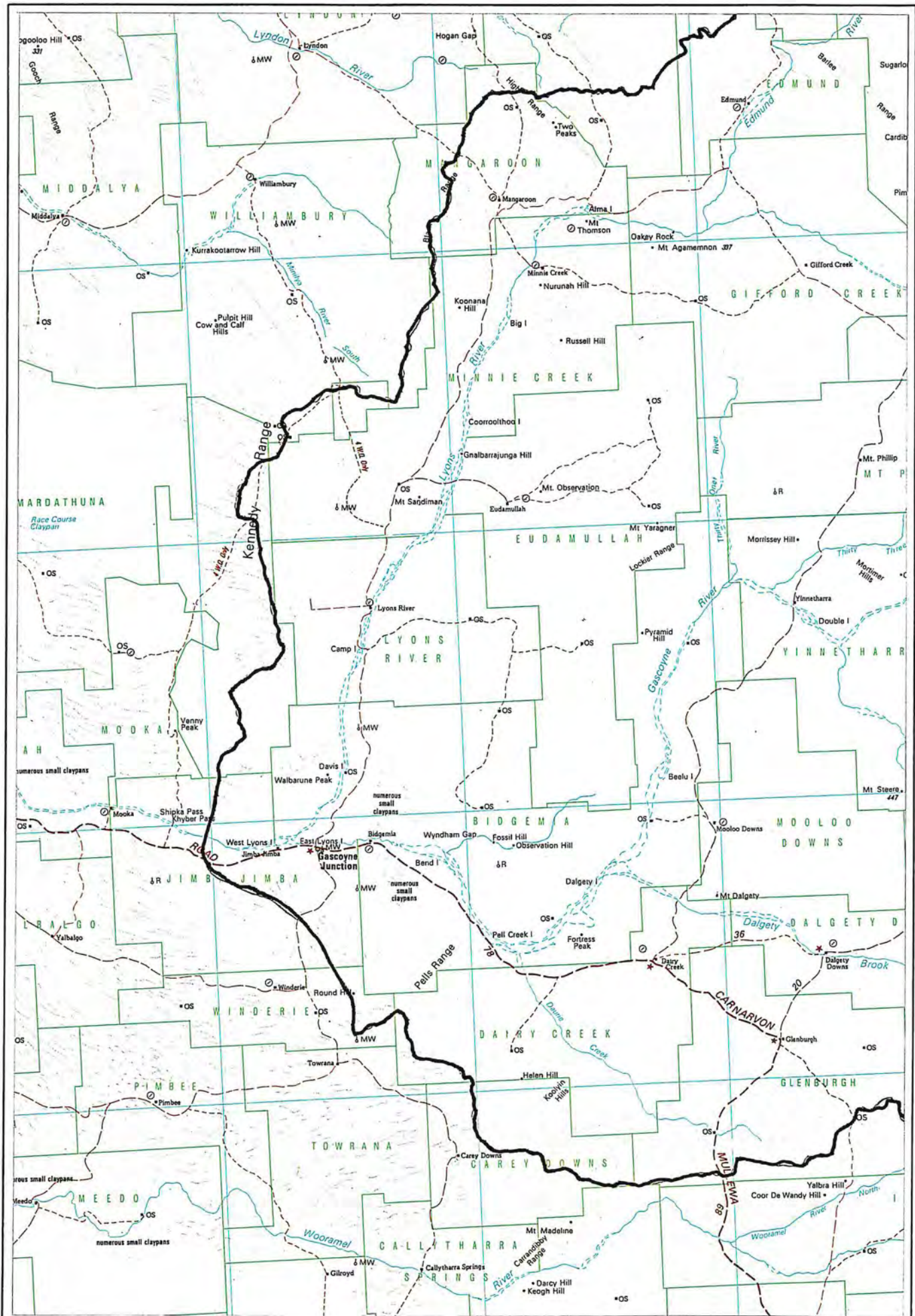
Supplement town water supplies to Carnarvon. Supplement water supplies to Carnarvon irrigation area and future developments at Rocky Pool. Potential off-stream and in-stream storages for irrigation.

**Factors (environmental, social and economic) which may affect future development:**

Major constraints of this site are considered to be the poor storage basin shape and the high risk of salinity failure. Gascoyne Junction may be subject to permanent inundation if the site is implemented.

**Comments:**

Reliability of estimate is reasonable. Mean annual flow is based on regional estimates from data close to the dam site.



Gascoyne River

River Basin: Gascoyne River

AWRC Basin No: 704

**Catchment Details:**

**Site location:** Rocky Pool; 7259234 m N; 209365 m E, - Zone 50  
**Area:** 73,615 km<sup>2</sup>  
**Rainfall Range:** 200 - 250 mm/annum  
**Pan evaporation:** 2900 mm/annum (at dam site)  
**Cleared:** No significant clearing.  
**Landuse:** Open range grazing of sheep and cattle on pastoral leases.

Mean Annual Flow (x 10<sup>6</sup> m<sup>3</sup>/ year): 689.7

Estimated Divertible Yield (x 10<sup>6</sup> m<sup>3</sup>/ year): 92.6

**Water Quality:**

**Salinity:** Fresh

**Other significant parameters:**

**Existing Developments:**

**Water Corporation:** None

**Other:** None

**Current uses:** None

**Possible Future Uses:**

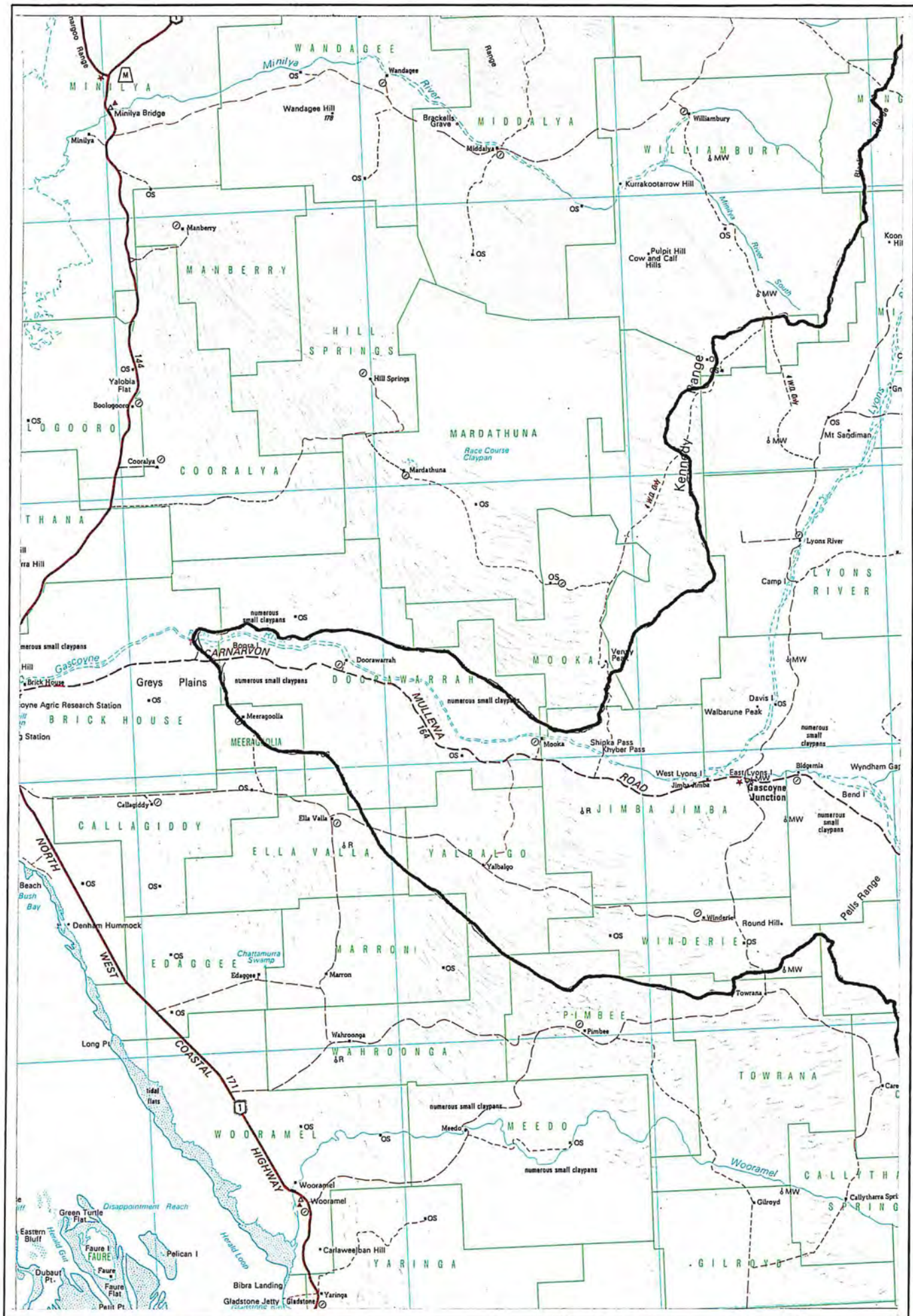
Supplement town water supplies to Carnarvon. Supplement water supplies to Carnarvon irrigation area and future developments at Rocky Pool. Potential off-stream and in-stream storages for irrigation.

**Factors (environmental, social and economic) which may affect future development:**

The height and capacity of this dam are constrained due to the poor topographic characteristics of the site. The width of the Gascoyne River is narrow and the topographic relief is extremely low. Possible development at Rocky Pool could affect construction of a dam at this site.

**Comments:**

Reliability of estimate is reasonable. Mean annual flow is based on regional estimates from data close to the dam site.



Gascoyne River

River Basin: Gascoyne River

AWRC Basin No: 704

**Catchment Details:**

**Site location:** Nine Mile Bridge; 7251150 m N; 779750 m E, - Zone 49  
**Area:** 73,746 km<sup>2</sup>  
**Rainfall Range:** 200 - 250 mm/annum  
**Pan evaporation:** 2700 mm/annum (at dam site)  
**Cleared:** No significant clearing.  
**Landuse:** Horticultural production.

**Mean Annual Flow** ( $\times 10^6$  m<sup>3</sup>/ year): 684.0

**Estimated Divertible Yield** ( $\times 10^6$  m<sup>3</sup>/ year): 4.5 (80% monthly reliability)

**Water Quality:**

**Salinity:** Fresh

**Other significant parameters:** Colour 30 Hazen, Turbidity 190 NTU.

**Existing Developments:**

**Water Corporation:** Groundwater extraction from river alluvium.

**Other:** Other private bores also operating from river alluvium.

**Current uses:** Groundwater extraction for irrigation and town water supply.

**Possible Future Uses:**

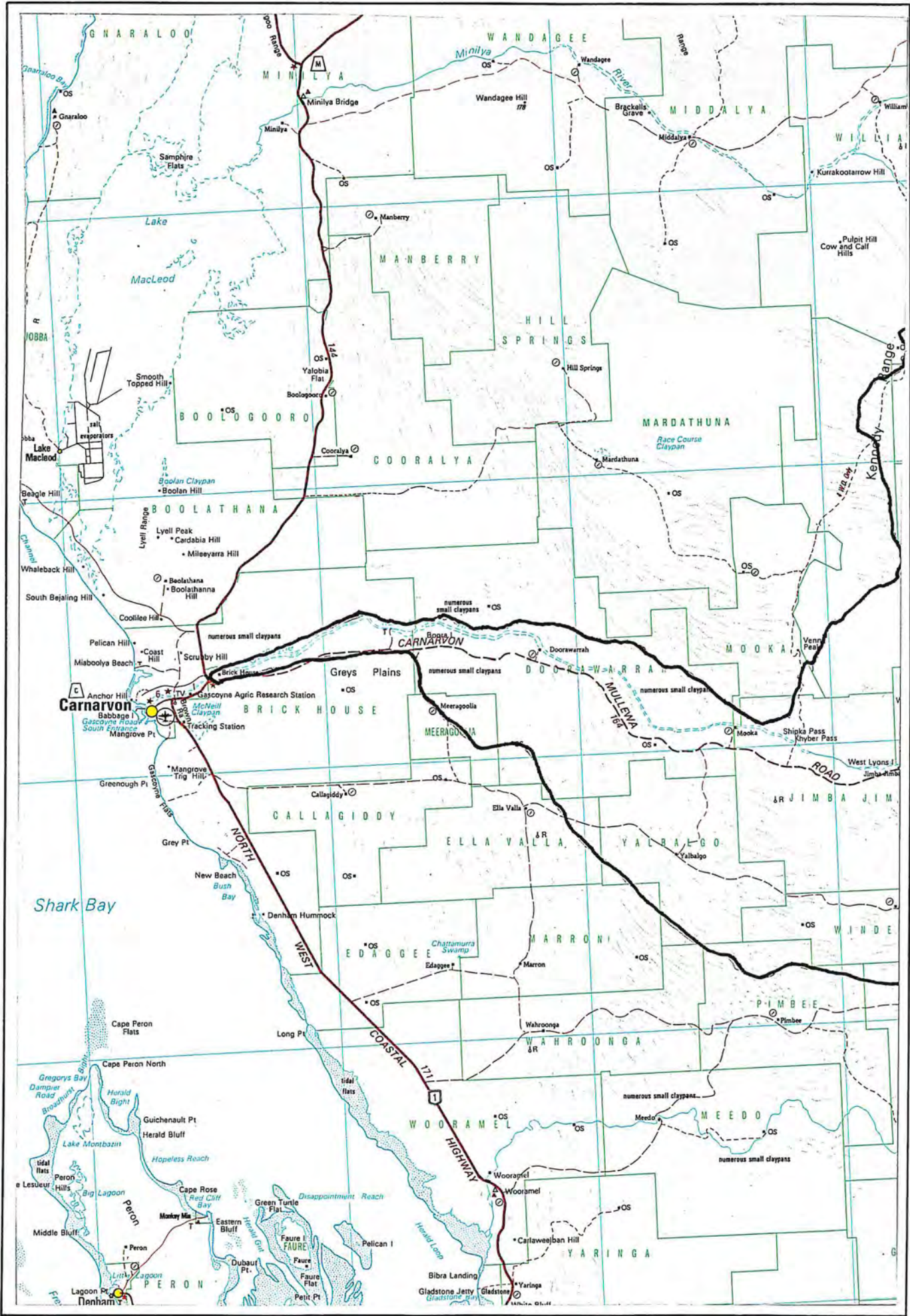
Supplement town water supplies to Carnarvon. Supplement water supplies to Carnarvon irrigation area. Potential off-stream and in-stream storages for irrigation.

**Factors (environmental, social and economic) which may affect future development:**

The height and capacity of this dam are constrained due to the poor topographic characteristics of the site. The width of the Gascoyne River is narrow and the topographic relief is extremely low. The area near Carnarvon has value for its fertile land and horticultural developments and should be managed with the goal of maintaining this.

**Comments:**

Reliability of estimate is good. Mean annual flow is based on at-site data. (S704139)



Gascoyne River

River Basin: Gascoyne River

AWRC Basin No: 704

**Catchment Details:**

**Site location:** Mooka Creek; 7246400 m N; 295290 m E, - Zone 50  
**Area:** 86 km<sup>2</sup>  
**Rainfall Range:** 200 mm/annum  
**Pan evaporation:** 3300 mm/annum (at dam site)  
**Cleared:** No clearing.  
**Landuse:** Open range grazing of sheep and cattle on pastoral leases.

**Mean Annual Flow** (x 10<sup>6</sup> m<sup>3</sup>/ year): 0.11

**Estimated Divertible Yield** (x 10<sup>6</sup> m<sup>3</sup>/ year): 0.04

**Water Quality:**

**Salinity:** Fresh

**Other significant parameters:**

**Existing Developments:**

**Water Corporation:** None

**Other:** None

**Current uses:** None

**Possible Future Uses:**

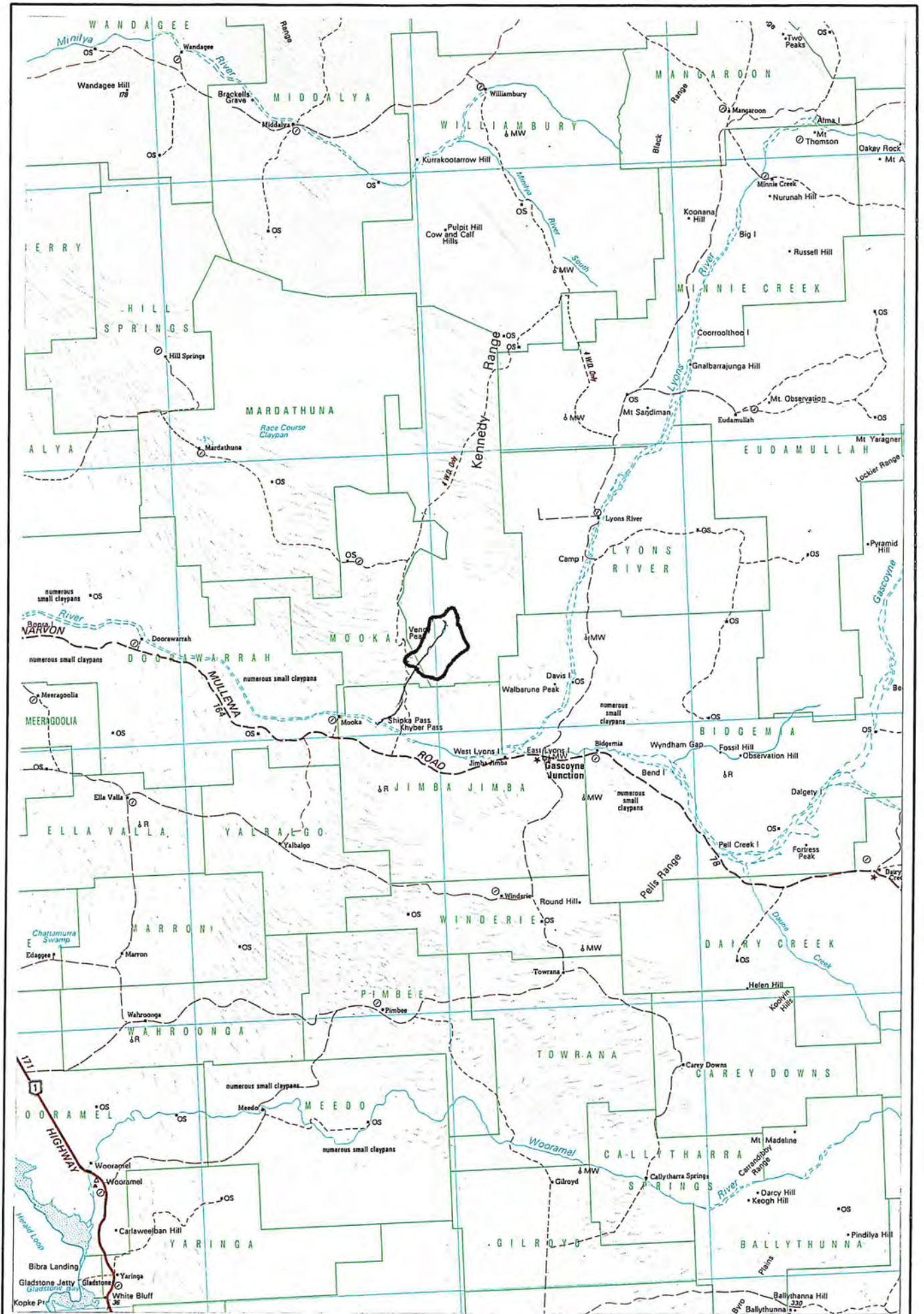
Supplement water supplies to future developments in the Mooka area.

**Factors (environmental, social and economic) which may affect future development:**

Major constraints of this site are considered to be the small catchment area and the lack of sufficient rainfall to the area, suggesting that the dam may be rarely filled to capacity.

**Comments:**

Reliability of estimate is poor. Mean annual flow is based on regional estimates.



Mooka Creek



River Basin: Gascoyne River

AWRC Basin No: 704

**Catchment Details:**

**Site location:** Mungarra Creek; 7247150 m N; 313250 m E, - Zone 50  
**Area:** 141 km<sup>2</sup>  
**Rainfall Range:** 200 mm/annum  
**Pan evaporation:** 3350 mm/annum (at dam site)  
**Cleared:** No clearing.  
**Landuse:** Open range grazing of sheep and cattle on pastoral leases.

Mean Annual Flow ( $\times 10^6$  m<sup>3</sup>/ year): 0.18

Estimated Divertible Yield ( $\times 10^6$  m<sup>3</sup>/ year): 0.07

**Water Quality:**

**Salinity:** Fresh

**Other significant parameters:**

**Existing Developments:**

**Water Corporation:** None

**Other:** None

**Current uses:** None

**Possible Future Uses:**

Supplement town water supplies to Gascoyne Junction. Supplement water supplies to future developments in the Mooka area.

**Factors (environmental, social and economic) which may affect future development:**

Major constraints of this site are considered to be the small catchment area and the lack of sufficient rainfall to the area, suggesting that the dam may be rarely filled to capacity.

**Comments:**

Reliability of estimate is poor. Mean annual flow is based on regional estimates.



River Basin: Lyndon-Minilya Rivers

AWRC Basin No: 705

**Catchment Details:**

**Site location:** Lyndon River; 7379200 m N; 332100 m E, - Zone 50  
**Area:** 386 km<sup>2</sup>  
**Rainfall Range:** 250 mm/annum  
**Pan evaporation:** 3400 mm/annum (at dam site)  
**Cleared:** No significant clearing.  
**Landuse:** Open range grazing of sheep and cattle on pastoral leases.

**Mean Annual Flow** (x 10<sup>6</sup> m<sup>3</sup>/ year): 1.3

**Estimated Divertible Yield** (x 10<sup>6</sup> m<sup>3</sup>/ year): 0.2

**Water Quality:**

**Salinity:** Fresh

**Other significant parameters:**

**Existing Developments:**

**Water Corporation:** None

**Other:** None

**Current uses:** None

**Possible Future Uses:**

Supplement water supplies to future developments in the area.

**Factors (environmental, social and economic) which may affect future development:**

This is not considered a viable site due to its location within the catchment, size of impoundment required and the resulting small amount of divertible yield.

**Comments:**

Reliability of estimate is reasonable. Mean annual flow is based on regional estimates.



River Basin: Lyndon-Minilya Rivers

AWRC Basin No: 705

**Catchment Details:**

**Site location:** Minilya River; 7348900m N; 303250m E, - Zone 50  
**Area:** 2142 km<sup>2</sup>  
**Rainfall Range:** 250 mm/annum  
**Pan evaporation:** 3400 mm/annum (at dam site)  
**Cleared:** No significant clearing.  
**Landuse:** Open range grazing of sheep and cattle on pastoral leases.

Mean Annual Flow (x 10<sup>6</sup> m<sup>3</sup>/ year): 20.2

Estimated Divertible Yield (x 10<sup>6</sup> m<sup>3</sup>/ year): 4.7

**Water Quality:**

**Salinity:** Fresh

**Other significant parameters:**

**Existing Developments:**

**Water Corporation:** None

**Other:** None

**Current uses:** None

**Possible Future Uses:**

Supplement water supplies to future developments in the area.

**Factors (environmental, social and economic) which may affect future development:**

This is not considered a viable site due to it's location within the catchment, size of impoundment required and the resulting small amount of divertible yield.

**Comments:**

Reliability of estimate is reasonable. Mean annual flow is based on regional estimates.



## **Appendix D : Groundwater Resource Estimates**

## Appendix D : Groundwater Resource Estimates

### Table D 1 : WOORAMEL RIVER - Renewable Resource Estimates For Major Aquifers

Ref. No.	Aquifer	Locality	Rainfall Recharge/Year			Throughflow/Year				River Recharge/Year				Calculated Resources (m <sup>3</sup> × 10 <sup>6</sup> )
			Area (km <sup>2</sup> )	Rainfall (mm)	Recharge Factor	Thickness (mm)	Hydraulic Conductivity (m/d)	Gradient	Flow Section (km)	Length h (km)	Width h (m)	Infiltration Rate (m <sup>3</sup> /m <sup>2</sup> /d)	Ave Flow (days)	
1	Alluvium	Wooramel - Meedo	-	-	-	-	-	-	-	35	50	0.01	103	1.802
2	Alluvium	Upper Wooramel	1460	200	0.01	-	-	-	-	-	-	-	-	2.920
3	Tamala Ist	Dirk Hartog Is	700	300	0.1	-	-	-	-	-	-	-	-	21.000
4		Heirisson Prong	200	300	0.1	-	-	-	-	-	-	-	-	6.000
5	Calcrete	Innouendy	100	200	0.05	-	-	-	-	-	-	-	-	1.000
6		Salt bore	50	200	0.05	-	-	-	-	-	-	-	-	0.500
7	Birdrong Sst	Coastal □ Wooramel R intake	-	-	-	30	2	1.3 × 10 <sup>-3</sup>	10	-	-	-	-	0.292
		□ North Wooramel R	-	-	-	30	2	1.0 × 10 <sup>-3</sup>	75	-	-	-	-	1.642
		□ South Wooramel R	-	-	-	30	2	0.8 × 10 <sup>-3</sup>	175	-	-	-	-	3.066
8	Mallens Sst	Bogadie Syncline	155	220	0.05	-	-	-	-	-	-	-	-	1.705
9	Moogooloo Sst	Pindilya	85	220	0.05	-	-	-	-	-	-	-	-	0.935
10		Darcy Hill	60	220	0.05	-	-	-	-	-	-	-	-	0.660
11		Ballythanna Anticline	15	220	0.05	-	-	-	-	-	-	-	-	0.165
12	Tumblagooda Sst	Coastal	-	-	-	600	0.5	3.7 × 10 <sup>-4</sup>	70	-	-	-	-	2.836
13	Fractured rock	Upper Wooramel	1300	200	0.0001	-	-	-	-	-	-	-	-	0.026
	(undifferentiated)	Upper Wooramel	900	200	0.0001	-	-	-	-	-	-	-	-	0.018



**Table D 2 : WOORAMEL RIVER - Stored Resource Estimates For Major Aquifers**

Ref. No.	Aquifer	Locality	Area (km <sup>2</sup> )	Saturated Thickness (m)	Adopted Specific Yield	Stored Resources (GL)	Comments
1	Alluvium	Wooramel - Meedo	7	20	0.2	28	River bed 35 km and zone 200 m wide contains groundwater resource
2	Alluvium	Upper Wooramel	1460	8	0.05	584	Assumed water table 2 m below surface
3	Tamala Ist	Dirk Hartog Is	700	35	0.2	4900	Saturated thickness sea level to -35 m
4		Heirisson Prong	200	35	0.2	1400	Saturated thickness sea level to -35 m
5	Calcrete	Innouendy	100	8	0.2	160	Assumed water table 2 m below surface
6		Salt bore	50	8	0.2	64	Assumed water table 2 m below surface
7	Birdrong Sst	Coastal □ Wooramel R intake	400	30	0.1	1200	Fully saturated
		□ North Wooramel R	5000	30	0.1	15000	Fully saturated
		□ South Wooramel R	9200	30	0.1	27600	Fully saturated
8	Mallens Sst	Bogadie Syncline	155	145	0.1	2248	Outcrop only; assumed water table 5 m below surface
9	Moogooloo Sst	Pindilya	85	45	0.1	383	Outcrop only; assumed water table 5 m below surface
10		Darcy Hill	60	45	0.1	270	Outcrop only; assumed water table 5 m below surface
11		Ballythanna Anticline	15	45	0.1	68	Outcrop only; assumed water table 5 m below surface
12	Tumblagooda Sst	Coastal	9600	600	0.05	288000	Fully saturated to 1000 m below surface
13	Fractured rock (undifferentiated)	Upper Wooramel	1300	30	0.005	195	Assumed water table 15 m below surface
		Upper Wooramel	900	30	0.005	203	Assumed water table 15 m below surface

**Table D 3 : GASCOYNE RIVER BASIN -Renewable Resource Estimates For Major Aquifers**

Ref. No.	Aquifer	Locality	Rainfall Recharge/Year			Throughflow/Year				River Recharge/Year				Calculated Resources (m <sup>3</sup> x 10 <sup>9</sup> )
			Area (km <sup>2</sup> )	Rainfall (mm)	Recharge Factor	Thickness (mm)	Hydraulic Conductivity (m/d)	Gradient	Flow Section (mm)	Length h (km)	Width h (m)	Infiltration Rate (m <sup>3</sup> /m <sup>2</sup> /d)	Ave Flow (days)	
1	Alluvium	Gascoyne Mouth-Rocky P	-	-	-	-	-	-	-	55	450	0.01	115	28.46
2		Rocky P - Fishy P	-	-	-	-	-	-	-	50	200	0.01	161	16.10
3		U Lyons R <1000	700	220	0.01	-	-	-	-	-	-	-	-	1.54
		1000 - 3000	990	220	0.01	-	-	-	-	-	-	-	-	2.18
		>3000	300	220	0.01	-	-	-	-	-	-	-	-	0.66
4		U Gascoyne R <1000 (A)	2600	220	0.01	-	-	-	-	-	-	-	-	5.72
		<1000 (B)	600	220	0.01	-	-	-	-	-	-	-	-	1.32
		1000 - 3000	2000	220	0.01	-	-	-	-	-	-	-	-	4.40
		>3000 (A)	1450	220	0.01	-	-	-	-	-	-	-	-	3.19
		>3000 (B)	80	220	0.01	-	-	-	-	-	-	-	-	0.18
5	Calcrete	Alma Island	110	220	0.05	-	-	-	-	-	-	-	-	1.21
		□ Edmund R	50	220	0.05	-	-	-	-	-	-	-	-	0.55
		□ Elliot Ck	100	220	0.05	-	-	-	-	-	-	-	-	1.10
6		James Creek	95	220	0.05	-	-	-	-	-	-	-	-	1.05
7		Scrubber B	110	220	0.05	-	-	-	-	-	-	-	-	1.21
8		Sawback P	50	220	0.05	-	-	-	-	-	-	-	-	0.55
9		Beasley W	75	220	0.05	-	-	-	-	-	-	-	-	0.82
10	Birdrong Sst	Coastal	-	-	-	30	2	7.1 x 10 <sup>-4</sup>	80	-	-	-	-	12.44
11	Mallens Sst	Binthabooka	120	220	0.05	-	-	-	-	-	-	-	-	1.32
12		Bitter W	70	220	0.05	-	-	-	-	-	-	-	-	0.77
13	Moogooloo Sst	Tabletop	70	220	0.05	-	-	-	-	-	-	-	-	0.77
14		Pell Rg.	70	220	0.05	-	-	-	-	-	-	-	-	0.77
15		Boonaberrie	100	220	0.05	-	-	-	-	-	-	-	-	1.10
16		Yinnillia	65	220	0.05	-	-	-	-	-	-	-	-	0.68
17		Jar Ck	125	220	0.05	-	-	-	-	-	-	-	-	1.38
18		Daurri Ck	100	220	0.05	-	-	-	-	-	-	-	-	1.07
19	Tumblagooda Sst	Brickhouse	-	-	-	600	0.5	3.7 x 10 <sup>-4</sup>	85	-	-	-	-	3.44
20	Fractured Rocks (undifferentiated)	U Lyons <1000	5400	220	0.0001	-	-	-	-	-	-	-	-	0.12
		1000 - 3000	6250	220	0.0001	-	-	-	-	-	-	-	-	0.14
		>3000	3200	220	0.0001	-	-	-	-	-	-	-	-	0.07
21		U Gascoyne <1000 (A)	11200	220	0.0001	-	-	-	-	-	-	-	-	0.25
		<1000 (B)	3700	220	0.0001	-	-	-	-	-	-	-	-	0.08
		1000 - 3000	5800	220	0.0001	-	-	-	-	-	-	-	-	0.13
		>3000	11450	220	0.0001	-	-	-	-	-	-	-	-	0.25

**Table D 4 : GASCOYNE RIVER BASIN - Stored Resource Estimates For Major Aquifers**

Ref. No.	Aquifer	Locaility	Area (km2)	Saturated Thickness (m)	Adopted Specific Yield	Stored Resources (GL)	Comments
1	Alluvium	Gascoyne Mouth-Rocky P	55	50	0.05	137.5	River bed 35 km and zone 1 km wide containing groudwater resources
2		Rocky P - Fishy P	50	35	0.05	87.5	River bed 50 km and zone 1 km wide containing groundwater resouces
3		U Lyons R <1000	700	8	0.05	280	Assumed water table 2 m below surface
		1000 - 3000	990	8	0.05	396	Assumed water table 2 m below surface
		>3000	300	8	0.05	120	Assumed water table 2 m below surface
4		U Gascoyne R <1000 (A)	2600	8	0.05	1040	Assumed water table 2 m below surface
		<1000 (B)	600	8	0.05	240	Assumed water table 2 m below surface
		1000 - 3000	2000	8	0.05	800	Assumed water table 2 m below surface
		>3000 (A)	1450	8	0.05	580	Assumed water table 2 m below surface
		>3000 (B)	80	8	0.05	32	Assumed water table 2 m below surface
5	Calcrete	Alma Island	110	8	0.2	176	Assumes 10 m vuggy calcrete water level 2 m below surface
		□ Edmund R	50	8	0.2	80	Assumes 10 m vuggy calcrete water level 2 m below surface
		□ Elliot Ck	100	8	0.2	160	Assumes 10 m vuggy calcrete water level 2 m below surface
6		James Creek	95	8	0.2	152	Assumes 10 m vuggy calcrete water level 2 m below surface
7		Scrubber B	110	8	0.2	176	Assumes 10 m vuggy calcrete water level 2 m below surface
8		Sawback P	50	8	0.2	80	Assumes 10 m vuggy calcrete water level 2 m below surface
9		Beasley W	75	8	0.2	120	Assumes 10 m vuggy calcrete water level 2 m below surface
10	Birdrong Sst	Coastal	9200	30	0.1	27,600	Fully saturated
11	Mallens Sst	Binthabooka	120	145	0.1	1740	Outcrop and shallow subcrop only, water table 5 m below surface
12		Bitter W	70	145	0.1	1015	Outcrop and shallow subcrop only, water table 5 m below surface
13	Moogooloo Sst	Tabletop	70	45	0.1	315	Outcrop and shallow subcrop only, water table 5 m below surface
14		Pell Rg.	70	45	0.1	315	Outcrop and shallow subcrop only, water table 5 m below surface
15		Boonaberrie	100	45	0.1	450	Outcrop and shallow subcrop only, water table 5 m below surface
16		Yinnillia	65	45	0.1	295	Outcrop and shallow subcrop only, water table 5 m below surface
17		Jar Ck	125	45	0.1	565	Outcrop and shallow subcrop only, water table 5 m below surface
18		Daurri Ck	100	45	0.1	450	Outcrop and shallow subcrop only, water table 5 m below surface
19	Tumblagooda Sst	Brickhouse	8000	600	0.05	240,000	Fully saturated to 1000 m below surface
20	Fractured Rocks (undifferentiated)	U Lyons <1000	5400	30	0.005	810	Water level 15 m below surface
		1000 - 3000	6250	30	0.005	940	Water level 15 m below surface
		>3000	3200	30	0.005	480	Water level 15 m below surface
21		U Gascoyne <1000 (A)	11200	30	0.005	1680	Water level 15 m below surface
		<1000 (B)	3700	30	0.005	55	Water level 15 m below surface
		1000 - 3000	5800	30	0.005	870	Water level 15 m below surface
		>3000	11450	30	0.005	1720	Water level 15 m below surface

**Table D 5 : LYNDON - MINILYA RIVER BASIN - Renewable Resource Estimates For Major Aquifers**

Ref. No.	Aquifer	Locality	Rainfall Recharge/Year			Throughflow/Year				River Recharge/Year				Calculated Resources (m <sup>3</sup> x 10 <sup>6</sup> )
			Area (km <sup>2</sup> )	Rainfall (mm)	Recharge Factor	Thickness (mm)	Hydraulic Conductivity (m/d)	Gradient	Flow Section (Kmt)	Length (km)	Width (m)	Infiltration Rate (m <sup>3</sup> /m <sup>2</sup> /d)	Ave Flow (days)	
1	Alluvium	Yannarie R	100	275	0.01									0.275
2		Lyndon R	60	250	0.01									0.150
3		Minilya R	15	220	0.01									0.030
4	Calcrete	Brady Ck	30	250	0.05									0.375
5		Mountain Ck	40	250	0.05									0.500
6	Tertiary Lst (undifferentiated)	Cape Range (outcrop)	1600	250	0.05									20.000
		Cape Range (subcrop)	4000	250	0.01									10.000
7		Quobba	1600	250	0.01									4.000
8	Birdrong Sst*	Coastal □ Grierson - Minilya				30	2	1.3 x 10 <sup>-3</sup>	70					1.99
		□ Minilya - Cape R				30	2	1.2 x 10 <sup>-3</sup>	180					4.73
		□ Cape R - Yanrey				30	2	1.6 x 10 <sup>-3</sup>	110					3.85
9	Moogooloo Sst	Moogooloo Hill	115	220	0.05									1.265
10		Karla W	25	220	0.05									0.275
11		Red Monkey B	15	220	0.05									0.165
12	Fractured rocks (undifferentiated)	Towera - Lyndon	7300	250	0.0001									0.183

\* Past 20 m contour

**Table D 6 : LYNDON - MINILYA RIVER BASIN - Stored Resource Estimates For Major Aquifers**

Ref. No.	Aquifer	Locality	Area (km2)	Saturated Thickness (m)	Adopted Specific Yield	Stored Resources (GL)	Comments
1	Alluvium	Yannarie R	100	8	0.05	40	Only an aquifer adjacent to river 10 m thick water table 2 m bns
2		Lyndon R	60	8	0.05	24	Only an aquifer adjacent to river 10 m thick water table 2 m bns
3		Minilya R	15	8	0.05	6	Very limited aquifer, water table 23 m below surface
4	Calcrete	Brady Ck	30	8	0.2	48	
5		Mountain Ck	40	8	0.2	64	Very limited aquifer, water table 23 m below surface
6	Tertiary Lst (undifferentiated)	Cape Range (outcrop)	1600	10	0.05	800	Underlain by seawater
		Cape Range (subcrop)	4000	10	0.05	2000	Underlain by seawater
7		Quobba	1600	10	0.05	800	Underlain by seawater
8	Birdrong Sst*	Coastal □ Grierson - Minilya	12300	30	0.1	36900	Fully saturated
		□ Minilya - Cape R	5600	30	0.1	16800	Fully saturated
		□ Cape R - Yanrey	~6600	30	0.1	19800	Fully saturated
9	Moogooloo Sst	Moogooloo Hill	115	45	0.1	517	Outcrop and shallow subcrop only, water table 5 m below surface
10		Karla W	25	45	0.1	113	Outcrop and shallow subcrop only, water table 5 m below surface
11		Red Monkey B	15	45	0.1	68	Outcrop and shallow subcrop only, water table 5 m below surface
12	Fractured rocks (undifferentiated)	Towera - Lyndon	7300	30	0.005	1095	Water level 15 m below surface

## **Appendix E : Water Quality Protection**

## Appendix E : Water Quality Protection

### *Inter-relationships between land use and water supply schemes*

The development and operation of water sources involves 'using' land and water. Land is 'consumed' by inundation behind a reservoir, for roads, pipelines, well sites, treatment plants and other structures and earthworks. Water is diverted from streams or by the lowering of groundwater levels in the vicinity of wells. The construction and operation of water infrastructure may have other impacts such as those of dust, odour, vibration and noise. These impacts occur on both the natural environment and the social environment.

The following tables indicate the types of impacts that developments of water resources for public supply have on land use and conversely the impacts that land use has on water sources. This broad assessment is made for surface water and shallow groundwater and for forested, rural and urban land uses.

The tables describe:

Table	Description
E1	Impacts of rural and urban land use on surface water resources.
E2	Impacts of surface water schemes on rural and urban land use.
E3	Impacts of land use on shallow groundwater resources.
E4	Impacts of shallow groundwater schemes on land use.

Confined aquifer wells have very little impact on land uses in their vicinity because they occupy a very small area of land and are not affected by, nor do they affect, nearby surface uses of the land. However, an operating well creates a local area of low pressure in the confined groundwater. Any other confined well within this area of low pressure will experience reduced pumping efficiency.

Note that one of the key impacts described in the tables is that of land use on the quality of water resources.

Table E.1 : Impacts of rural and urban land use on surface water resources.

	PASTURE	CROPS	HORTICULTURE	RURAL INDUSTRY (e.g. abattoir, refineries)	INTENSIVE ANIMAL HUSBANDRY	SPECIAL RURAL (Hobby farms)	URBAN
FLOW VOLUME (yield)	Large yield increase compared to forested area. Irrigation may increase or reduce yield depending upon source of water.	As for pasture.	As for pasture.	Demand for industrial water supply may reduce flow.	Minor reduction in yield if water supply required.	As for intensive animal husbandry.	Increased runoff from road, and roofs, but not usually significant because urban areas are usually only a small fraction of catchment.
SALINITY FROM GROUNDWATER DISCHARGE	Clearing may cause brackish or saline streams after clearing in lower rainfall, higher soil-salt storage areas.	As for pasture.	Not usually in salinity - risk areas.	N/A	N/A	As for pasture.	N/a
TURBIDITY	High risk of turbidity if animals have direct access to stream.	High risk of turbid runoff from ploughed fields.	As for crops.	Poor management of site or process can cause severe turbidity.	Turbidity is only a risk in some cases of poor management.	Low risk of turbidity, except when there is a large number of different land owners.	Runoff from roads and verges can cause turbidity.
CHEMICAL POLLUTION	Risk of pollution from agricultural chemicals, pesticides and fertilisers.	As for pasture.	High risk of pollution from pesticides and fertilisers if their application is not controlled.	Harmful chemicals may be discharged to stream if pollution is not controlled.	Risk of pollution from high nutrient loads in effluent and runoff from site unless adequately managed.	As for pasture.	Risk of pollution from urban runoff which contains rubber, fuel and oil, spillage of poisons; drainage from rubbish disposal sites.
BIOLOGICAL POLLUTION	Risk from human and stock access to stream or reservoir.	Minimal.	Usually higher density of human habitation then crops or pasture hence higher risk.	Highly polluting effluent should be treated to acceptable standard before discharge to stream or preferably removed from catchment.	High risk if effluent not adequately treated or removed from catchment.	Relatively high density of housing using septic systems increases risk of pollution of streams. Generally higher level of human activity near streams produces significant pollution.	Disposal of sewage can present a risk of pollution. High concentration of people increases risk of people increases risk of pollution from human contact with stream water or impounded water.



**Table E.2 : Impacts of surface water schemed on rural and urban land use.**

	PASTURE	CROPS	HORTICULTURE	RURAL INDUSTRY (e.g. abattoir, refineries)	INTENSIVE ANIMAL HUSBANDRY	SPECIAL RURAL (Hobby farms)	URBAN
Catchment areas	No impact on conservative farming practices. Potential for rezoning to more densely inhabited or industrial land use may be restricted.	As for pasture.	As for pasture.	Imposes cost of careful management. Industry producing toxic wastes should be excluded from catchment.	Imposes cost of careful management and possible relocation if near stream.	As for pasture and urban. Control on location of septic tanks.	Possibly extra costs for sewage and rubbish disposal. Need to keep urban development away from streams.
STORAGE DAMS	Private land would need to be resumed in reservoir basin and dam works area.	As for pasture.	As for pasture.	As for pasture.	As for pasture.	As for pasture.	As for pasture.
a) Impacts of dam and reservoir basin							
b) Downstream impacts	Flows greater than required for riparian rights are markedly reduced. Flooding is reduced.	As for pasture.	As for pasture.	As for pasture. If industries have used stream for water supply, special arrangements for continued use may be required.	As for pasture.	As for pasture.	As for pasture.
PIPEHEAD DAMS	As for storage dam except that required land area is very much smaller.	As for pasture.	As for pasture.	As for storage dam except that impact on downstream flows is less.	As for pasture.	As for pasture.	As for pasture.
PIPELINES	Easement required on pipeline route. Above ground pipe can give problems of access and slight loss of productive land. Below ground pipe has minimal impact.	As for pasture.	As for pasture.	Pipe route would probably avoid industrial site.	As for special rural.	As for pasture, except pipe route would probably avoid private land.	If pipeline must pass through urban land, there may be difficulty fitting in with other services.

**Table E.3 : Impacts of land use on shallow groundwater resources.**

	NATURAL VEGETATION	WETLANDS	PINE FOREST	MARKET GARDEN HORTICULTURE SPECIAL RURAL	URBAN	RURAL INDUSTRY	INTENSIVE ANIMAL HUSBANDRY
VOLUME AVAILABLE YEARLY	May be limited by need to maintain native vegetation except where the depth to groundwater is sufficiently deep.	May be limited by need to maintain wetlands.	For about 10 years after clearing to plant pines, there is increased recharge. As trees grow older there is less recharge than with native vegetation.	Water available for public supply is reduced by most of the amount withdrawn for irrigation (remainder soaks back to the water table).	Increased runoff from roads and roofs increases recharge, but stormwater drainage may divert some flow away from recharging groundwater.	Water available for public supply reduced by amount drawn from groundwater by industry.	As for market gardens.
POLLUTION	No impact.	No impact unless wetlands receive drainage from urban, industrial or market garden areas.	No impact unless there is inappropriate use of chemicals.	Groundwater pollution by pesticides, fertilisers, effluent from septic tanks.	Groundwater pollution by pesticides, fertilisers, waste and leaked petroleum. Drainage from rubbish disposal sites, effluent from septic tanks.	Groundwater pollution specific to the industry may occur through waste disposal.	Groundwater pollution by effluent from treatment of wastes.

**Table E.4 : Impacts of shallow groundwater schemes on land use**

	NATURAL VEGETATION	WETLANDS	PINE FOREST	MARKET GARDEN HORTICULTURE SPECIAL RURAL	URBAN	RURAL INDUSTRY	INTENSIVE ANIMAL HUSBANDRY
UNDERGROUND WATER POLLUTION CONTROL AREAS, GROUNDWATER AREAS, PUBLIC WATER SUPPLY AREAS	No impact.	Conservation value is maintained through management plans.	Plantation management may be modified to give priority to water production.	Licensing of private wells raises the awareness of the limited availability of the water resource and encourages efficient use. Management is required to prevent pollution of groundwater.	Private wells are licensed and care is taken by public authorities in siting of waste disposal and industry. Management is required to prevent pollution of groundwater.	Water Authority generally objects to industry with potential for groundwater pollution being sited in these areas. Other industries as for market gardens.	As for rural industry.
WELLS	Tree deaths may occur near wells in droughts. Yearly groundwater production plans are designed to limit this occurrence. 200 sq. m of land is required for works at well site.	Locations of wells chosen and wells operated to minimise effects on wetlands.	Viability of pines not affected by groundwater level. 200 sq. m of land is required for works at well site.	Lowers the water table in immediate vicinity. Where wells are situated close together, they may need to be deeper than if further apart. Allocation policy and management are required.	Sites for wells are usually found on public land where their impact is similar to other service installations.	Wells should not be sited in the vicinity of an industry with potential for pollution. Other industry as for market gardens.	As for rural industry.
COLLECTOR MAINS	Mains are generally buried but access is required along route. Existing roads used wherever possible.	Mains are not located in wetlands.	As for natural vegetation.	An easement is required if mains must be located on private land. Impact of main on land use is minimal.	Routes for collector mains must be found in road reserves as for other services.	Routes for mains would avoid conflict with requirements of industry.	As for rural industry.
GROUNDWATER TREATMENT PLANTS	Approx. 6 ha site required for treatment works and disposal of sludge.	N/A	As for natural vegetation.	N/A	Works would be visually obtrusive, and may be source of odour and noise for adjacent houses. Buffer zone required.	N/A	N/A

## **Appendix F : Water Supply Statistics**

GASCOYNE REGION WATER RESOURCES REVIEW							
WATER SUPPLY STATISTICS							
Year	Number of Services		Water Consumed (kL)			Water Delivered (kL)	
Ending June 30	Domestic	Total	Domestic	Other	Total Consumed	From Main Headworks	Peak Week
<b>CARNARVON</b>							
81/82	0	1549	723038	443705	1166743	1545680	41909
82/83	0	1600	767268	550014	1317282	1515710	38787
83/84	0	1613	681138	493183	1174321	1298510	36309
84/85	0	1667	740982	489320	1230302	1421330	38640
85/86	0	1706	799895	513794	1313689	1606481	47530
86/87	1407	1786	852561	575460	1428021	1715980	46158
87/88	1433	1807	904239	549265	1453504	1832010	49800
88/89	1483	1855	898566	552470	1451036	1767879	
89/90	1490	1858	868675	551617	1420292	1688728	42200
90/91	1512	1884	837101	496600	1333701	1593214	41700
91/92	1521	1880	869377	500715	1370092		
92/93	1539	1907	840541	456229	1296770	1565758	0
93/94	1553	1946	837275	467854	1305129		
94/95	1575	1956	917517	515280	1432797		
<b>DENHAM</b>							
81/82	0	306	34878	19617	54495	54887	0
82/83	0	313	37502	23406	60908	56900	1757
83/84	0	320	34654	25292	59946	67396	2366
84/85	0	348	26123	32548	58671	79409	2303
85/86	0	369	27513	44909	72422	85471	2505
86/87	152	389	31282	48124	79406	90195	3269
87/88	158	229	37873	49777	87650	102656	2901
88/89	173	251	35954	58598	94552	121428	0
89/90	184	263	37761	65733	103494	140643	3684
90/91	210	285	44124	69713	113837	148641	3695
91/92	208	293	43755	67930	111685	132712	
92/93	217	320	46050	67959	114009	148737	4588
93/94	243	338	52514	65379	117893	160060	
94/95	259	346	55310	75546	130856	143280	
95/96					134038	149493	
<b>EXMOUTH</b>							
81/82	0	671	395327	199119	594446	747009	19754
82/83	0	677	361691	182483	544174	708970	16912
83/84	0	690	369203	186252	555455	709108	17598
84/85	0	699	397453	195195	592648	826032	22071
85/86	0	706	530118	177608	707726	858520	21896
86/87	591	727	565012	192465	757477	868355	25060
87/88	607	761	494446	214043	708489	830149	20906
88/89	634	789	464935	223113	688048	916948	
89/90	677	832	513675	220566	734241	934907	24707
90/91	685	845	521760	244408	766168	976329	26964
91/92	687	843	476378	202994	679372	882738	
92/93	686	845	345875	186487	532362	715037	18971
93/94	684	850	346073	214760	560833		
94/95	690	866	358019	240692	598711		
<b>GASCOYNE JUNCTION</b>							
81/82	0	16	6462	9352	15814	15814	
82/83	0	18	8428	7525	15953	15953	
83/84	0	16	8707	7991	16698	24940	770
84/85	0	16	13229	8607	21836	32146	1225
85/86	0	16	9920	10219	20139	23400	763
86/87	9	17	7477	6933	14410	28358	1316
87/88	9	16	10673	13158	23831	26832	946
88/89	9	16	7568	14733	22301	19182	
89/90	9	16	6312	14332	20644	20662	678
90/91	9	17	7387	17391	24778	24672	1426
91/92	9	17	10416	14295	24711		
92/93	9	16	6573	16397	22970	30571	1711
93/94	9	17	4146	14644	18790		
94/95	9	17	5560	13511	19071		

## **Appendix G : Tourism Development**

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## **TOURISM DEVELOPMENT AND GROWTH POTENTIAL**

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### **Tourism Industry Growth and Water Issues**

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 mean an increased demand on water resources. Periods of high water consumption during the peak holiday seasons may place pressure on existing water sources and promote the need for the 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 its salinity. Considerations to the availability and quality of water resources must be made in planning for the future development of the tourism industry.

The quality of water resources may also be affected by tourism development within the Gascoyne Region. Developments that may potentially impact on water resources, including water reserves, should be referred to the Water and Rivers Commission for advice.

Competition for water resources may arise when existing sources cannot supply demand. The tourism industry is only one growing industry in the Gascoyne Region in which future water requirements is an important issue related to its development. Other areas of growth include mining and horticulture. Competition for water resources may occur when existing sources can no longer sustain demand. If future sources are not allocated sustainably, water resources may become exhausted under the pressure of competition.

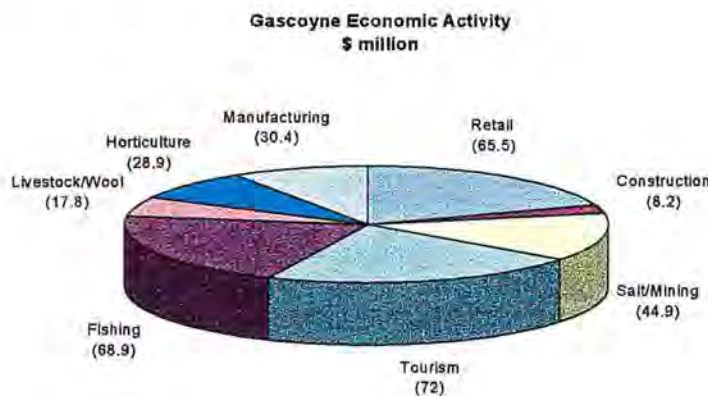
The availability and quality of water resources in the Gascoyne Region are limited. It is important that the planning of the tourism industry in the future allows for the related increases in the demand for water to ensure the safekeeping of sustainable resources.

### **The Tourism Industry Now**

Tourism is the Gascoyne Region's fastest growing industry and is now valued at over \$70 M annually. In recent years, a growing tourism sector has become a major element of the economy and is now one of the largest contributors to the region's economy. Extensive nature based and indigenous tourism opportunities exist in the region and the continued development of tourism is regarded as a key to future development.

The chart below indicates the value of economic activity in the Gascoyne Region.

**Figure G-1: Economic Activity in the Gascoyne Region**



Source: Department of Commerce and Trade

The region has great natural beauty with the Ningaloo Marine Park and the Shark Bay World Heritage area which encompasses a marine park with attractions such as Shell Beach, stromatolites at Hamelin Pool and the world renowned dolphins at Monkey Mia. The whale shark phenomena near Exmouth and the recent “fish feeding frenzies” at Cape Cuvier have also attracted great interest. The coastal Zuytdorp Cliffs, south of Shark Bay, are well known for their rugged beauty. Shark Bay also includes Steep Point, the most westerly point of mainland Australia. Mount Augustus in the eastern Gascoyne Region is the largest monocline in the world.

The Western Australian Tourism Commission and the Australian Bureau of Statistics have both made estimates of the tourist numbers. The Western Australian Tourism Commission, using a newly enhanced method for determining regional travel activity (WATS), estimate that approximately 222,000 visitors travelled to the Gascoyne Region during 1994/95 and approximately 167,000 of these visitors stayed in commercial accommodation. Alternatively, the ABS estimate that the Gascoyne Region was visited by over 300,000 people in 1993/94 with approximately 275,000 of these visitors staying in commercial accommodation. Different data collection methods or data interpretation methods are likely to have caused the discrepancy in visitor numbers.

It is estimated that approximately 70 per cent of visitors to the Gascoyne Region live in other parts of Western Australia and of the remainder, approximately 18 per cent are from interstate and 12 per cent are from overseas. There is an increasing trend towards interstate and international visitors and this is likely to be due to increased visitation to the Shark Bay and Ningaloo Reef areas and the increased availability of fully inclusive (package) tours. Nature based tourism is the most popular reason for visiting the Gascoyne Region.

The development and future potential of the tourism industry in the shire regions are described below.

### **Shire of Shark Bay**

The Shark Bay Shire encompasses a World Heritage area and Francois Peron National Park. The Peron Peninsula is the site of Project Eden, which is a CALM initiative to reintroduce/protect rare and endangered fauna. Other National Parks are proposed for Dirk Hartog Island and Eden Land.



Denham is the regional centre of the Shire which provides a range of accommodation for a broad cross section of the tourism market and is a service town for tourism and the fishing industry. Denham is also a staging point for visits to other parts of the Bay and is the access point for fishing charters and for trips to Dirk Hartog Island.

Monkey Mia is a small holiday destination which has its own accommodation and the Monkey Mia dolphins are of great significance in the region. The area is visited by over 100,000 people annually.

The expansion of the existing tourism facilities at Monkey Mia are under consideration and several proposals have been made. The Government is currently finalising its position on further development options and it is likely that expansions of the existing facility and/or the development of new facilities at Monkey Mia will occur in the next 5 years.

Tourist attractions at Shark Bay may be divided into the natural, man-made and recreational categories.

The natural attractions of Shark Bay relate primarily to the marine environment and the recreational opportunities it provides. Some of the attractions include algal stromatolites at Hamelin Pool, dolphins at Monkey Mia, Shell Beach, Big Lagoon and Little Lagoon, Dirk Hartog Island, Steep Point South Passage and False Entrance, Zuytdorp Cliffs and the local flora and fauna.

The man-made attractions are mainly related to the historical development of Shark Bay and include Freshwater Camp - located at Nanga (containing the pioneer Homestead Museum and the Pottery), shell block buildings (including the Old Pearler Restaurant, St Andrews Church and the Shark Bay Hotel), Denham Townsite and the solar salt operation at Useless Loop.

Existing recreational activities in Shark Bay are almost entirely related to the marine environment including fishing, diving, boating, windsurfing and sailing.

The first Regional Plan for Shark Bay was released in 1988. Subsequently, in 1991, Shark Bay was listed as a World Heritage Area which recognised it as an outstanding example of the major stages of the earth's history in its evolution. It was also nominated for its exceptional natural beauty and for containing significant natural habitats for conservation. A review of the 1988 Shark Bay Region Plan (*Shark Bay Regional Strategy, A Review of the 1988 Shark Bay Region Plan*) was published for public comment in March 1996 to provide guidance for the use and management of all regional and marine use issues in the World Heritage Area and continued planning and management to protect and enhance World Heritage values.

The review supports the following tourism initiatives for the Shark Bay region:

- Small-scale developments and tourism experiences which link the many natural and World Heritage values of the region and extend the length of stay and diversity of tourist activities;
- Wilderness experiences, which reflect the isolated nature of the region and its attractions, would benefit from the identification of the region as a priority destination area as part of the statewide initiatives for nature-based tourism;
- Tourism facilities in Denham which enhance the existing character of the town; and
- Tourism facilities and activities which acknowledge or utilise the maritime heritage of the region.

Tourism holds the greatest potential for economic development at Shark Bay and has significant potential for employment opportunities. The expansion of this industry requires the development of infrastructure, recreational facilities and protection of the resources which attract tourists to the area.

There has been substantial investment in tourism infrastructure in the region including:

- Development of a resort hotel in Denham;
- Construction of an airport including sealed runway and terminal;
- Other projects including holiday houses, units or caravan sites.

Proposed developments under consideration include:

- Monkey Mia expansion;
- Foreshore redevelopment and improved signage;
- Road realignment to Denham and Monkey Mia;
- New marine facilities.

Much of the tourism attraction to the region is assisted by its status as a World Heritage site.

The principal considerations emerging in relation to the development of the tourism industry in the Shark Bay region are:

- A nature-based approach, which builds on the isolated wilderness character of the region and which promotes education, scientific development and the protection of environmental and World Heritage values, is preferred; and
- There are many small-scale opportunities available in the region and these need to be linked together as part of the tourism marketing and information services for the region. The diversification of product and provision of more options for visitors leads to extended stays. Opportunities for operators to work toward providing diverse products which are complimentary need to be provided.

## **Shire of Carnarvon**

Carnarvon is the major town in the region and is a service centre for tourism. Carnarvon and the adjacent coast are popular for coastal fishing, however water based activities are relatively undeveloped in the Carnarvon area.

Although Carnarvon is located away from the region's key natural attractions, the town will continue to provide an important tourist service centre. In addition, Carnarvon will provide for tourist markets such as retirees seeking more extensive holidays during the winter period. It is also anticipated that the Fascine development, located within walking distance of the town centre, will give Carnarvon a higher profile and become a focal point for tourism, and that local attractions such as Red Bluff, Cape Cuvier and Lake MacLeod will be promoted to encourage tourists to extend their stay.

The Gnaraloo/Quobba area includes supervised and unsupervised camping areas and low-key chalet style accommodation and is a popular recreational destination for people from Carnarvon and other parts of Western Australia. The area is popular for surfing, fishing and low key coastal tourism, however, it has some constraints including access limitations and coastal cliffs. Tourism development should be limited to low-key facilities such as camping,

farmstays and possibly caravan facilities, in keeping with environmental values (Ministry for Planning, 1996).

## **Coral Bay**

Coral Bay is a significant tourism destination, offering a range of recreational opportunities and exceptional access to the Ningaloo Reef and quality beaches. Coral Bay currently provides a limited range of low-key accommodation facilities, mostly for intrastate and some interstate tourists. However, demand for accommodation facilities can outstrip supply at Coral Bay during peak periods. A relatively small number of international tourists visit Coral Bay, usually on day trips. Coral Bay is the southern portion of the Maud's Landing townsite.

### ***Tourism Potential***

Coral Bay comprises an existing major tourism site in the region, but the layout and servicing of settlement and the standard of past development seem not to have centred on long term sustainability. Planning strategies for the area indicate that natural resources are under stress and may have already surpassed their carrying capacity for tourism. The Coral Bay experience demonstrates the future need for coordinated planning, implementation and management of developments based on natural resources.

There is enormous potential to broaden the tourism market of this area by providing the necessary infrastructure and by marketing the region as an international tourism destination.

### ***Proposed Developments***

The development of Coral Bay as a tourist destination has been adversely affected by the lack of quality infrastructure. In 1995/96, the State Government established the Coral Bay Infrastructure Task Force which is to provide Cabinet with recommendations related to the infrastructure development needs of the town. It is likely that improvements will be made to the community's water, sewerage and power infrastructure. In addition, several sites have been examined for the development of a new boat launching facility, with associated services. These initiatives are likely to provide for additional tourist related development in the Coral Bay area.

## **Maud's Landing**

### ***Tourism Potential***

The northern part of the Maud's Landing townsite (also referred to as Maud's Landing) is currently vacant Crown land. In terms of the development of the tourism industry, the marina and resort elements of the proposed development at Maud's Landing are probably not economically sustainable without a predominant housing component. The proposal should therefore be considered primarily in town planning terms, including evaluation of the public cost of infrastructure, to ensure that the combined populations of the settlement and Coral Bay at peak times is consistent with the management of the resources in the area. The marina

proposals at Exmouth and Maud's Landing, being at opposite ends of the Ningaloo Marine Park, could optimise tourism use of the Marine Park.

There is enormous potential to broaden the tourism market of this area by providing the necessary infrastructure and by marketing the region as an international tourism destination.

### ***Proposed Developments***

The development of an integrated tourist and residential development at Maud's Landing, with a population of up to 5000 people, has been proposed by Coral Coast Marina Development Pty Ltd. This project, which would be built in stages over 15 to 20 years, could ultimately see the development of a 400 room resort, a 250 room hotel and convention centre, as well as the provision of caravan park, chalet and backpacker facilities.

## **Shire of Exmouth**

### **North West Cape**

The North West Cape area is a significant zone for marine activities. These include diving, interacting with whale sharks, fishing, turtle watching, general boating and swimming. These activities occur along the Ningaloo Reef and extend to Exmouth Gulf and Exmouth's offshore islands.

The North West Cape area is arid and has a very sensitive natural environment. It is remote and expensive to service and is already showing signs of degradation from the pressure of people. The focus of tourism development in this area must move toward "low volume and high yield".

Because the marine environment is the most valuable attraction, the carrying capacity must be established here first and land based facilities, such as accommodation, then follow. Extensive land based development without this context will almost certainly destroy the natural assets which are currently attracting people. Because the tourist experience in the area is "sensitive wilderness", any industrial development must be carefully evaluated to establish the impact on this perception.

The North West Cape Technical Advisory Committee has identified activity specific issues in relation to tourism and recreation. The following issues concerning the tourism industry in the North West Cape region were identified:

- Inadequate infrastructure and distance from major centres are impediments to developing the tourism industry;
- Accommodation capacity, diversity and quality is currently low or poor;
- Visitor numbers need to increase before airlines consider better utilisation of the Learmonth airport;
- Additional development in or near Exmouth requiring significant power generation will attract headworkers charges to enable existing station to be upgraded;
- Uncertainty of cooperate marketing agreements with other regions; and
- More information and incentives needed for development generally.

## **Tourism Potential**

Cape Range is of considerable specialist interest. In terms of tourism development, the area has potential as a day visitation area. Longer stay visits would be encouraged by the establishment of walk and mountain bike trails and would help establish the nature focus of the area and connect its many viewpoints.

### **Milyering**

The accommodation most suitable for Milyering would take the form of a Wilderness Lodge set into the foothills with various types of accommodation units to suit a wide range of tourist market segments. A key feature of consolidation of functions at Milyering is to market increasingly to family groups as well as the base market of couples in caravans. This will enable access to all facilities of the National Park and encourage longer stay visits, whereas the current situation of a long drive from Exmouth discourages repeat visits.

### **Turquoise Bay**

Turquoise Bay forms part of one of the Marine Park's eight Sanctuary Zones. Apart from the car park, there are no built structures present. The site was previously identified as suitable for tourism development in the Exmouth survey of residential and tourist opinions. The major constraint to development are the sanctuary zone and its relatively small size compared to other sites in the region. Overnight accommodation would spoil the superb characteristics for day visitation. Instead the site could be considerably enhanced as a day visitation area with the addition of toilet facilities and shade areas.

### **Sandy/Osprey Bay**

The bay lies adjacent to one of the Marine Park's Sanctuary Zones and has several built structures including the access road, toilet and gas barbecues. This site is identified as a secondary development area for camping and caravanning and possibly chalets due to its large area of buildable land behind the dune system and rock platform. It could function as an annex to Milyering, with management based at Milyering. The site also forms a node on the Learmonth - Sandy Bay touring route.

### **Ningaloo**

The site has potential for three or more "superlot" developments, each containing a major resort based on the recreation values of the locality and framed within the surrounding ecological values. The site has the potential to become a location for tourist accommodation in terms of a high level of inventory at the upper level of quality of accommodation type.

The site has features that make it a prime site for further investigation for possible international quality development, including the natural attributes of the other beaches and rangelands to the north, as well as the nearby foothills of the Cape Range.

Ningaloo is the focus of the opportunity to build a tourism industry of high inventory and high quality. The site should be reserved for this purpose under strict guidelines and the necessary work to release it for the desired form of tourism development. Supporting infrastructure requiring investigation includes desalination of the brackish groundwater, a stand-alone power generation plant and sewage treatment facility.

The site contains two historic buildings of intrinsic tourism value; the Ningaloo homestead and the former lighthouse. These buildings could be retained until it is desirable to incorporate them in the overall tourism development plan.

Shearer's Shed Bay lies north of the Ningaloo site adjacent to the existing shearing sheds of Ningaloo Station. This appears to be a safe "family beach" which would support a small development or act as an annex for other large scale tourist development in the area. There is adjacent land for development, although some of it is a salt marsh adopted for pastoral use. The beach is used for small boat launching and if required, a ramp could be sighted in the lee of the rocky headland for protection.

### **Tantabiddi**

Existing built structures include a boat ramp and associated groyne, ablution block, car park, fenced area enclosing a tower and a beach "house". These are not of high standard and if/when new development is contemplated, the present leases would need to be reviewed and the whole area re-planned.

The boat launching and mooring facilities at Tantabiddi could be improved as it is the only west coast location servicing these needs. It is well placed for access to the reef and open sea for seasonal events such as whale watching and game fishing.

There is a proposal to develop a 240 room tourist resort in the Tantabiddi area.

### ***Proposed Developments***

Tourist developments are predicted along the west side of the North West Cape, extending as far south as Maud's Landing. If a tourist road was constructed, extending Charles Knife road to Milyering, low profile development may be promoted in this area due to the potential construction of power lines along the road. Sandy Bay has been suggested for low-key development and Tantabiddi has been suggested as the most likely place for development north of the Cape Range National Park. There is keen interest in this area, particularly along the coast and proposals for development have reportedly been received. Turquoise Bay is unlikely to be developed. Proposals for hotel development have been reportedly rejected by the government.

Development has been delayed until it can be determined what effects the residential and tourism development has on the ecosystem. It is important to determine the maximum capacity of people who go to the North West Cape, as a high volume of visitors may have a serious impact on the natural environment. This impact also indirectly influences the utilities (water, power, sewerage) needed to support an increased tourist population.

## **Tourism Scenarios**

The *North West Cape Tourism Development Study (1993)* identified regional scenarios for tourism potential in the North West Cape region. The basic criterion is that both regional scenarios are sustainable through appropriate development and management techniques. The ideas of these potential tourism scenarios are outlined below.

### **The Minimum Sustainable Development Scenario**

This scenario is considered the minimum requirement to bring the management of the natural resources into line with tourism demand. It represents a management response to trends and the approach can be considered as a “maintenance of the resource” policy.

- This scenario envisages:
- The existing tourist accommodation could be approximately doubled over the next 5-7 years.
- The National Park to be doubled in size (incorporation of Ningaloo Station), which is considered the minimum essential to sustain the resource under the foreseeable tourism pressures.
- The northern section of the extended Park would primarily consist of nature based tourism, with some recreational use and the southern section would comprise mainly of recreational use, with some nature based tourism.
- Three major and seven minor sites suitable for development.
- There are northern and southern “Gateways” to the Park at Milyering and Lefroy Bay, which would have a number of functions, including:
  - concentrate tourism accommodation in nodes for efficiency of managing and servicing;
  - provide a user-revenue collection point;
  - create a commercially attractive development and operational opportunity;
  - sustain a viable tourism industry with reliable leasing income to the State;
  - reinforce the sense of arrival at a special place;
  - relate accommodation with natural resource interpretation;
  - increase and improve interactions between tourists and rangers;
  - reduce the need for daily travel from distant accommodation;
  - eliminate the need for high speed road access to the extremities of the Park;
  - encourage longer stay visitation.
  - Milyering would have a camping and caravan annex at Sandy Bay.
  - Lefroy would operate with an annex at Winderabandi.

The cost associated with the provision of basic infrastructure is \$5.8 M and the potential uplift in accommodation is about a 74 per cent increase on the current inventory. The associated benefits would be increased direct permanent jobs, increased tourism spending and

associated indirect job growth, together with increased investment flowing to construction jobs. In addition, further jobs will be created in natural resource management associated with increased revenues from leases and user fees.

### **The Maximum Carrying Capacity Scenario**

The scenario is considered the maximum level at which management of the natural resources would be comfortably in line with tourism provision. It represents a purposeful economic development initiative and the approach can be considered as a “resource development” policy.

This scenario envisages:

- A peak of approximately 13,000 bed spaces over the next 15-20 years.
- Exmouth as the major staging point, administrative centre and service centre.
- Domestic and especially overseas tourists would be targeted.
- Northern and southern gateways to the expanded park with accommodation nodes concentrated at Milyering and Lefroy Bay.
- Ningaloo would be a major site for high level, high quality tourism accommodation and Lefroy Bay would be extended to the same standard.
- Winderabandi would be a site for a wilderness lodge.

This scenario involves first steps similar to the minimum sustainable development scenario, however, there is a distinct difference in approach, in order to build a viable tourism industry of national and international standard.

### **Exmouth**

The Town of Exmouth has a range of tourism infrastructure and is the natural centre for the Reef Range area. The Reef Range area incorporates two attractions of international significance, the Ningaloo Marine Park and the Cape Range National Park. The town, however is some distance from the Ningaloo Marine Park and the Cape Range National Park. Exmouth provides an administrative and service function for the region’s growing tourism trade. The infrastructure of Learmonth Airport and the boat harbour development (under construction), are major assets which will facilitate tourism development.

### ***Tourism Potential***

The development of Exmouth could take four phases. Throughout all phases, tourism accommodation and services in Exmouth would continue to be upgraded and expanded as the focus for tourism activity in the region.

In the first phase, a number of marine access facilities would either be built or upgraded. A minor accommodation facility at Jantz Beach would be the second phase. In the third phase, 2 caravan parks could be developed on the Gulf side of the Cape at Qualing Pool and Learmonth Jetty. In the final phase, 2 significant tourism developments could occur; a marina at Exmouth and the upgrade of Learmonth airport.



## ***Proposed Developments***

Learmonth Airport is proposed to be improved and redeveloped to a 747 runway, with associated infrastructure for a 45 minute turnaround. This would encourage overseas visitors and as the demand for the airport grows, the industrial component of the airport would be developed also. A major airline has indicated interest in flights to Exmouth if the 747 turnaround is within the above time.

Approximately \$10 M has been invested in providing quality small boat facilities through the Exmouth Boat Harbour Project, due for completion in 1996. The project, which will probably be linked to the development of residential land and tourist resort facilities, will provide improved small boat facilities for the growing number of recreational fishers who visit the area. Landcorp are currently examining the development of residential land and tourist resort developments associated with the Exmouth Boat Harbour. This project could lead to the development of a canal style estate and location of at least one tourist resort project near the Boat Harbour. Expressed interest in the resort site has been received by a number of private sector organisations who are keen to take advantage of likely tourist interest in the North West Cape region.

## **Shire of Upper Gascoyne**

Land based tourism activities throughout the region primarily revolve around natural features and wildlife and the provision of accommodation.

Three local operators in Shark Bay and Exmouth provide safari tours as do safari operators from outside the region. The region's landscape is a feature for coach tours from Perth and the north.

Accommodation is provided in the region's towns, on stations and in the Mount Augustus area. With only a few exceptions, accommodation is not well linked with tourism product and land based tourism activities are limited throughout the Gascoyne.

## **Future Needs for Tourism**

In order to capitalise on the tourism potential in a sustainable manner the following actions would be required:

### **Preservation and Management of the Environment**

It is essential that all developments acknowledge the fact that the natural environment is the biggest asset for the Gascoyne Region's tourism industry. Therefore, to ensure the long term economic sustainability of tourism, all tourism development must be compatible with the region's environmental values. Access to tourist attractions and facilities must be controlled and developments should be consolidated both to minimise environmental impacts and to facilitate effective environmental monitoring. In addition, tourism developments, including hotels and resorts, should be developed and managed to comply with strict environmental criteria. Hotel and resort designs must be sensitive to the natural environment.

## **Accommodation**

As well as providing for existing tourism markets, world class accommodation facilities could be developed to take advantage of the interstate and international markets. In addition, it is essential that all accommodation developments are supported by effective and convenient transport infrastructure. To access development on the Coral Bay/Reef Range sites there will need to be an upgraded coastal access road from Coral Bay to Milyering.

## **Transport**

During 1992/93, 77 per cent of tourists travelled to the Gascoyne Region by private vehicle, 11 per cent by air and 8 per cent by coach/bus. In order to attract new tourist markets, particularly interstate and international tourists, the Learmonth airport must be upgraded to international standard. In addition, all tourist attractions and accommodation developments must be conveniently linked by transport infrastructure. This would involve the development of good access roads to Cape Range, strategic coastal locations and all tourism facilities.

## **Marketing**

While attractions in the southern Gascoyne Region, such as Monkey Mia, are becoming well known within Australia and internationally, the North West Cape region is less well known. It is essential that tourism developments in the region are supported by extensive marketing strategies which are directed towards a variety of tourism markets. These promotions should target the Australian and international tourism markets with a specific interest in the natural attractions of the region.

Recent initiatives by the Western Australian Tourism Commission and the Gascoyne Tourism Association (GTA) has led to a consolidation of the region's marketing activities. The GTA appointed a full time Executive Officer and a Marketing Consultant to further promotional activities in the region.

## **Water**

The planning of developments related to the tourism industry should consider the impact they may have on existing and future water resources in the Gascoyne Region. This includes the sustainable allocation of resources as well as the consideration of potential pollutants.

In the future, other water source options may have to extend further than the potential resources within the region. These may include desalination of sea water or brackish water or the piping of water from other regions of the State, which at present are considered uneconomical. As the water resources in the region become fully allocated and technology is improved, the economic viability of these options will become more favourable.

## **Appendix H : Agricultural Development**

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## AGRICULTURAL DEVELOPMENT AND GROWTH POTENTIAL

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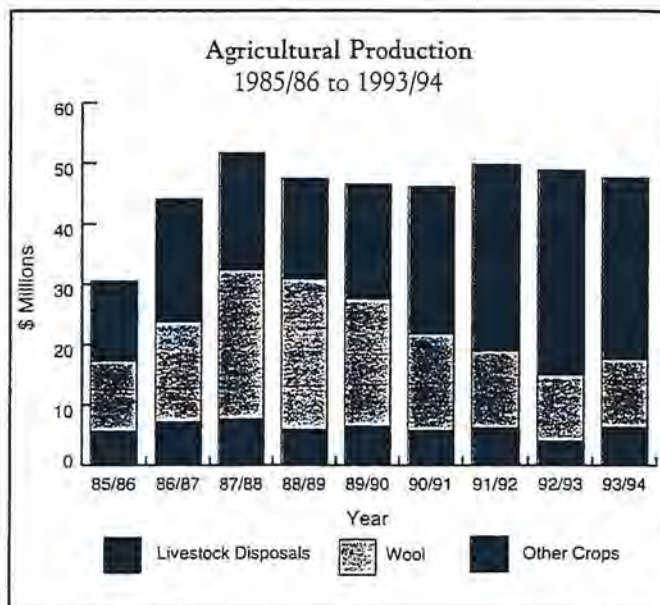
### General

Primary industries have historically been the mainstay of the Gascoyne regional economy. Activities such as pastoral production and horticulture have contributed much to the prosperity of the region through the years.

Two distinct types of agricultural activities take place in the Gascoyne. Horticulture takes place along the banks of the Gascoyne River between 5 and 18 km from its mouth, and pastoral activity occurs extensively throughout the region.

The total value of the agricultural sector was approximately \$47.0 million in 1993/94 (GDC, 1996). Horticulture increased its contribution to total agricultural production in the several years prior to 1993/94 and now accounts for just over two thirds of production. In the mid to late 1980's this share was closer to one half.

*Figure H-1 : Agricultural Production - 1985/86 to 1993/94*



Source: Department of Commerce and Trade (using Australian Bureau of Statistics data).

Agriculture and horticultural production in the region continue to adjust to changes in market condition. In the agriculture sector, depressed prices for wool have resulted in diversification into cattle, and in some instances goats. The horticultural sector diversification has occurred away from bananas into vegetables, grapes and other fruits such as mangoes and low chill stone fruits. These changes provide further strength to the region's economy by protecting it from a major downturn in any one sector.

In an attempt to maximise the value attained from agricultural and horticultural production and to maintain the viability of these industry sectors, producers are attempting to develop export markets. The markets which are being targeted vary depending on the commodity, but for horticulture the initial target markets are in the South East Asia as well as in the Middle East (GDC, 1996).

In addition to the efforts to extend product markets, the region's producers are also examining ways to improve the quality of products through plant or animal development, better handling and packaging techniques and improved transport efficiency.

The Gascoyne region contributes to the State's agricultural production because it is:

- has a well developed horticultural industry with substantial supporting infrastructure and is backed by Growers' Associations, the Gascoyne Research Station and transport companies;
- readily accessible to Perth markets as produce can reach markets overnight due to dedicated transport services which commute regularly between Carnarvon and Perth.

The relationship between agriculture, the natural environment and other land uses in the region are changing and the values placed on agriculture and its location are being redefined.

In particular, the focus of the pastoral industry has been affected in recent years due to the impacts of fluctuating market prices and demand. The industry has also been affected by the need to reduce livestock numbers in order to reduce environmental effects (such as drought and land degradation) and promote sustainable development.

The horticultural industry has been largely constrained by the limited availability of fresh water resources and suitably defined land in the region. Demand for produce has been strong and there has been considerable pressure for reliable water supplies and expansion opportunities to be made available to ensure the continued prosperity of the horticultural industry.

The infrastructure in the irrigation district is ageing, with parts of the scheme being over twenty years old. This infrastructure is likely to be costly to restore. The irrigation area is also prone to salt intrusion. Areas of the irrigation district were abandoned in the past due to the ingress of salt water into the aquifer by over pumping.

Water demand projections have been undertaken for the agricultural industry and are presented graphically. Most of the agricultural water usage is obtained from private bores.

## **Pastoral Industry**

### **Current Situation**

The pastoral industry has contributed significantly to the settlement and development of Gascoyne region. Sheep were introduced to the Gascoyne in 1876. Today, sheep, cattle and feral goats graze the region's rangelands. It is believed that 650,000 sheep were grazed in 1995.

The use of land in the Gascoyne pastoral industry use is extensive. About 117,000 km<sup>2</sup> or approximately 80 per cent of the region's land asset is utilised by pastoral leases. The area covered by the pastoral leases includes large portions of the Gascoyne, Wooramel and Lyndon-Minilya Rivers basins. The pastoral leases have been developed and improved by the lessees under terms and conditions of their leases with the State Government.

The pastoral industry has generally been declining since the mid 1980's when falling demand for wool led to the collapse of Australia's wool marketing system. The market price for wool is often below the cost of production.

The value of wool production in the region has halved from about \$25 million in 1987/88 to approximately \$12 million in 1993/94. The value of meat production has remained relatively steady during the same period and is approximately \$6 million.

Decreasing livestock numbers in the region can be attributed to the diversification which is being undertaken, seasonal conditions and better management practices.

Sustained grazing pressure brought on by the development of permanent water points and the introduction of hard footed livestock has caused some degeneration of the rangelands over a 70 year period. To sustain pastoral activity, while protecting the bio-diversity of the native rangelands is a challenge which confronts pastoralists and the State.

The long term use of the State's rangelands will require co-operative planning and strategic decision making to ensure that the resource is used in a sustainable manner. This will require ongoing effort to better understand the dynamics of the rangelands.

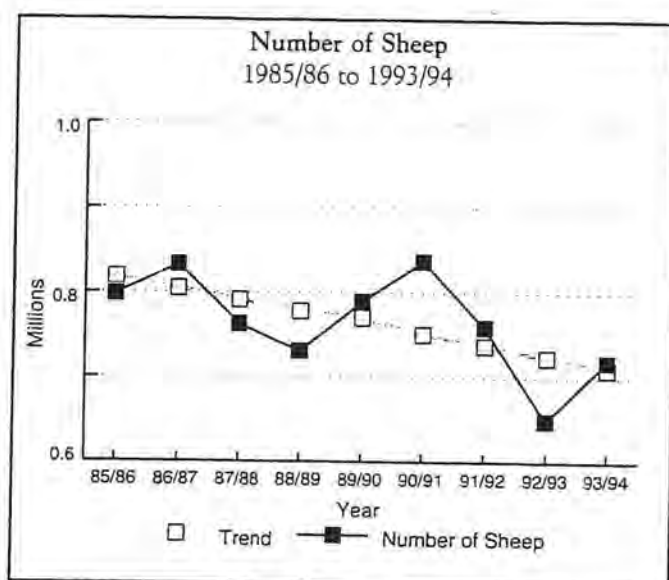
### Sheep and Lambs

It is estimated that 650,000 sheep were in the region in 1995.

Although stocking rates fluctuate with environmental, market and seasonal conditions, each station typically runs between 8 000 and 12 000 sheep with stocking rates varying between 10 and 20 hectares per sheep. The viability of the leases is questionable in many instances when stock numbers fall below 8 000 (Pastoral Industry Wool Taskforce).

Traditionally sheep have been raised in the region for wool growing. However, the value of wool has declined significantly in recent years and this caused lessees to move away from wool. Sheep are also utilised for meat and sheep sold for meat contributed \$2.1 million to the region's economy in 1993/94.

**Figure H-2 : Number of sheep 1985/86 to 1993/94**



Source: Agriculture Western Australia

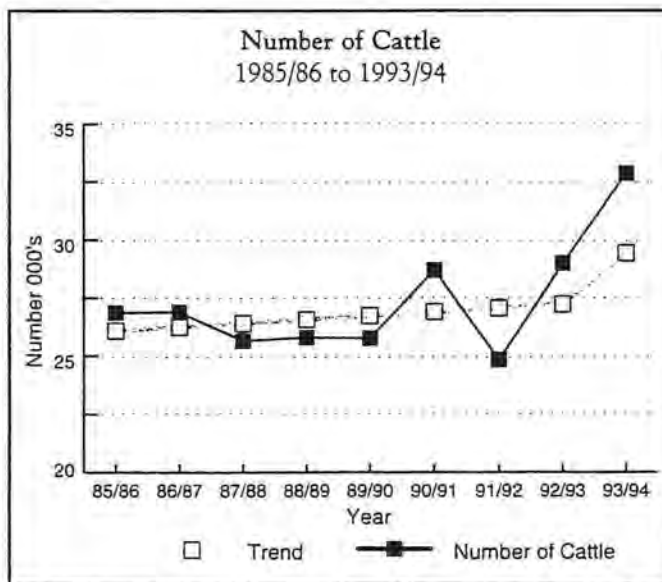
With the value of wool and sheep meat production remaining depressed and a trend of declining real returns to the region's producer from these commodities, the local pastoral sheep industry is under considerable pressure to change.

This presents some major challenges for the pastoral sector and for the region as this sector is important due to its linkages to other sectors. Some of these challenges are already being met with significant efforts now being made to diversify. Some producers are moving towards beef while others are looking at option such as domesticated goats, floriculture and even aquaculture.

### Cattle and Calves

Cattle numbers in the region have increased considerably in recent years to reach a high of 33,000 head in 1993/94. This increase results from the diversification from sheep to cattle and it is envisaged that it may increase further as Australian beef producers secure new markets in the future.

*Figure H-3 : Number of Cattle 1985/86 to 1993/94*



Source: Department of Commerce and Trade (using Australian Bureau of Statistics data).

Production occurs mainly in the eastern parts of the region. In drier seasons, more cattle are turned off and sent to properties in the south west of the State.

### Goats

The region's rangelands are home to significant numbers of feral goats. In the past, efforts have been made to eradicate the goats since they are considered to be a pest which is contributing to the degradation of the rangelands. However, some pastoralist have been harvesting the feral goats for meat and live export as there is considerable demand for goat meat and live goats in a number of countries in South East Asia and the Middle East.

Agriculture Western Australia, while continuing to manage goat numbers on the rangelands through eradication programs, has commenced goat production demonstration trials. These trials are aimed at determining the value of domestication of goats. Should the trials be successful, it is likely some pastoralists will consider diversifying to goat production (GDC, 1996).

### **Future Direction**

Forecasts by the International Wool Secretariat suggest that the depressed state of the industry is likely to continue in the short to medium term due to the poor demand and over supply of wool.

Industry infrastructure within the region is in danger of collapsing due to the ongoing depressed state of the wool market. Continued downward pressure on the wool industry is likely to cause a gradual swing away from fibre production in the pastoral regions.

In the short term, diversification to meat production appears to be the most viable option for pastoralists with production from cattle, sheep, goats and native species such as kangaroos. Diversification of pastoral activity into alternative areas such as tourism and in some instances horticulture, floriculture or aquaculture may also be viable.

Commercialisation of feral goats has occurred in the region and some of these animals are being processed in abattoirs in Carnarvon. Agriculture WA has been supporting a trial goat domestication project which would attempt to produce higher quality animals for the live export market.

Existing transport and marketing infrastructure will adequately cover current levels of live animal production from the region. However, further expansion in the industry would require upgrading of the main feeder roads and regional export facilities.

Proposed strategies for the pastoral industry as determined by the Gascoyne Development Commission are to:

- Encourage and support restructuring of the pastoral industry to improve viability of individual leases and total industry,
- Identify and secure access to areas of rangeland which are essential to the maintenance of the pastoral industry,
- Implement recommendations of the Gascoyne Murchison Rangelands Strategy,
- Encourage and assist the wool sector of the pastoral industry to diversify the animals which are harvested in the rangelands area,
- Promote and encourage participation by pastoralists in nature-based and station visit type tourism as a supplement to pastoral activity,
- Return areas in the rangeland where pastoral activity can not be sustained and which have high environmental value to the conservation estate,
- Promote and support the live animal export trade into SE Asia and in particular Indonesia and Malaysia,



- Ensure any general use port infrastructure developed in the region provides access for live animal export trade.

It is anticipated that the impacts of future pastoral development on the surficial groundwater resources of the region will be minimal (because they are localised). This is due to the remoteness of the pastoral stations from other developments, the lack of competition for the groundwater resources and the limited amount of water that is drawn from bores for stock usage.

The impacts of future pastoral development on the artesian groundwater resources are likely to be greater, because the resource is regional. This is particularly due to the large number of free flowing artesian bores in the western portion of the Gascoyne region which are flowing to waste. Measures should be taken to curb this wastage, as the potentiometric heads in the artesian aquifer are believed to be declining.

### **Water Demand**

The pastoral industry is the main user of the artesian aquifers. The annual abstraction from artesian bores is estimated to be approximately 45 GL (Allen, 1986). This estimate may be high, however, even if it was conservatively estimated, it would still exceed the total recharge of 27.9 GL per annum to the aquifer of which only 17.3 GL per annum is recharged to the most heavily exploited part of the aquifer. The groundwater salinity generally ranges from 3,000 to 6,000 mg/L TDS.

The effect of allowing artesian bores to flow has probably extended to the recharge areas in the southern part of the basin. However, the apparent continued decline in flow rates indicates there has been no large compensating recharge. Furthermore, it is unlikely that there has been any improvement in groundwater salinity as the unconfined groundwater in alluvium overlying the intake areas to the Birdrong Sandstone is generally brackish.

The main effect of controlling artesian flows would be to maintain artesian pressures over a relatively large area for an indefinite period. This would reduce the necessity for windmills or pumps in some areas and thus reduce operating costs to some station owners. A secondary effect of controlling artesian flows would be to conserve groundwater.

By the year 2026, it is anticipated that groundwater usage from the artesian pastoral bores will be in tune with the sustainable yield of the aquifer, which is estimated to be approximately 20 GL per annum.

## **Horticulture**

### **Current Situation**

Horticulture first began in the Gascoyne region in the 1920's with the development of irrigated banana production on the fertile soils of the Gascoyne River delta. Plantations in the Carnarvon horticultural district are located along the banks of the Gascoyne River and extend from 5 to 18 km from the river mouth.

Apart from pastoral activities, horticulture is the region's only other commercial agricultural activity. The area under intensive cultivation is relatively small at 750 hectares. However, production values are high, with the industry worth being approximately \$32 million in 1995.

Prices are subject to fluctuation from year to year as a result of seasonal factors and commodity prices.

The climate of the Carnarvon area is suited to the growth of tropical and sub-tropical fruits. Temperatures in autumn, winter and spring are ideal for the growing of vegetable crops. These same crops are produced in southern areas during summer. The ability to meet out-of-season demand in the Perth market is a major contributor to the success of vegetable production from the region. An additional advantage of the region's horticultural industry is its capacity to deliver quality produce in excellent condition to the metropolitan markets overnight.

To remain competitive, growers in the region must continue to improve the quality and presentation of their product. Generally, growers who have maintained a high level of product quality control have been rewarded with better than average prices. The challenge will arise when most growers have increased the quality and standard of product presentation and the margin between quality difference is insignificant.

The industry outlook is encouraging on both a statewide and regional basis. Western Australia is Australia's largest exporter of vegetables, delivering 52 different products to 20 countries. Western Australia also has the capacity to produce a wide range of export vegetables on a year round basis. The Gascoyne region will play a major role in filling the increasing demand for off-season fruit and vegetables because of the unique climate and high quality water resources.

The challenge facing the industry lies in the need to expand the region's production area in line with the domestic population growth and export demand. This would ensure that the level of output continues to increase as market demand increases.

### **Bananas**

Banana production accounts for about 40 per cent of the total value of production from the region. However, Gascoyne bananas are facing increasing competition from bananas produced in the Kimberley region.

Historically, the level and value of banana production has varied considerably due to seasonal factors and market price variations. The production value peaked in 1991 and has since declined, but the banana growing industry continues to remain an important and viable sector of the region's economy.

In 1994, Carnarvon produced the second largest value of total fruit within WA and accounted for 15 per cent of the State's total production.

In the last few years, there has been a trend away from banana production and some diversification into table grapes and stone fruit production.

### **Vegetables**

The region produces approximately 15 per cent of the State's vegetables. Growing occurs in autumn, winter and spring. The ability to meet out-of-season demand in the Perth market is a major factor in production.

Production values rose through the 1980's and until 1992 when the region experienced a decline. Since 1992 the value of production has fallen by approximately \$4.6 million due to price and seasonal factors (GDC, 1996).

In 1995 production was valued at \$20.3 million This was achieved through production of a wide range of vegetables including; tomatoes (\$10.9 million), capsicum (\$2.7 million), and beans (\$1.8 million). Other crops contributed the remaining \$4.9 million.

### **Fruits**

Fruit production in the region has been growing and the value of production in 1995 reached its highest level ever at \$3.9 million.

A variety of tropical and sub-tropical fruits are produced in the region including mangoes, watermelons, rock melons, grapefruit and honeydew melons. Carnarvon fruit producers have a significant advantage over their southern counterparts in that their produce can be marketed earlier in the year.

### **Grapes**

Table grapes growing is a rapidly emerging industry in the region. The growing of grapes is expected to further diversify the region's product base and will be beneficial in respect to employment, as the industry is labour intensive, and in achieving higher returns while using less land and water.

1994 ABS agricultural statistics indicated that Carnarvon Shire was one of the top five shires based on the total value of table grape production.

### **Future Direction**

The region's horticultural industry is progressive and well structured. Growth in both the domestic and export markets will in the medium term determine the extent of the future expansion of the region's horticultural industry.

Technical support for the industry is comprehensive and is available through the horticultural section of the Agriculture WA office at Carnarvon. On farm trials and extension of crop variety information is practised as a means of technology transfer.

Proposed strategies for the horticultural industry as determined by the Gascoyne Development Commission are to:

- Assess the commercial viability of the existing horticulture area as currently structured and support industry restructuring if required,
- Increase water availability and dependability to current growers through the extensive use of water harvesting principles of both on and off-stream storage techniques and enhance industry utilisation of existing irrigation water potential through the adoption of better water management and use practices,
- Promote the development of new horticultural areas within the region at sites where adequate water reserves exist,

- Continue to develop crop varieties that satisfy market demands and encourage diversification of the industry to high yield and value, and where possible low water consumption, products,
- Encourage grower awareness of the collective benefits of produce quality control,
- Link commercial expansion of the industry to an appropriate learning institution so that technology transfer occurs,
- Monitor the variety and quantity of chemicals used in the industry and where appropriate disseminate information on their impact on the environment and the use of suitable alternatives,
- Improve transport efficiencies by enabling the use of triple trailer road trains on the North West Coastal Highway south of Carnarvon to Perth through the removal of existing impediments in the Mid West region.

Existing groundwater supplies in the existing horticultural area are already fully committed. Therefore, future development will rely on new water harvesting techniques, better water management and/or resource expansion. Changing the production to crops which use lower amounts of water may also be beneficial.

Groundwater resources are known to exist at Rocky Pool, Mooka, Meedo and Wooramel. These water resources could be used for horticultural development.

Initial research indicates that up to 1,000 hectares could be developed at Rocky Pool. If this area is established, it would double the available horticultural land in the region and on the basis of the returns from the existing horticulture area, it could lead to the doubling of the value of horticulture in the region over the next 5 to 10 years. A significant number of jobs could also be provided.

If development of the Rocky Pool area is to proceed, transport infrastructure such as a sealed road from Carnarvon to Rocky Pool would also be required. This road would not only benefit the horticultural industry but would also facilitate development of the tourism industry by improving access to areas such as the Kennedy Ranges and Mount Augustus.

On a water perspective, the extent of horticultural development at Rocky Pool will be constrained by the availability of suitable water resources. Although, firm decisions have not been made on the management and allocation of water in this area, it is expected that the criteria will be similar to that for the existing horticultural area. The water infrastructure is likely to be privately developed.

It is expected that the use of water at Rocky Pool will be managed in a way which will minimise the adverse effects on water availability in the existing horticultural area at Carnarvon. This could be achieved by limiting the amount of water which may be drawn from the Gascoyne River when it is flowing. Small flows at Rocky Pool would be required to pass unhindered and work is in process to determine the level at which water may be drawn from the river at Rocky Pool without affecting recharge to the aquifers downstream in the Carnarvon horticultural area.

## Water Demand

Existing groundwater supplies in the current horticultural area are already fully committed. Currently 8.5 GL of water is utilised for horticultural practices. In order for the horticultural industry to develop, the identification and utilisation of potential water resources needs to be addressed. Groundwater resources are known to exist at Rocky Pool, Mooka, Meedo and Wooramel. These water resources could be used for horticultural development.

In the Rocky Pool area, the renewable groundwater resource is estimated to be 8.0 GL/annum with salinity less than 1,000 mg/L TDS. The estimation of the sustainable yield is based on inferred limits derived from groundwater information. Abstraction quotas, therefore should progress gradually from about 5.0 GL/annum to about 8.0 GL/annum, at which time the maximum vertical hydraulic gradient will be induced (Panasiewicz, 1995).

Currently SMEC consultants are investigating the future management and augmentation of the Carnarvon Irrigation area. The consultants are undertaking a detailed feasibility study of options to augment water available to Carnarvon irrigators by approximately 3.5 to 4.0 GL/annum.

The resources of the Mooka and Meedo areas are unknown and have been omitted in the planning process until information concerning the resources is available. Rockwater (1996) estimated the groundwater resources of the Wooramel River basin to be 2.2 GL/annum.

Two scenarios for the horticultural projections for the region were developed based on the above available water resources. Both scenarios assume the augmentation study is successful, consequently 4.0 GL/annum is available.

Scenario 1, assumes the development of all possible resources to their maximum potential. This incorporates developing the resource at Rocky Pool in two stages; firstly developing, 5.0 GL/annum then, secondly progressing to the maximum 8.0 GL/annum.

Scenario 2 assumes that only the first stage of Rocky Pool will eventuate and that the Wooramel resource is constrained to provide only 1.1 GL/annum.

Water projections indicate water requirements in the year 2010 of 17.5 GL for the two scenarios and the year 2026 of 22.7 GL and 18.6 GL for scenario 1 and 2 respectively.

(Note: 1 GL = 10<sup>6</sup> kL)

Year	Scenario 1 (GL/annum)	Scenario 2 (GL/annum)
2010	17.5	17.5
2026	22.7	18.6

Figure H-4 : Horticultural Projection Scenario 1

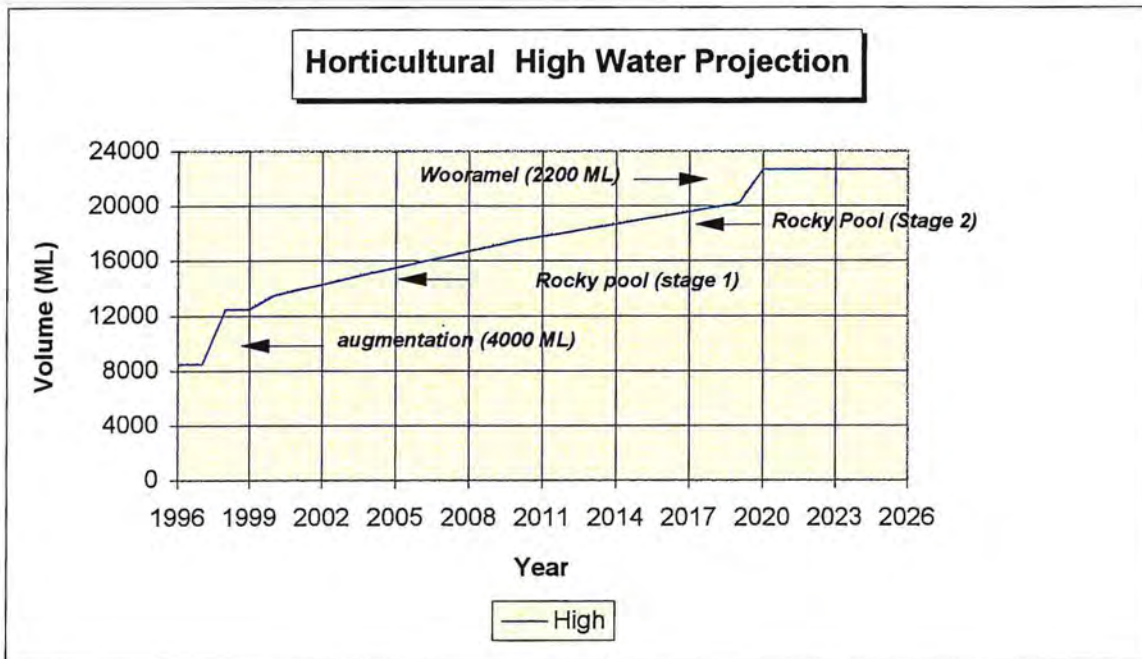
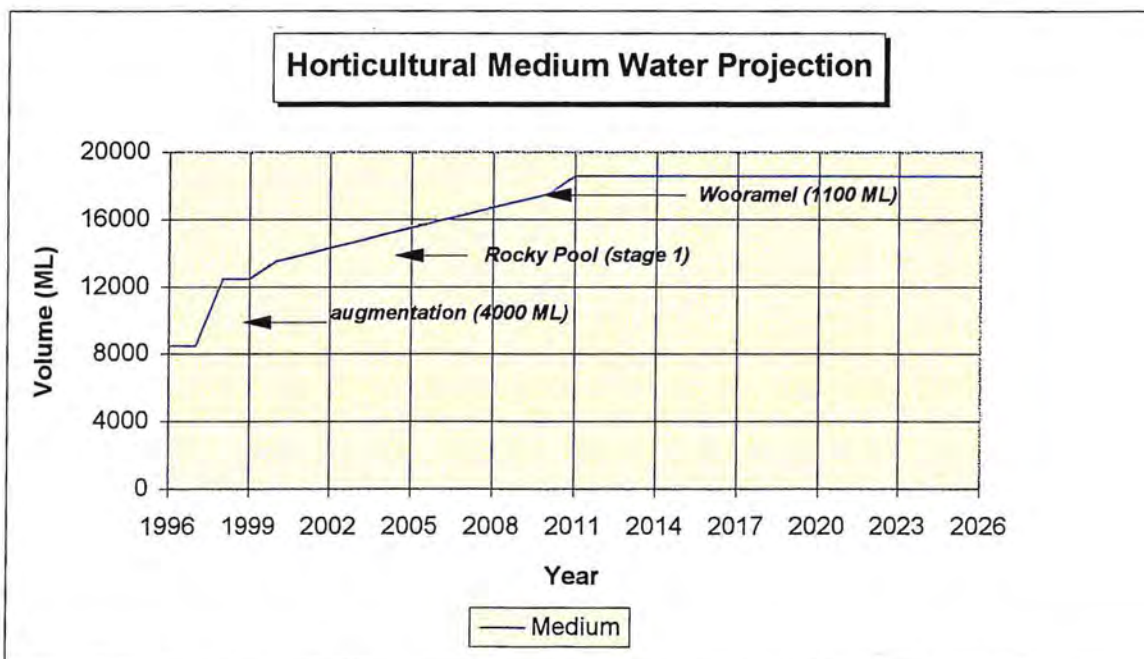


Figure H-5 : Horticultural Projection Scenario 2



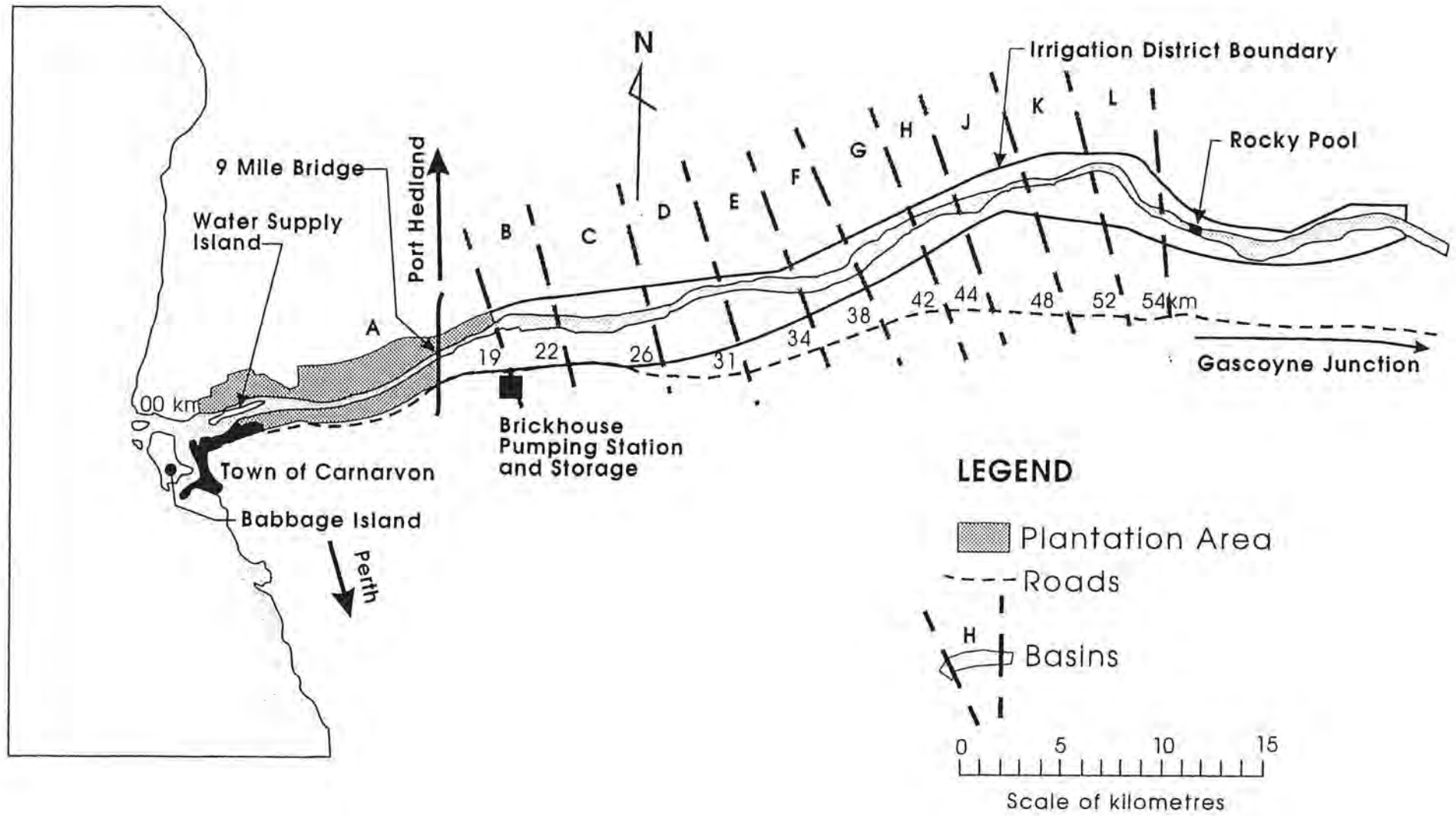


Figure H-6 : Carnarvon Irrigation District and wellfield basins (A -L)

## **Appendix I : Industrial Development**



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## INDUSTRIAL DEVELOPMENT AND GROWTH POTENTIAL

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### General

The region's economic activity is diverse and relatively well balanced. Almost all of the product from the region is directed to either the Perth metropolitan domestic market or to export markets. While the region has the smallest economy in total, 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 and consideration is being given to the Cape as a site for natural gas related initiatives.

The region's mining sector makes an important contribution to the region in both economic and employment terms. However, the lack of diversity from this sector is of concern to the region and efforts are being made to enhance the role played by this sector in the region's economy. Production from the region is almost entirely attributable to salt mining.

The region's fishing sector provides a rich variety of seafood to the domestic and international market. Fishing in the Gascoyne is based on prawns, scallops and varieties of fish such as snapper, tuna, shark and mackerel. The catch is also processed in the region and this is the region's principal manufacturing activity.

Infrastructure such as the proposed new boat harbour at Exmouth will provide improved facilities for the growing number of recreational fishers who visit the area. It will also benefit the Exmouth Gulf fishing industry through the provision of servicing facilities and safe anchorage in cyclonic conditions. The upgrading of the airport terminal at Learmonth will enable the provision of improved export and cold storage facilities to industries.

Water demand projections have been undertaken for the mining and fishing industries and are presented graphically. Most of the industrial water usage is obtained from private bores.

### Fishing

#### Current Situation

The region is a rich source of fish, molluscs and prawns. The fishing and pearling industries have been an important part of the region's economy for many years. Shark Bay, the site of Australia's first pearling industry, was established in the 1850's. Development of the fishing industry has continued since then and is now worth an estimated \$70 million.

The majority of the catch is exported, with a significant portion of this sent to markets in Asia and North America. The opportunity to increase production in the traditional industry is expected to be limited as the resource in the region has reached a production level which is sustainable.

## **Prawns**

The volume of prawns taken from the region's Exmouth and Shark Bay prawn fisheries has remained relatively constant in recent years. In 1994/95, the catch was over 3000 tonnes, representing 75 per cent of the state total and worth over \$30 million to the region's economy.

Prawning, on a value basis, is the most important fishery in the Gascoyne and the region contains the most important prawn fisheries in the state. Further extension of the industry is not likely as the prawning grounds are finite and management practices ensure the resource is not over exploited. The Exmouth prawn fishery is unique in that the catch is returned daily to the factory with little or no processing on board the trawlers.

The two major fisheries in the region are located at Shark Bay and Exmouth and each fishery harvests slightly different prawns. The size of production varies on a seasonal basis and the total value of the catch varies according to market prices, but it is expected that the contribution will increase as world demand for fish product increases. Almost all of the current catch is exported, with Asia being the dominant market.

## **Molluscs**

In 1994/95, the mollusc industry was worth approximately \$17 million to the region's economy. This represents 36 per cent of the state's output of molluscs which was worth around \$45 million. The mollusc industry is based almost entirely on scallops. A significant proportion of the scallops are exported to markets in the US and Asia.

The mollusc harvest in 1994/95 was 2935 tonnes, which is slightly below the average harvest size. However, in the 1991/92 season the harvest peaked at 20,000 tonnes. Although, the reason for the increase is not understood, it is believed that scallop numbers were influenced by changes in the Leeuwin Current.

## **Wetline Fish**

In 1994/95, the wetline fishery was worth over \$2 million to the region. This accounted for approximately 6 per cent of the total value of this fishery to the state and was derived from 1270 tonnes of wetline fish.

Snapper, whiting, tuna, shark and mackerel are all commercially fished in the region from Shark Bay to Exmouth Gulf. Snapper fishery accounts for over 60 per cent of all snapper caught in Western Australia and comprises 35 per cent of all fin fish caught in the region.

In recent years, wetline fishery has declined in relative importance when compared to other types of fishery undertaken in the region. A number of factors could be responsible for this. The most likely among them would be the relative increase in the size of the mollusc and lobster catches, which have shown steady increases.

## **Lobster**

The region's rock lobster catch peaked and was worth \$7.5 million to the region's economy in 1993/94. However, as with other forms of fishing in the region, there is currently little opportunity to enhance catch volumes as the grounds are exploited to their sustainable limits.

### **Pearls**

The pearl industry is well established in Exmouth Gulf and to a lesser extent at Shark Bay and Carnarvon. The industry is regulated and any further expansion will be demand driven.

### **Aquaculture**

The Gascoyne region is ideally suited to the development of aquaculture, especially mariculture. Significant development of the aquaculture industry in the region is likely to come from the farming of fin-fish for both domestic and export markets. Opportunities also exist for the region to produce beta carotene and other algal products.

### **Future Direction**

The region's fishing industry is well managed and there is limited opportunity for catch volume enhancement within this sector. However, there is an opportunity to make commercial use of off-catch species which are harvested with the main catch. Any extension of catch utilisation would be conditional on product demand and viability.

The most significant potential for industry development in the medium term lies in the further expansion of aquaculture in the Gascoyne region. The region contains extensive offshore, near shore and inland sites and supports many species of fish and shell fish, which are high value and could have potential for aquaculture development.

World natural fish stocks are declining and some heavily fished species are reportedly nearing extinction. However, demand for fish and fish products is still increasing. The estimated sustainable yield of the world's fish industry is expected to plateau at 100 million tonnes per year. By the year 2000, the world demand for fish products is expected to be 120 to 130 million tonnes per year and by the year 2026 demand could reach approximately 160 million tonnes per year.

As the gap between product availability and demand widens, the value of the product will rise. Increasing prices for natural fish products will encourage the further development of the aquaculture industry. It is expected that the yield from aquaculture worldwide will be about 20 million tonnes per year by the year 2000 and this is expected to rise to over 60 million tonnes per year by the year 2026.

Proposed strategies for the natural fisheries industry as determined by the Gascoyne Development Commission are to:

- Continue to protect natural fishery stocks and breeding grounds throughout the region through the use of exclusion and sanctuary zones, management regimes and ongoing fisheries research,
- Clearly define on-shore and near-shore areas that are zoned as recreational fisheries,

- Ensure that the fishing industry is represented in discussions when marine parks and marine nature reserves are established in the region,
- Ensure continued Government support of fishing and aquaculture industry trade initiatives at an international level,
- Maximise the value of natural stocks through the better management of catch processing,
- Encourage industry research into downstream processing of catch by-products,
- Encourage continued processing of fishery products within the region,
- Ensure that the effect of pollution on ocean and coral reef habitats is recognised and action is taken to protect fish breeding grounds from pollution,
- Develop and maintain marine shore-based facilities and services at strategic and regulated landing points throughout the region for commercial and recreational fishers.

Aquaculture is an evolving industry which is able to be ecologically sustainable, provided effective management procedures are developed and implemented while the industry is still emerging. At present, aquaculture activity within the region is primarily based on pearl oysters, however, pilot projects involving giant clams, fresh water aquarium fish, edible oysters and beta carotene production have been trialed with some success.

To facilitate the development of this industry, it is necessary to establish strategic planning, management and environmental guidelines and recommendations, by way of an Aquaculture Development Plan for the Gascoyne region. The objectives of the aquaculture plan are to:

- Identify, describe and assess the resources of the region (including land and water sites and native aquatic species) which are suitable for aquaculture production,
- Identify areas within recognised aquaculture sectors that are best suited for future aquaculture development, and
- Provide strategic management planning guidelines and recommendations, that provide a sound basis for the sustainable use of the Gascoyne's resources in an efficient and equitable manner.

It is expected that fin-fish farming will achieve economic potential in the longer term. This is to be achieved by developing a fin-fish hatchery in the region. Pearling is already undertaken in the region and there are proposals to produce pearls, prawns and fin-fish in the future. The region is expected to become a centre of excellence for future fin-fish and pearl aquaculture developments.

The areas with the greatest potential for aquaculture are considered to be at Exmouth, Shark Bay and Carnarvon, although inland sites with access to artesian waters also offer some opportunities.

Outcomes which could be achieved by implementing the Gascoyne aquaculture development plan recommendations are:

- Western Australia's share of the domestic market for aquaculture products will increase,

- An increase in Western Australia's share of the export market will be achieved by developing new products for export, and
- The current value of aquaculture products from the region will increase substantially.

The water requirements for aquaculture projects are likely to vary considerably depending on the species to be farmed and the location (land based or ocean based). This in turn impacts on the amount and quality of water that is required.

## **Mining**

### **Current Situation**

The region's mining sector presently contributes little to the state economy, although, it makes an important contribution in both economic and employment terms within the region. Production, which at present is almost entirely attributable to salt mining, was valued at approximately \$45 million in 1994/95.

The low level of contribution from this sector is of concern to the region and efforts are being made to enhance the role played by this sector in the region's economy. New mining initiatives are being established or are under consideration and include developments in the gypsum and limestone sectors. These projects will increase the value of the region's mining industry.

### **Salt**

Current mining activity in the Gascoyne region is centred mainly on the production of salt at both Useless Loop and Lake MacLeod. In 1994/95, the salt industry contributed 99.8 per cent to the mineral production value for the entire region and produced 30 per cent of Western Australia's salt production value. The total value of salt production in the region has increased by \$10 million and is now valued at over \$44 million.

The region's two main salt producers are Dampier Salt, who operate at Lake MacLeod and Shark Bay Salt, who operate at Useless Loop. It is possible that salt production will be reduced at Lake MacLeod because Dampier Salt are intending to produce gypsum and because Dampier Salt also produce salt in the Pilbara. Shark Bay Salt has been developing its operations and production levels are likely to increase considerably.

Demand for salt is likely to continue in the short to medium term at much the same level of volume and price as that presently experienced. Most of the region's salt is exported to Japan, where it is used for the production of chemicals.

### **Gypsum**

Gypsum deposits exist at Lake MacLeod. There is significant demand for the product and production in excess of 1 million tonnes per annum for export to Japan has commenced. The production of gypsum is a new venture which is expected to inject millions of dollars as well as additional employment into the region's economy.

## **Oil and Gas**

Oil exploration has been undertaken in the region since 1953 when the first oil discovery in Western Australia was identified at Rough Range. There have been no finds which warrant production at this stage. The region has several exploration tenements, however, these provide little economic value to the region.

The coastal areas have yet to be sufficiently evaluated. Mobil, Lasmo Oil and Minora Resources have been exploring for resources. Resources may exist in parts of the Ningaloo Marine Park, however, a decision has been made by the government to disallow exploration or mining in the park.

Large scale gas fields and extraction on the North West shelf are somewhat remote from the region and currently has little effect on the economy of the Gascoyne region. Major expansions to the North West shelf operations may affect the region in future, if the North West Cape is chosen as a site for associated infrastructure.

## **Limestone**

In 1993, limestone and hard rock extraction in the region was valued at \$96,000. Most of the materials, such as local hardrock, are used locally for road aggregate and general construction. The limestone product is of low quality and is used for road surfacing. Some areas of higher grade limestone have been identified in the Exmouth region.

The extraction of hardrock and limestone will need to increase over time to supply raw material for tourism developments, marinas and road construction. The current production levels are low, although, development opportunities are likely to become available in future. Whitecrest Enterprises and Swan Portland Cement Pty Ltd are proposing to develop the limestone resources in the Exmouth area, which has the potential to supply both domestic and international markets.

## **Mineral Exploration**

The area within the Gascoyne region is almost entirely underlain by sedimentary rocks of the Carnarvon Basin. A relatively small section to the north east of Gascoyne Junction is underlain with Precambrian igneous and metamorphic rocks and holds some geological interest.

Early mining activity was limited to a number of small gold mines which operated at Cobra and at Mangaroon in the northeast of the region. However, recent exploratory drilling in the area has not yet indicated the existence of viable quantities of gold bearing material. Diamonds were discovered in the Wandagee area in the late 1970's, but their size and quantity do not allow viable exploitation.

## **Future Direction**

Shark Bay Salt is expected to increase the amount of salt produced at their Useless Loop operation from 1 million tonnes per year to about 1.5 million tonnes per year in the short term. The site is expected to undergo significant expansion and new salt evaporators are

likely to be constructed to cater for this increase in production. The population at Useless Loop (a closed mining community) is expected to increase by one third to approximately 200.

Significant gypsum resources exist in thick beds below Lake MacLeod. Dampier Salt has commenced development of a gypsum processing plant and initial production is anticipated by 1997/98. When full production is reached, it is expected that approximately 1 million tonnes per year will be exported to companies in Japan. The project is expected to make a significant contribution to the region's economy for many years.

The future potential of the petroleum industry depends largely upon production commencing in the region or in adjacent offshore areas. Should production occur, supporting infrastructure would be required both on-site and within local centres such as Exmouth and Carnarvon. These facilities could include servicing of support craft, transfer sites for fly-in fly-out staff and engineering and maintenance facilities.

World trade in Liquefied Natural Gas (LNG) has grown steadily over the past 5 years. Demand for LNG is strong and projected future growth is high. By the year 2000, consumption is expected to be between 90 and 100 million tonnes per year. By 2010, consumption is expected to reach 146 million tonnes per annum. With increasing world demand, the future of this sector appears to be assured for many years.

The proposed development of the Gorgon Field gas resources are of interest to the region and the location of an LNG processing plant would have significant development implications for the North West Cape. Other natural gas resources may create development opportunities on North West Cape in future.

The region contains high grade limestone reserves in the Cape Range near Exmouth. Whitecrest Enterprises and Swan Portland Cement Pty Ltd propose to develop a limestone mining project which would initially provide 200,000 tonnes per annum of limestone ore to Swan Portland's new processing plant at Kwinana. It is expected that ore production would rise to 1 million tonnes per year and this would be used to supply domestic and international markets.

A proposal to develop a quicklime processing facility in the North West Cape area which would produce 200,000 tonnes per annum of lime product is also being considered. Product from the plant is expected to be of very high quality and has the potential to be exported. Initially, the plant would be powered by electricity. However, it is expected that the plant would be powered in the long term by gas from the LNG reserves.

The prospectivity of the region's hinterland is also being re-examined and mineral such as gold may be found in quantities which could be economically viable to mine.

Proposed strategies for the mining industry as determined by the Gascoyne Development Commission are to:

- Encourage further investigation of the region's mineral prospectivity and disseminate information to encourage development,
- Develop a plan to provide resource security to ensure appropriate mineral resource development is possible,
- Support and encourage long term planning for mining within the region to ensure that resource development projects undertaken in ecologically sensitive areas are not in conflict with the long term sustainability of the environment,
- Encourage the efficient establishment of service and transport infrastructure,

- Promote close liaison between mining proponents and regional communities to maximise local involvement directly and indirectly in developments, to minimise potential conflicts and to encourage efficient use of infrastructure,
- Promote utilisation of local labour in the industry,
- Promote development of mining initiatives associated with the downstream processing of natural gas on the North West Cape,
- Link mining activities in the region to appropriate learning institutions to encourage technology transfer.

The water requirements for mining projects are likely to vary considerably depending on the product to be produced and the location (land based or ocean based). This in turn impacts on the amount and quality of water that is required.

## **Water Demand**

Currently, 1,445 ML of water is utilised in the region for industrial purposes and includes the mining, fishing and manufacturing sectors. The water demand for the industrial sector has been projected and considers only the known large scale developments which are expected to require water within the next 5 to 10 years. This assessment includes the water requirements associated with the expansion of the salt, gypsum, limestone and fishing/fish processing industries. The water usage from the naval base is expected to increase as industries take advantage of the water and infrastructure available at the base.

The water projections indicate that in 2026 the industrial water requirements are likely to be about 2,886 ML. This is an estimate based on the best available knowledge and may need to be reviewed in the next 5 to 10 years.

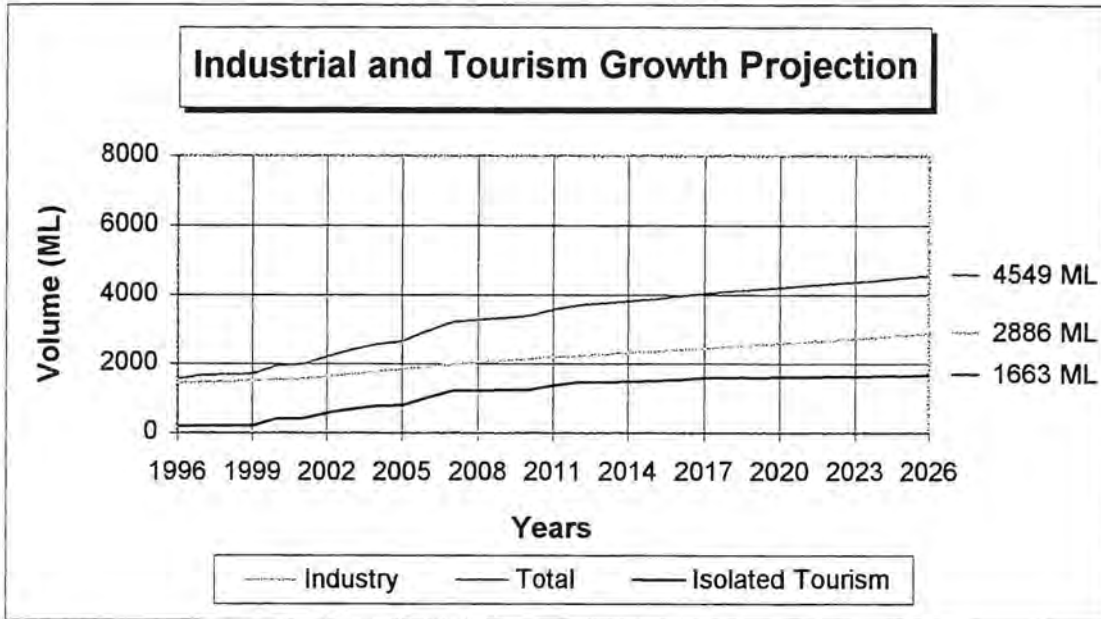
Approximately, 191 ML is believed to be used by the tourism industry in areas remote from the major towns in the region. The water demand for the tourism industry (remote from towns) has been projected and considers only the known large scale developments which are expected to require water within the next 5 to 10 years. This assessment includes the water requirements associated with the expansion of the tourism industry at Coral Bay, Monkey Mia, Nanga and the North West Cape.

The water projections indicate that in 2026 the tourism water requirements are likely to be about 1,663 ML. This is an estimate based on the best available knowledge and may need to be reviewed in the next 5 to 10 years.

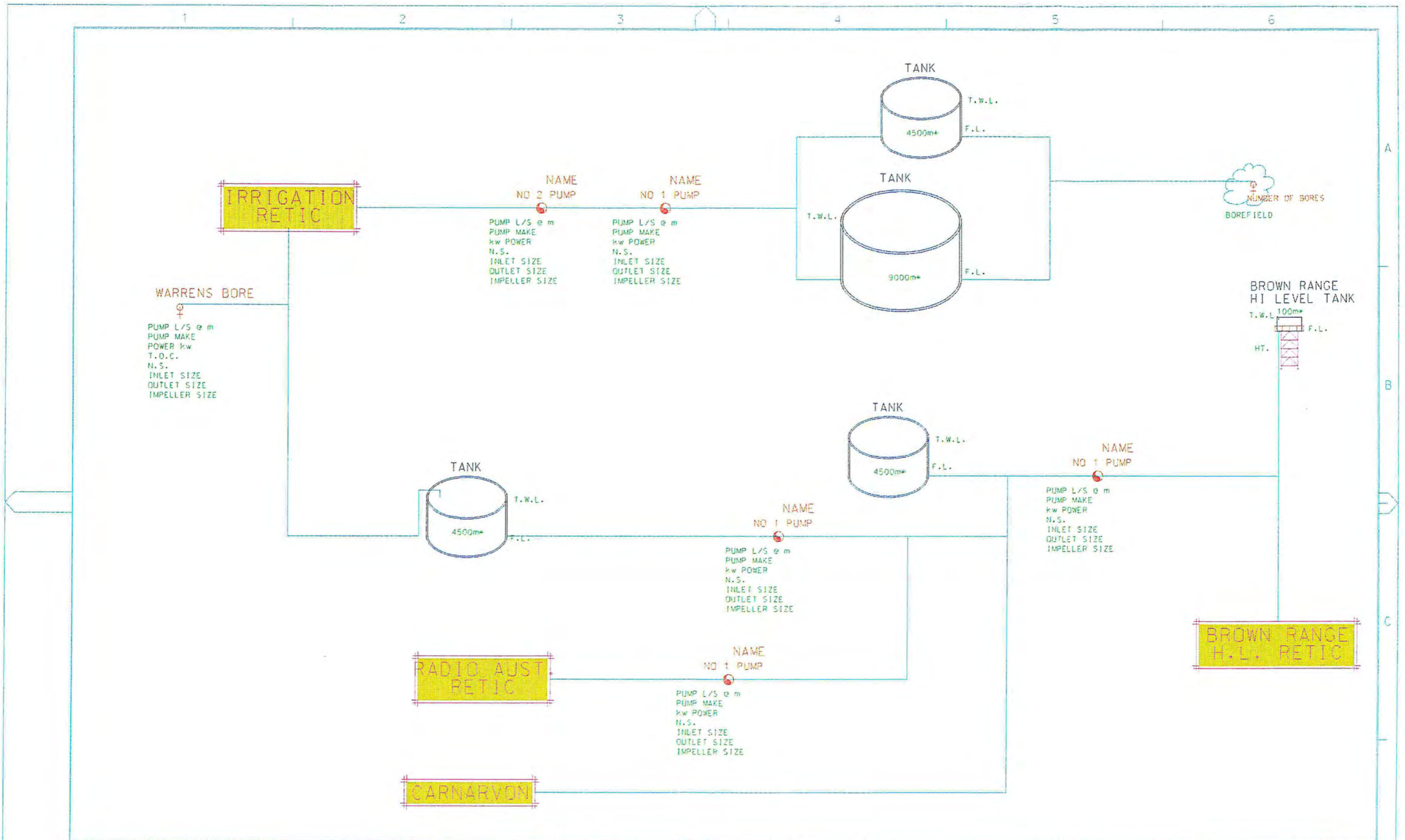
In 2026, the combined industrial and tourism water requirements are believed to be approximately 4,549 ML.



Figure I-1 : Tourism and Industrial Projection



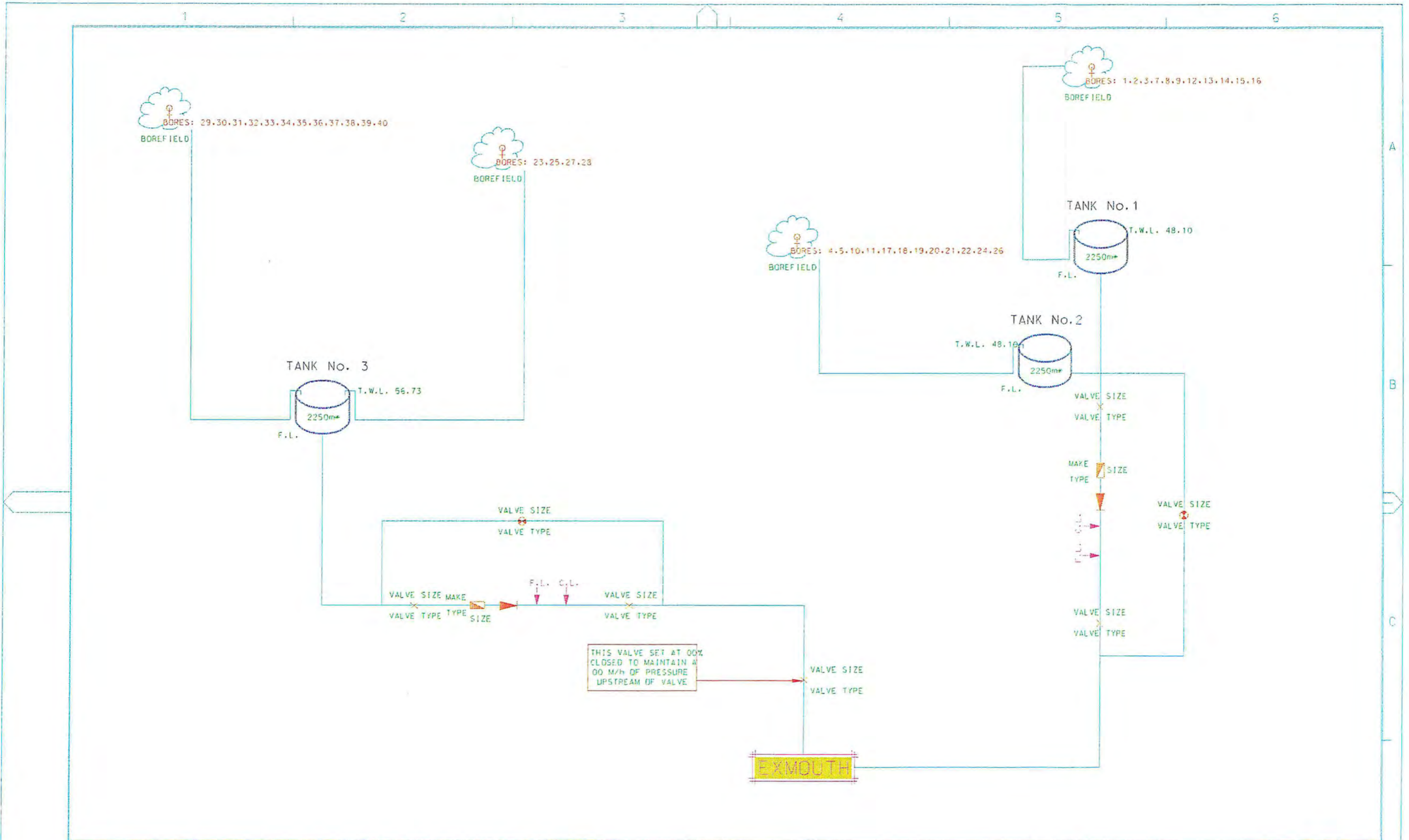
## **Appendix J : Schematics for Town Water Supply Schemes**



DES REF	RECOMMENDED 15/09/95		FILE	PROJECT	PLAN	CAD	ISSUE	ORIGINAL SHEET SIZE
DATE	G. A. VAN KEULE REGIONAL DRAFTSMAN							
DRN A. J. S.	APPROVED 15/09/95	J. CITIZEN	A	MF				
O.C. CHD G. A. V. K.	OPS. MANAGER NORTH MIDLANDS							

283

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DES REF  
DATE  
DRN  
A. J. S.  
O.C. CHD  
G. A. V. K.

RECOMMENDED 15/09/95  
G. A. van. KEULE  
REGIONAL DRAFTSMAN  
APPROVED 15/09/95  
J. CITIZEN  
GPS. MANAGER NORTH MIDLANDS

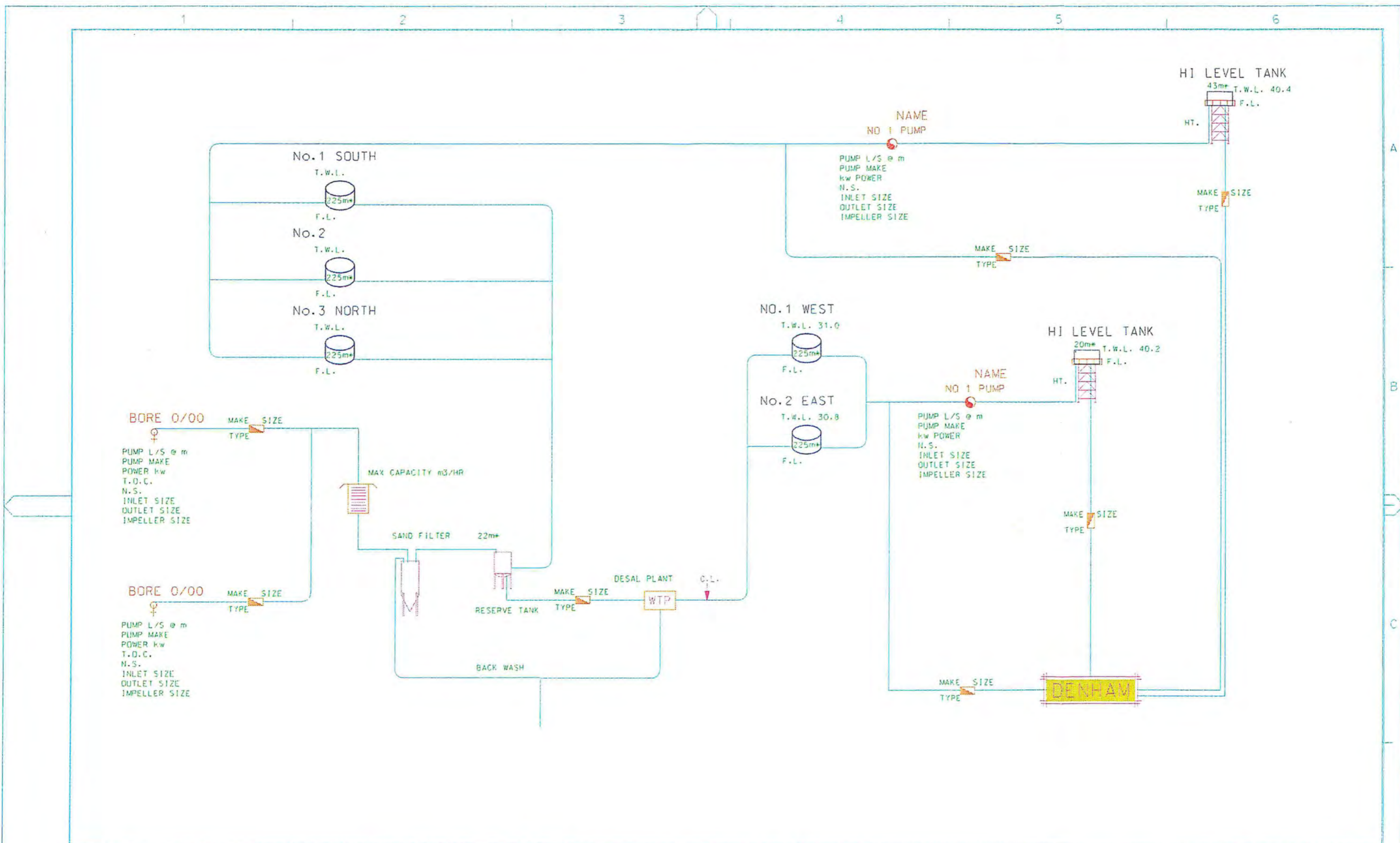


FILE  
PROJECT CY01-17-01  
PLAN  
CAD  
ISSUE A

ORIGINAL SHEET SIZE  
A3  
MF

283

394



DES REF	RECOMMENDED 15/09/95		ORIGINAL SHEET SIZE	
DATE	G.A.van.KEULE REGIONAL DRAFTSMAN		A3	
DRN A.J.S.	APPROVED 15/09/95 J.CITIZEN		FILE	PROJECT CY01-14-01
O.C. CHD G.A.V.K.	OPS. MANAGER NORTH MIDLANDS	PLAN		

283

394

BORE 19/79

♀  
 PUMP L/S @ m  
 PUMP MAKE  
 POWER kw  
 T.O.C.  
 N.S.  
 INLET SIZE  
 OUTLET SIZE  
 IMPELLER SIZE

BORE 3/79

♀  
 PUMP L/S @ m  
 PUMP MAKE  
 POWER kw  
 T.O.C.  
 N.S.  
 INLET SIZE  
 OUTLET SIZE  
 IMPELLER SIZE

NAME

T.W.L.  
 225mm  
 F.L.

HI LEVEL TANK

76m\*  
 T.W.L.  
 HT. F.L.

MAKE SIZE  
 TYPE

ULTRA  
 VIOLET  
 PLANT

MAKE SIZE  
 TYPE

GASSDYNE JUNCTION

DES REF	RECOMMENDED 15/09/95		ORIGINAL SHEET SIZE	
DATE	G. A. van KEULE REGIONAL DRAFTSMAN		A3	
DRN A.J.S.	APPROVED 15/09/95 J. CITIZEN		FILE	PROJECT CY01-18-01
O.C. CHD G.A.v.K.	OPS. MANAGER NORTH MIDLANDS	PLAN		

283

394