Water Futures for Western Australia 2008-30

Volume 1: State Report

J. F. Thomas

Resource Economics Unit

December 2008

Resource Economics Unit

WATER FUTURES FOR WESTERN AUSTRALIA 2008-2030

VOLUME 1: STATE REPORT

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Resource **E**conomics **U**nit, Perth

Mobile: 04 32 66 44 07
Email: rec_unit@bigpond.com

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Author: J. F. Thomas

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This report has been prepared in accordance with the scope of services described in the agreement between Resource Economics Unit and the Department of Water, Western Australia, July 2007. Any findings, conclusions or recommendations only apply to the aforementioned circumstances and no greater reliance should be assumed or drawn by the Department of Water. Furthermore, the report has been prepared solely for the Department's use. Resource Economics Unit accepts no responsibility for use by other parties.

The report gives a summary of the projections of water use for 60 user groups in 19 WA regions, prepared using a *Water Demand Scenario Modelling Tool*, which was developed as part of the project. The results described are not necessarily accepted by the Department or any other department or agency of the Western Australian Government.

Before relying on material in this publication, users should independently verify the accuracy, currency, completeness and relevance of the information for their purposes and obtain appropriate professional advice.

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CONSULTANT TEAM

- Jonathan Thomas, Resource Economics Unit
- Duncan Macpherson, Resource Economics Unit
- Sonya Bateman, Ecoscape Pty Ltd
- Glyn Wittwer and Philip Adam Monash University Centre of Policy Studies
- Brian Sadler, Water Policy Services
- Trevor Winton, James Wright and Steve Marshall, Sinclair Knight Merz Pty Ltd

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EXECUTIVE SUMMARY

Method

Potential future demand for water has been assessed in 19 Water Demand Regions across Western Australian from 2008 to 2030.

Using a purpose-built model, the *Water Demand Scenario Modelling Tool*, estimates of water demand were based on expected trends in industry value added, employment by industry, and population in each region. Economic trends were based on Monash University projections, drawing on Access Economics publications, produced in early 2008: that is, prior to the world financial crisis. Our judgement is that (i) the global economic crisis of 2008-09 is likely to lower the trajectories of growth in water use in the short term (up to five years) but that (ii) the long term trend to 2030 may be not be very much affected, depending on how well and when the world economy recovers.

The use of water obtained under license in 2008 was estimated using the Department of Water's Water Resources Licensing data base (WRL) and assumptions about the proportion of licensed allocation that was actually used by consumers. Unlicensed uses were estimated independently using data from a variety of sources. Water use includes all taking of water from the environment, including the diversion of surface water, groundwater abstraction, and mine dewatering. In addition, account is taken of water produced through sea water desalination plants and wastewater re-cycling. The estimates take account of the net imports (or exports) of water to (or from) each region. All demands are "gross". Return flows to the environment are not considered.

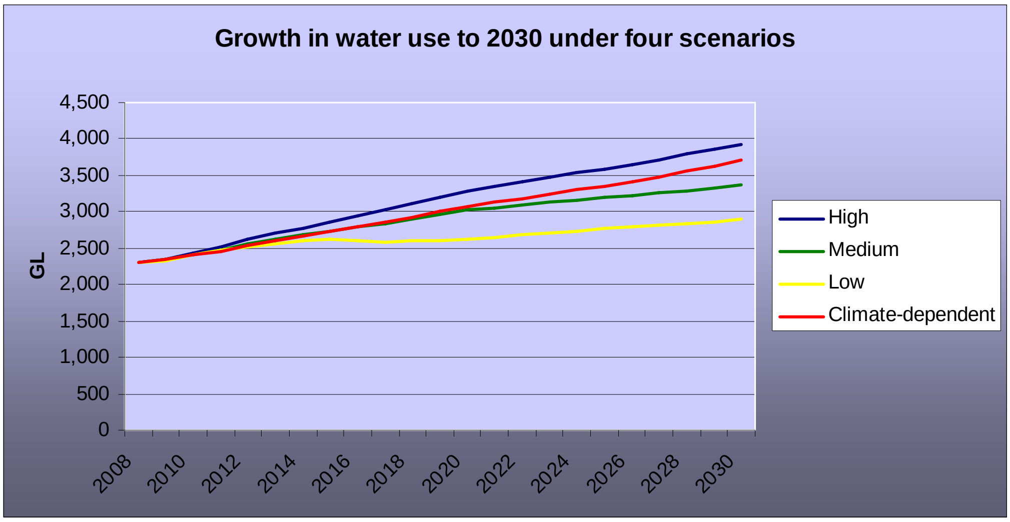
The potential future demand estimates at regional and State level are unconstrained by water or land availability. An assessment is then made of the potential demand against water availability in each Water Demand Region.

Water Use in 2008

Total water use in Western Australia in 2007-08 was approximately 2,286 GL. This compares with an estimate for 1999-00 made in the Water 2000 Study of approximately 1,800 GL. Thus water use has increased at the rate of more than 3% per year cumulative over the past eight years. The State's population grew at an average rate of 1.8% over the same period. Aggregate water use tends to grow faster than population because it depends primarily on trends in the agriculture and mining industries. Per capita use of scheme water supplies in Perth has been restrained by a series of water demand management initiatives, in particular the two-day per week controls on garden watering.

Projected Water Use

The results suggest that total water use could rise from approximately 2,286 GL in 2008 to around 3,900 GL in 2030 under the High Growth Scenario; and to about 2,870 GL under the Low Growth Scenario. The Medium Growth Scenario produces an estimate of 3,345 GL in 2030. The respective average annual growth rates implied by these projections are 2.46% (High), 1.75% (Medium) and 1.04% (Low), all of which are significantly lower than the rate of growth in water use in the last eight years. Reasons for expecting lower growth rates than in the past include: (i) the assumption that per capita residential demand in Perth can be held constant, in line with the WA Water Corporation's planning assumptions; (ii) our expectation that long term output growth in the State's mining and agricultural industries will be slower than the rates experienced in the early 2000s; and (iii) an assumption that industry growth rates in the latter part of the projection period will tend towards parity with general Australian experience. In other words the bigger the WA economy gets, the more likely it will experience typical national growth rates.



The Perth and Peel Demand Regions head the expected growth in absolute terms, with an increased demand of 281 GL reaching 912 GL in 2030 under the Medium Scenario from a base of 631 GL in 2008. This growth occurs despite the relatively conservative assumption we have made that per capita household demand for both domestic bores and scheme supplies can be kept constant. The other three regions where water use would increase substantially under all scenarios are the West and East Pilbara Demand Regions (a combined increase of 250 GL under the Medium Scenario from a base of 250 GL in 2008) and the East Kimberley Demand Region (an increase of 144 GL under the Medium Scenario mainly in irrigated agriculture in the Ord Scheme, from a base of 385 GL in 2008). It is notable that the projection for East Kimberley Demand Region, being based on projected industry growth rates from the 2008 Base Year, is lower than estimates based on planned expansions of the irrigated area.

In terms of User Sectors, under the Medium Scenario, by far the largest additional demand comes from mining, both ferrous and non-ferrous (an additional 445 GL from a base of 619 GL in 2008 under the Medium Scenario), followed by irrigated agriculture (additional 246GL from a base of 812 GL in 2008), and household demand for scheme supply (additional 88 GL from a base of 243 GL in 2008). Domestic bores produce an estimated demand increment of some 57 GL (from a base of 125 GL in 2008). Both the residential public water supply and domestic bore demand projections assume that household consumption grows no faster than population. Demands for irrigation of parks and gardens add another 46 GL from a base of 75 GL in 2008: the projection here is based on industry potential (e.g. sporting facilities as well as public open space).

Impacts of Climate Change on Water Use

A detailed assessment was made of the latest national and international work on potential climate change and a preliminary assessment was made of the implications for water use in Western Australian regions to 2030. It is noted that the Department of Water and CSIRO intend to review sustainable yields and environmental demands in the context of climate modelling during 2009. It is emphasised that much of the available literature on climate change considers a much longer time period than that used in this study, and generally does not address climate impacts on water demand.

Water use might be affected by: (i) changing unit water demands (e.g. the amount of water used per household, per $ of real value added or per employee); (ii) structural economic change (e.g. reduced exports as a result of a reduction of growth in global GDP as a result of unabated climate change); or (iii) greenhouse incentives (e.g. leading to the conversion of farmland to plantation forestry).

Based on our assessment of the available literature, Western Australian regions where water demand appears most likely to be *increased* by a changing climate are precisely those where demographic and economic growth is highest and a hotter and drier climate is most likely to depress surface water and groundwater yields. The Demand Regions most likely to be affected include Greenough, Moore, Perth, Peel and Preston. It was assumed that unit water use in agricultural and urban irrigation in these regions could increase by around 1% per year over the projection period. The result would be to increase total water use by around 120GL (10%) above the Medium Growth projection for 2030 of 1,200 GL for these four regions.

Further south, in the Vasse, Blackwood, King and Esperance Demand Regions, it is expected that climate change impacts will be less marked.

Concerns have been raised about the potential future impacts of climate change on the productivity of dry land agriculture, which is the dominant land use in the Moore, Midlands, Upper Great Southern, Pallinup and Esperance Demand Regions. The scenario projections do not allow for any resulting structural change. For water use the key drivers will be population -

which has been increasing in some towns due to non-agricultural developments - and livestock production. Any decline in the productivity of grains production due to a drying climate could lead to an increased emphasis on livestock, possibly with more intensive management practices, and therefore increased water demand.

On the basis of the reported models, climate change seems unlikely to be a major influence on water demand or supply in the East and West Kimberley Demand Regions although climate variability may intensify. An expected increase in cyclonic intensity seems unlikely to change water demands.

Assessment of Future Demand versus Availability

Projected water demands were compared with preliminary estimates of the volume of water available for use in each region, after taking account of water requirements for the environmental and the likely feasibility of development for surface water and groundwater. Results are as follows.

Perth

The situation in Perth can be considered to be the most serious of all Demand Regions. The region enters absolute water deficit by 2020 under all scenarios, comparing available resources with likely demands including inter-regional transfer supply and demands. Perth currently imports around 40GL from sources to its south and exports an estimated 27GL to the Goldfields and agricultural areas. Under the Medium Growth Scenario the deficit exceeds 200GL in 2030, primarily in self-supply. Even under the Low Growth Scenario demands exceed available resources by 2020.

If potential reductions in water availability due to climate change were taken into account the situation would be significantly worse. It may be concluded that agricultural and other rural water demands are likely to be constrained by water availability, competition from growing urban water demands, and climate impacts. The scenario projections therefore support the need for significant gains in water use efficiency and the development of alternative water supplies including desalination, water re-use or substantial new inter-regional transfers into the Metropolitan Area.

The South West

Demand-availability balance in the Preston Demand region is highly sensitive to assumptions about the future for irrigated pasture production, and the long-term yields of surface water sources under climate change. Under the Climate-dependent Scenario this region enters significant deficit by 2025, largely as a result of increasing unit water demands.

In the Vasse and Blackwood Demand regions there are growing urban and agricultural demands. The latter are leading to increased investment in commercial farm dams, which is likely to continue into the future. However, on the basis of current knowledge it appears that these more southerly Demand Regions may experience more moderate climate impacts.

Pilbara

If economic growth proceeds as per the scenarios, allocation limits are likely to be increased to account for additional mine dewatering requirements. Increasing demands for urban scheme supply, to cater for growth of population, industry and commerce in the East and West Pilbara Demand Regions will need to be met from coastal groundwater resources and/or desalination.

Goldfields

Mineral processing in the Goldfields Demand Region uses hyper-saline groundwater from extensive palaeochannels. Although very little modern groundwater recharge occurs the palaeochannels are being recharged from adjacent fractured rock aquifers. The principal concern should be with alternative ways of providing for long-term scheme supply demands, especially as this region obtains its water from the Perth Demand Region, which is clearly under stress.

Wheat Belt Regions

These Demand Regions (Pallinup, Upper Great Southern and Midlands) have been in water "deficit" for many years, due primarily to the lack of fresh groundwater in the fractured rock aquifers. The scenarios suggest relatively small growth in demands. Nevertheless, the stresses on the water resources of the west coast regions imply that every effort needs to be made to find ways of limiting the demand of these regions for imported water.

South Coast

While apparently in "surplus" the south coast regions - and particularly the King Demand Region - face numerous challenges given the limited groundwater resource, the growth of irrigation in un-proclaimed areas and the marginal quality of many of the surface water resources.

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WHY WATER DEMAND SCENARIOS?

Integration of Water Planning

The population and economy of Western Australia have grown at historically rapid rates in the early part of this the 21st Century. Demands for water have grown apace with economic and demographic development. The Department of Water is charged with oversight and guidance of the way we use our water and to administer water allocation policies. To do this effectively it needs to integrate with planning activities at a whole-of-government level. State development alone is a sufficient reason to take stock, once more, of the State's water availability and use.

Planning for Climate Change

It is now considered un-contestable that climate change has impacted, and will continue to have impacts, on both the demand side and the supply side of the water equation. These impacts are likely to continue to grow. Australian greenhouse policy will impact on the Western Australian economy and water use in ways that are only just beginning to be understood.

National Water Initiative

Western Australia is a signatory to the Intergovernmental Agreement on a National Water Initiative, and is progressing with implementation of its Blueprint for Water Reform (Water Reform Implementation Committee, 2006; and Government of Western Australia, 2007). A new Act will consolidate and replace the *Metropolitan Water Supply Sewerage and Drainage Act* (1909) and the *Rights in Water and Irrigation Act* (1914).

As a part of the National Water Initiative the Department of Water is committed to a program of State water planning, which will be undertaken at three levels:

- The State Water Plan provides a broad framework for water allocation policy and planning;
- Regional Water Plans identify key issues for water management and allocation, and recommended actions, at the regional level; and

- Statutory Water Allocation Plans will *inter alia* establish "consumptive pools" for the water resources in key localities, implement water trading initiatives within a new system of water entitlements, and will inform new water legislation. Finally, as a part of its commitment to the National Water Initiative, Western Australia will be developing new systems of water accounting that are appropriate for Western Australian conditions, consistent with the national framework.

This report will assist decision makers in each of the above tasks. A scenario approach has been adopted to enable the user (primarily the Department of Water) to identify "best" and "worst" case outcomes in its resource planning and environmental management roles. The *Water Demand Scenario Modelling Tool*, developed for the study (see below), will facilitate easy up-dating of the projections and rapid response to requests for information such as those arising from the National Water Initiative, regional water planners and development proponents from the private sector.

STUDY METHODOLOGY

Previous Studies

This report on water futures for Western Australia follows two earlier audits of water demand and availability, notably:

- *Review '85*: a national study which brought together estimates of (i) water allocation and use and (ii) surface/groundwater resources at the level of Australian Water Resources Council River Basins and Drainage Divisions in 1985 (Department of Primary Industries and Energy and the Australian Water Resources Council,1987). The study made no attempt to project future water demands; and
- *Western Australia Water Assessment 2000: Water Availability and Use (Water and Rivers Commission, 2000)*. The study was undertaken in 1999 as part of the National Land and Water Resources Audit, and is referred to as the Water 2000 Study. The Study identified levels of current utilisation of sustainable yield (interpreted as water allocations) in 174 Groundwater Management Units and 44 Surface Water Management Areas in 1999-00. It also produced projections of water use across nineteen regions of Western Australia to 2030. The Water Demand regions used in the current report are amended from those used in the Water 2000 Study in order to produce better alignment with groundwater and surface water management areas.

Demand Scenario Modelling Tool

The approach adopted for this study encompassed the following major steps:

- Base Year water use estimates were developed for 60 User Groups in 19 Demand Regions, using the Department of Water's Water Resources Licensing (WRL) data base plus ancillary data sources. Data were extracted from the WRL database using two methods: (i) by defining Demand Regions in terms of Groundwater Management Areas and Surface Water Management Areas and then using these lists in interrogating the WRL data base, and (ii) by a GIS analysis using the recorded draw-point coordinates for individual licenses. The WRL data were then coded in terms of ANZSIC categories. Water licenses held by the bulk water suppliers (WA Water Corporation, Harvey Water, Gascoyne Irrigation Cooperative and the Ord River Irrigation Cooperative) were distributed amongst final users using ancillary information. Similarly, WRL license codes such as "General Industry" or "Mining" were distributed into ANZSIC (Australia and New Zealand Standard Industrial Classification) categories using employment data and typical water use per employee. For the bulk water suppliers and the mining industry estimates were made of actual versus licensed use.

- A *Water Demand Scenario Modelling Tool* was developed. The prime data sources for this are (i) the Base Year water estimates,; and (ii) a set of economic and demographic growth rates for each year from 2008 to 2030, for the 60 user groups in each of the 19 Demand Regions under four different scenarios (termed "High", "Medium", "Low" and "Climate-dependent" respectively). Projected growth rates for value added, employment or population were used selectively as indicators of potential growth in water use, using different indicators for different User Groups. A large scale regionalised economic model, described in Annex C and Volume 3, has been used. In framing assumptions for the model, the Centre of Policy Studies at Monash University incorporates the views on future prospects for the Australian economy promulgated by groups such as ABARE and Access Economics. It is notable that the projections in this report were compiled before the global financial crisis in July-August 2008. The implications for water use projections are discussed at relevant points in this report.

- Finally, projected water use under each scenario is compared with likely water resource availability for each Demand Region. This step draws on preliminary estimates made by Resource Economics Unit based on discussions with staff of the Department of Water. However, no attempt was made to make any assessment of the impacts of climate change on resource availability. The estimates of the available resource are therefore based on current Allocation Limits for groundwater and an assessment by Resource Economics Unit of the potential for any further surface water development. Our climate impact assessment is limited to the demand side.

This project has thus delivered a unified data base and software package, called the *"Water Demand Scenario Modelling Tool",* including a User Manual (Volume 5) and supporting documents (including Volumes 2 to 4) that will allow the Department of Water to periodically up-date the scenario projections reported here. The *Tool* is contained in a single Microsoft

Office 2003 Directory of approximately 100Mb containing the Base Year estimation procedure, a Projection Tool and all supporting documents, connected by an over-arching Navigation program.

THE RESOURCE

Allocation Limits

The emphasis in water allocation and planning in Western Australia has shifted away from the concept of Sustainable Yield", used in the Water 2000 Study for the purposes of the National Land and Water Resources Audit, and now focuses on proposed Allocation Limits. The same approach is being applied for both groundwater and surface water resources.

The Department of Water undertook a comprehensive re-appraisal of the Allocation Limits for groundwater during 2008. The new Allocation Limits are based on an assessment of the level of water use (including unlicensed use) which, if it were exceeded, would trigger a Statutory Environmental Assessment by the Environmental Protection Authority. This differs from a "Sustainable Yields" approach, because it ties water availability estimates into the statutory processes involved in water allocation, and recognises that development proposals need to be assessed with the latest available authoritative information on trends in resource availability and potential competing uses.

The approach used in assessing proposals for surface water development is similar to that for groundwater, though at this stage formal allocation limits have not been set. The Department of Water has been developing estimates of Sustainable Diversion Limits, with particular emphasis on small-scale rural catchments. Most of the larger surface water sources outside of the Kimberley are highly committed. They offer few viable dam sites and have experienced severely reduced yields as a result of declining rainfall in the South West.

Under the new water reform package for Western Australia, a "Consumptive Pool", including both surface water and groundwater, will be set for particular areas under Statutory Water Allocation Plans. These plans will operate at a sub-regional level and are not considered further in this study. New water resources legislation will be required to give affect to the development of consumptive pools.

Groundwater Resource

Groundwater is the prime source for water supply in Western Australia. It serves nearly all of the requirements of the mining industry, the majority of supplies to the Metropolitan Area and a substantial proportion of the agricultural industry.

Two types of aquifer system that exist in the State are (i) the sedimentary aquifers within large sedimentary basins, notably the Canning, Carnarvon, Officer and Perth Basins; and (ii) fractured rock aquifers, notably those of the Kimberley, Pilbara, and Yilgarn Block fractured rock provinces. Useful supplies of groundwater are also available from alluvial aquifers within the fractured rock provinces, and within limestone (fractured rock) aquifers within the coastal Perth Basin. Within the sedimentary group there are both confined and unconfined (surficial and superficial) aquifers. Hyper-saline water is used by the gold mining industry, and non-potable water is used for irrigation in many places. All standards of water quality are included in Allocation Limits.

In general it is easier to determine yields of the sedimentary basins than the fractured rock aquifers, though many hydrologic, geologic and climatic uncertainties remain. Water abstraction from superficial aquifers may have serious environmental implications through impacts on groundwater-fed lakes and wetlands especially during period of reduced rainfall and recharge: as for example in the Gnangara Groundwater Management Area. The issue of possible environmental impact was pivotal in the recent debate about the future use of the South West Yarragadee aquifer for the Integrated Water Supply Scheme (IWSS). Environmental impacts from groundwater abstraction continues to be an issue in the Pilbara.

This study uses Groundwater Management Areas (GMAs) in assessing the likely pressures of future demand on groundwater resources. All GMAs are sub-divided into sub-areas which in turn may contain more than one water resource (aquifer) against which Allocation Limits are set. The GMAs are statutory proclaimed areas, whereas the sub-areas are not. The enabling legislation is currently being reviewed as a part of the water reform process within the State. The GMAs cover most of the State with the exception of un-proclaimed areas in the Yilgarn Block and along the southern coast.

Map 1 shows the GMA boundaries. These generally follow cadastral boundaries or lines of longitude and latitude. As a result they do not necessarily correspond with physiographic features or aquifer extent. In many (but not all) cases the GMA boundaries correspond with economic and social boundaries used by the Australian Bureau of Statistics, which define the data sets in the MONASH-TERM model used in this study.

The new (2008) total allocation limit for all groundwater in the State has been set at 3,864 GL, of which 2,358 GL are in sedimentary basins and 1,506 GL in fractured rock aquifers. This may be compared with the Total Sustainable Yield of 6,304 GL/year given in the Water 2000 Study (Page 33), of which 3,279 GL was attributed to the sedimentary basins and 3,025 to the fractured rock aquifers.

Table 1 shows licensed groundwater allocation in 2008 versus the Aggregate Allocation Limit for ground water in each Demand Region. In many Demand Regions the Aggregate Allocation Limit for groundwater is being approached or is already exceeded. This particularly so in the south west, where many aquifers of the Perth Basin are close to their Aggregate Allocation Limit. Other regions where allocations are high in relation to Aggregate Allocation Limit include King, East Pilbara and West Pilbara. There are also some Demand Regions where particular groundwater sub-areas are stressed even though total water use remains well within the Aggregate Allocation Limit.

Table 1: Groundwater Allocation Limits and Licensed Allocations, by Demand Region, 2008 (GL/Yr)

	Demand Region	Aggregate Allocation Limit in 2008	Allocated in 2008	% Allocated
1	E. Kimberley	0.0	15.1	Over-allocated
2	W. Kimberley	436.6	26.3	6.0%
3	E. Pilbara	295.0	252.1	85.5%
4	W. Pilbara	202.9	89	43.8%
5	Gascoyne	201.1	31.7	15.8%
6	Murchison	240.0	97.5	40.6%
7	Greenough	189.1	60.0	31.7%
8	Midlands	11.8	14.8	125.0%
9	Moore	427.5	157.7	36.9%
10	Perth	469.7	326.7	69.5%
11	Peel	109.8	17.6	16.0%
12	Preston	97.4	126.0	129.4%
13	Vasse	113.5	80.5	70.9%
14	Blackwood	2.9	0.2	8.3%
15	King	4.2	4.8	115.1%
16	Pallinup	0.2	0.1	58.8%
17	Upper Great Southern	0.2	0.7	374.3%
18	Esperance	43.8	3.7	8.5%
19	Goldfields	1,018.0	237.3	23.3%
	TOTAL	3,863.8	1,541.8	39.9%

The total volume of groundwater currently potentially available for use within the 2008 Aggregate Allocation Limits in Western Australia was 3,863 GL/Yr. The volume actually licensed for use in that year was 1,542 GL/Yr. It is notable that in several Demand Regions the recently revised Allocation Limits are less than the volume actually licensed. This indicates that the aggregate volume licensed may be scaled back in future as old licences expire.

Map 1: Groundwater Management Areas overlain with Demand Region boundaries

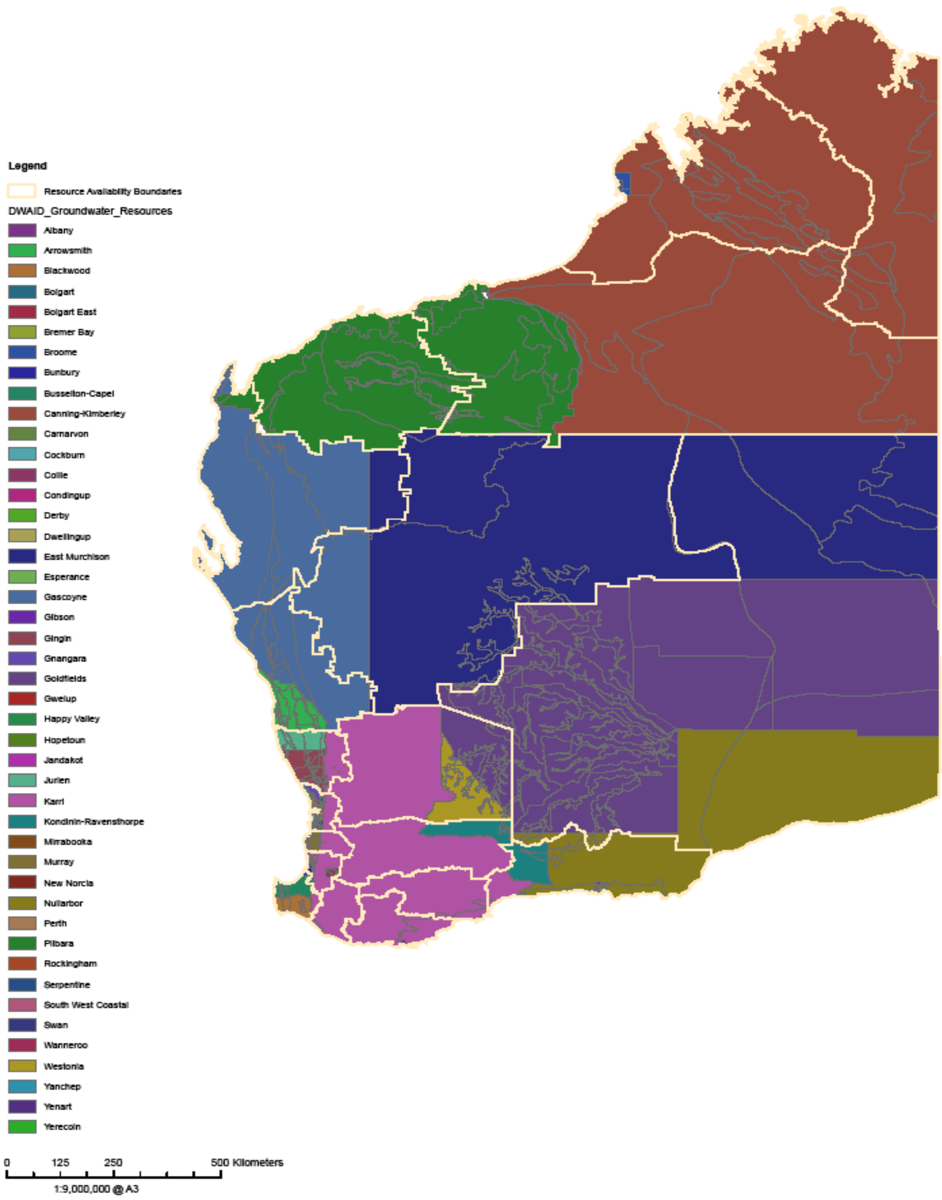


Table 2 shows estimated groundwater use in 2008 for each Demand Region after deducting unused licences and adding estimated unlicensed uses.

Table 2: Licensed and estimated unlicensed groundwater use, 2008 (GL)

	Demand Region	Total Groundwater Allocation	Unused Allocations	Used Allocations	Estimated Unlicensed Use	Total Use
1	East Kimberley	15.1	-1.3	16.4	2.1	18.6
2	West Kimberley	26.3	-2.1	28.4	0.8	29.2
3	East Pilbara	252.1	70.6	181.5	2.3	183.9
4	West Pilbara	88.9	34.4	54.4	1.8	56.2
5	Gascoyne	31.7	-1.5	33.1	3.1	36.2
6	Murchison	97.5	0.6	96.9	3.0	99.9
7	Greenough	60.0	0.7	59.3	4.8	64.1
8	Midlands	14.8	0.0	14.8	4.2	18.9
9	Moore	157.7	2.0	155.7	3.9	159.5
10	Perth	326.7	0.0	326.7	112.7	439.3
11	Peel	17.6	0.7	16.9	3.4	20.4
12	Preston	126.0	0.0	126.0	3.6	129.6
13	Vasse	80.5	9.5	71.0	2.3	73.3
14	Blackwood	0.2	0.0	0.2	0.0	0.3
15	King	4.8	0.1	4.8	0.3	5.1
16	Pallinup	0.1	0.0	0.2	5.2	5.4
17	Upper Great Southern	0.7	0.0	0.7	6.7	7.5
18	Esperance	3.7	0.0	3.7	3.0	6.7
19	Goldfields	237.3	46.2	191.1	0.9	192.0
	TOTAL	1,541.8	159.8	1,382.0	164.2	1,546.2

Notes:

1. "Unlicensed use" includes urban domestic bores and rural domestic and stock uses.
2. A negative in the "unused" column indicates that abstraction exceeded licensed allocation.
3. Row and Column totals may not add due to rounding

In preparing these estimates it was assumed that 100% of licensed allocation for self-extraction was used, except in the Goldfields, Murchison and the two Pilbara Demand Regions. Following discussions with staff of the Department of Water it was assumed that the mining industry used 70% of its licensed allocation in the Goldfields and Murchison Demand regions, and 80% in the Pilbara. The usage rate for scheme suppliers was inferred by reference to published data from the Western Australian Water Corporation and the three irrigation cooperatives (viz. Harvey, Gascoyne and Ord River). Unlicensed extraction for domestic, livestock and other purposes was estimated from independent data published by the Australian Bureau of Statistics. Total usage is estimated to have been 1,546 GL in 2007-08, representing a 36% increase since the year 2000. Of this, 1,382 GL was under license with the balance of some 160GL being un-licensed abstraction including that from domestic bores.

Surface Water Resource

While groundwater provides for most of the water abstracted in Western Australia, surface water still plays a critical role. It provides water supplies for irrigation and urban uses throughout the south west of the State, and in the Kimberley. The potable reticulated water supply for the Goldfields and agricultural regions is also supplied from surface resources in the south west of the State. Conjunctive use of surface water and groundwater resources is fundamental in supplying irrigation and urban demands in the Gascoyne and towns in the Pilbara.

Surface Water Management Areas (SMAs), shown in Map 2, conform to the Australian Water Resources Council Drainage Divisions and River Basins, as defined in Review '85 (Department of Primary Industries and Energy, 1987); and as used in the Western Australia Water Assessment, 2000. These have been used in assessing likely future pressures of demand.

The Department of Water with CSIRO is currently reviewing current and future availability of surface water, against a background of (i) substantially reduced rainfall and runoff in the south west of the State over the past thirty years; (ii) the current levels of “unused” allocations that cannot be used because rainfall-runoff is not replenishing storages at a rate which would justify the present allocations; and (iii) the possibility that future climate change may further accentuate declines in rainfall/runoff and increase evapotranspiration rates. For the purposes of this report discussions were held with the Department of Water to estimate, region by region, the likely volume of surface water that might be developed, taking account of the practical viability of potential diversion sites that had previously been included in “Sustainable Yield” as defined in the Water 2000 Study. In many cases - for hydrological, water quality, environmental, and engineering reasons - rivers that were included in earlier “Sustainable Yield” estimates have little practical prospect of being developed. The estimates given in this study are therefore offered as the amount of surface water realistically available for economic purposes.

Surface water allocations within each Demand Region are shown in Table 3. Surface water allocations totalled 874 GL in 2008, of which only 749 GL was able to be used, due to severely reduced storages in the Darling Range reservoirs. This actual use figure is slightly higher than the 658 GL reported for 1999-00 in the Water 2000 Study, but this masks a substantial decline of surface water use in the South West and an increase in the East Kimberley. Surface water use is dominated by the Perth, Peel, Preston and East Kimberley Demand Regions. Elsewhere, surface water use is very small. Nevertheless, the relatively small volumes remain an important source of supply in West Pilbara. The Gascoyne River replenishes alluvial groundwater in the Carnarvon area, and so is important even though there are no surface water allocations. The table also shows the significant volumes of "unused" allocations in Perth, Peel and Preston Demand Regions.

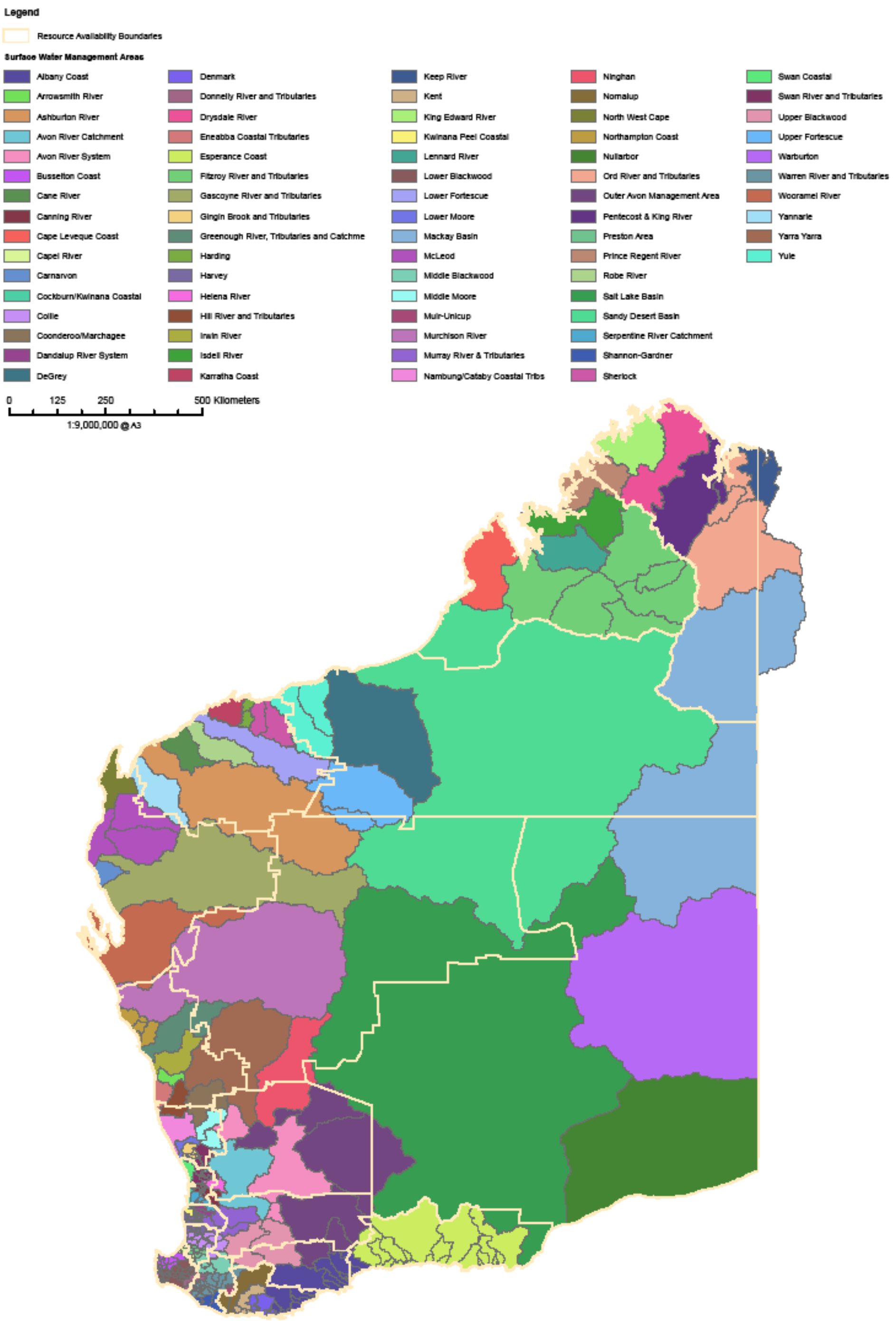
Table 3: Surface water allocations and estimated utilisation, 2008 (GL)

	Demand Region	Total Allocation	Unused Allocations	Licensed Use	Unlicensed Use	Total Use
1	East Kimberley	357.0	-0.4	357.4	8.6	366.0
2	West Kimberley	6.4	-0.4	6.8	7.1	13.9
3	East Pilbara	0.0	0.0	0.0	2.3	2.3
4	West Pilbara	16.0	10.5	5.6	1.8	7.3
5	Gascoyne	0.1	0.0	0.1	0.7	0.8
6	Murchison	0.0	0.0	0.0	0.0	0.0
7	Greenough	0.0	0.0	0.0	2.2	2.3
8	Midlands	0.0	0.0	0.0	4.2	4.2
9	Moore	5.6	0.0	5.6	0.9	6.6
10	Perth	140.6	92.1	48.5	0.0	48.5
11	Peel	102.1	37.7	64.4	0.1	64.5
12	Preston	210.3	83.5	126.8	0.1	126.9
13	Vasse	4.6	0.7	3.9	2.0	5.9
14	Blackwood	36.6	0.9	35.8	0.3	36.0
15	King	2.0	0.0	2.0	8.9	10.9
16	Pallinup	0.0	0.0	0.0	2.2	2.2
17	Upper Great Southern	0.2	0.0	0.2	6.7	6.9
18	Esperance	0.0	0.0	0.0	1.0	1.0
19	Goldfields	0.0	0.0	0.0	0.0	0.0
	TOTAL	881.5	224.6	657.1	49.1	706.2

Totals may not add due to rounding

Estimated unlicensed use of 49 GL is widespread across regions. These estimates are very tentative. They are based on estimated livestock requirements and relative yields of surface water and groundwater regionally. The estimate for King Demand Region includes unlicensed irrigation use in un-proclaimed areas.

Map 2: Surface Water Management Areas overlain with Demand Region boundaries



WATER USE IN 2008

Definition of Water Use

The focal point of this study is the likely future demand for water. A prime objective is to compare the amount of water that is likely to be required for social and economic purposes with potential resource availability in each of the 19 Demand Regions, so that perceived "stresses" on the resource may be anticipated and taken into account in planning and water allocation.

Water use within a Demand Region as defined in this study is equal to:

- ***the total of licensed water allocations that is actually used (taken from the resource within the region) + estimated unlicensed use (mainly by domestic bores and farm dams used for domestic and stock purposes) + water manufactured through seawater desalination or re-use of wastewater + water imported to the region – water exported from the region .***

This includes water of all quality classes, from potable to hyper-saline.

Items that are excluded from our definition of "use" include

- Licensed water storage
- Licensed reservations for future use
- Discharges to the environment following use are not netted out: for example mine dewatering or return flows from hydro-electricity generation
- Unused allocations to scheme water suppliers, including the WA Water Corporation and the three irrigation cooperatives. These typically occur when physical water availability falls short of the licensed amount: for example as has happened with the reservoirs of the Darling Range. It should be noted in this regard that, due to depressed levels of rainfall and runoff into Darling Range reservoirs, the Water Corporation has extracted in excess of its licensed allocation for some aquifers in recent years. This has been done with the concurrence of the Department of Water ands is taken into account in our estimates.
- Unused allocations for self-extraction in irrigated agriculture
- Unused allocations to the mining industries that embody some provision for hydrological variability: for example where an allocation for mine dewatering takes account of the possibility that higher-than average volumes may need to be de-watered from time to time.

Water Accounting

Our approach is consistent with concepts generally used in national water accounting. Details of Australian national concepts and definitions will not become available until at least late 2009. However, the concepts embodied in this report:

- distinguish licensed allocation from actual use;

- identify use within the Water Sewerage and Drainage Services industry , mainly comprising evaporation from reservoirs, distribution system losses, water used for backwashing in water and wastewater treatment, irrigation of facilities owned by water suppliers and office uses;
- identify non-licensed use by urban domestic bores and rural domestic and stock users; and
- identify water produced from "manufactured" sources such as seawater desalination plants and wastewater re-use schemes in accounting for the total amount of water used.

Annex D gives a formal specification of the water accounting categories used in this report, and estimation methods applied in particular sectors.

User Groups

Taking account of the different economic structures and development prospects of regions is critical to development of future water use scenarios. The economic model delivers projections of value added and employment for 55 user groups in each of the 19 Demand Regions. These conform to the Australia and New Zealand Standard Industrial Classification (ANZSIC). An additional 6 user groups were used for items that had to be estimated separately. A broad summary of the breakdown of all 60 user groups (number of user groups in brackets) is as follows.

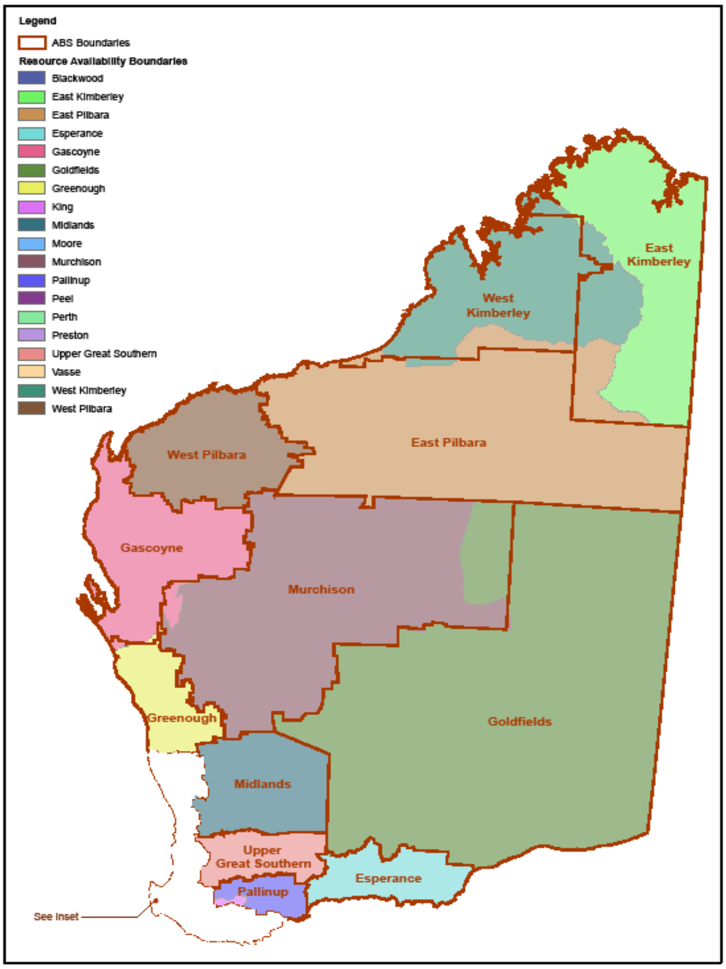
- Agriculture Forestry & Fishing – Licensed Use (13)
- Mining, Oil & Gas (5)
- Manufacturing Industry (19)
- Water Utilities (1)
- Electricity and Gas Utilities (1)
- Recreation & Leisure Uses (1)
- Service Industries (13)
- Scheme Supply to Households (1)
- Household Bores (1)
- Licensed rural domestic and stock uses (2)
- Environmental Allocations (1)
- Unlicensed/Unclassified Use (2)

The full set of user groups and their definition in terms of the Department of Water's WRL database is given in Annex C of the User Manual.

Demand Regions

For the purposes of this report 19 Demand Regions were selected reflecting the geography of the State and the major concentrations of water use. These are listed in Tables 1 to 3. Demand Region boundaries, shown in Map 3 and Map 4 conform to Western Australia's regional planning boundaries and the Australian Geographical Classification System used by the Australian Bureau of Statistics. Annex A gives the Statistical Area composition of each Demand Region. These boundaries reflect economic, social and administrative units, and are therefore useful for establishing basic demographic and economic data.

Map 3: Demand Regions and Associated Resource Availability Regions: whole of State

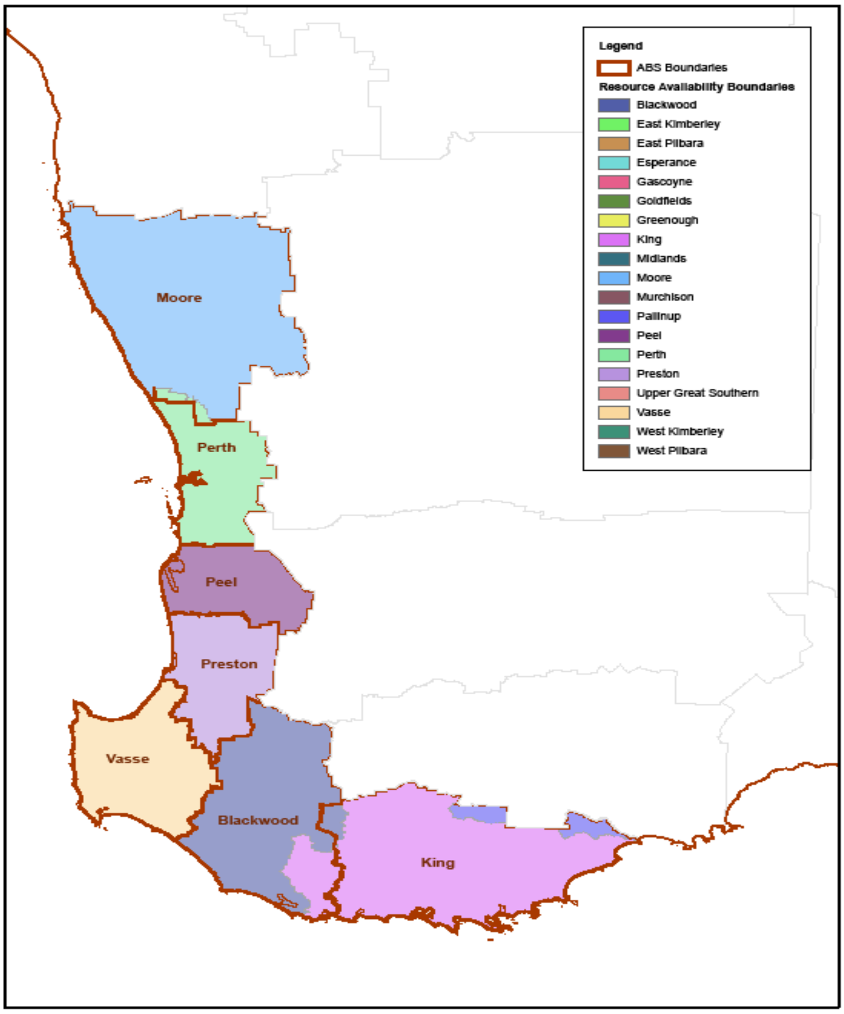


The boundaries of Groundwater Management Areas and Surface Water Management Areas generally do not conform to those of the Demand Regions. Rather, they are based on the natural extent of aquifers and river basins, though for some Groundwater Management Areas administrative boundaries have been used to subdivide large aquifers for management purposes.

In order to compare water demands and water availability, for each Demand Region, an "Associated Resource Region" was delineated. These are also shown in Maps 3 and 4. The

Associated Resource Regions are a close approximation to the Demand Regions. The areas of overlap generally contain very small populations and economic activity.

Map 4: South West Demand Regions and Associated Resource Availability Regions



Total Water Use in 2008

It is estimated that total water use in the State in 2008 was 2,286 GL, of which 1,494 GL was self-supplied and 792 GL was obtained through an urban scheme supply or irrigation cooperative. Estimated system losses amounted to approximately 154 GL, most of which occurs in the Ord River Scheme, where system losses amount to some 34% of the total scheme use. The urban supply system now has a very low system loss compared with international standards.

Table 4: Water use by type of use and method of supply in 2008 (GL)

AWRC Category	*Scheme supplied*			*Self supplied*	*Total Use*
	Net	Losses	Gross		
URBAN-INDUSTRIAL					
Domestic					
Households (PWS)	220.0	22.5	242.5	0.0	242.5
Garden Bores	0.0	0.0	0.0	124.5	124.5
Commercial institutional	0.0	0.0	0.0	0.0	0.0
Parks and Gardens	1.9	0.2	2.1	73.1	75.2
General Commercial	81.4	8.9	90.3	33.7	123.9
Industrial	0.0	0.0	0.0	0.0	0.0
General Industrial	40.2	4.1	44.3	102.0	146.3
Mining & Mineral Processing	0.0	0.0	0.0	619.3	619.3
Power -thermal	0.3	0.0	0.3	3.1	3.4
IRRIGATION	0.0	0.0	0.0	0.0	0.0
Pasture Use	47.9	8.2	56.1	86.3	142.4
Crop Use	156.5	80.6	237.1	0.0	237.1
Horticulture Use	80.6	28.6	109.2	280.4	389.6
RURAL	0.0	0.0	0.0	0.0	0.0
Stock	0.5	0.1	0.6	87.6	88.2
Domestic & Other	6.5	1.1	7.6	63.7	71.3
Forestry	2.0	0.0	2.0	2.0	4.0
Fishing	0.0	0.0	0.0	8.2	8.2
Environmental	0.0	0.0	0.0	6.3	6.3
Not Specified	0.0	0.0	0.0	3.2	3.2
TOTAL	637.8	154.3	792.1	1,493.5	2,285.6

Sources of Water Used in 2008

Table 5 shows sources of water in 2008. Total allocations plus estimated unlicensed use and manufactured/reclaimed water totalled 2,692 GL of which 407 GL were unused allocations, equating with a total use of 2,286 GL. Most of the unused allocations were in the area of surface water, and are attributable to the low storages in Darling Range reservoirs in 2008 (Perth, Peel and Preston's Associated Water Resource Regions), which precluded full use of the licensed amount. Mining in the two Pilbara Demand Regions also "underused" its licensed allocation. However, it is noted that the allocations to mining take account of the possibility of extreme hydrological (cyclonic) events leading to above-normal requirements for de-watering. 2007-08 was a normal year when actual usage could be expected to be below the licensed amount.

Table 5: Sources of water, 2008 (GL)

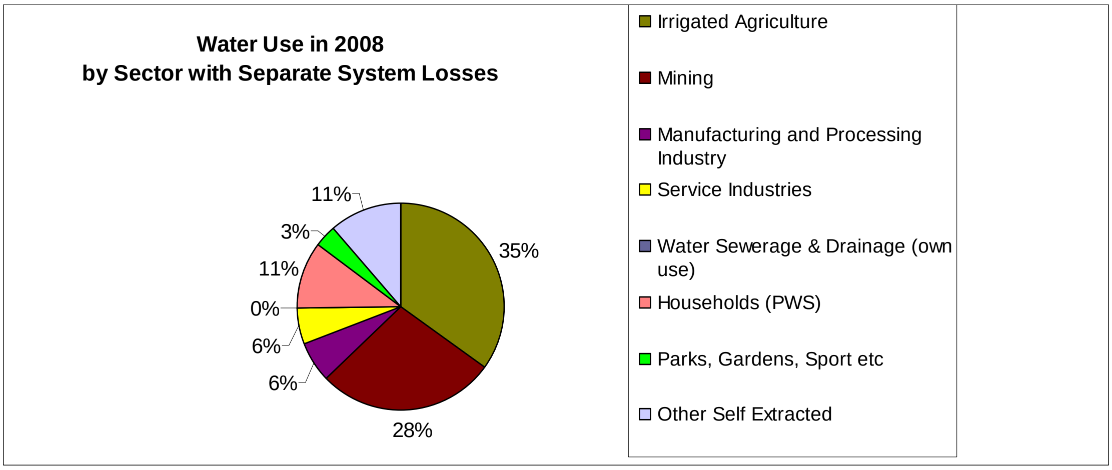
Source	*GL*
Licensed Groundwater Use	1,540.5
Licensed Surface Water Use	874.8
Use from Unlicensed Sources	213.3
Manufactured Water(1)	45.0
Reclaimed Waste Water	18.7
Unused Allocations	-406.8
Total	2,285.5

(1)Excludes desalinated water from a private scheme serving the Burrup Peninsula in the West Pilbara Demand Region.

2008 Use by Sector

As can be seen from Table 4 and Figure 1, two sectors dominate water use in Western Australia, namely irrigated agriculture and the mining industries.

Figure 1: Western Australian water use by sector, 2008



Irrigated agriculture used a total of 806 GL in 2008. Horticultural products in the south west and sugar cane in the Ord River Irrigation Area are the two largest components. Irrigation of pastures for beef and dairy cattle, predominantly in the Peel and Preston Demand Regions, has been a declining use, due in part to gains in distribution efficiency in the Harvey Water Irrigation

Area, and partly as a result of changes in land use. The domestic and stock requirements of dryland agriculture, obtained from bores and farm dams, are also significant. These are included in the "Other Self Extracted" group in the pie chart.

The second biggest user group is the Mining and Energy industry, with an estimated use of 619 GL from a total license allocation of 766 GL. The wide geographical spread of the mining industry means that the sector is represented in many Demand Regions outside of the wheat belt regions of Midlands, Upper Great Southern and Pallinup. Mining activities use water for many different purposes, including supply to camps, dust suppression, exploration, and mine de-watering. In fractured rock environments mines usually "create" water when large open pits are excavated or underground mines are pumped. Nevertheless this constitutes an abstraction of water from the environment, even thought the product water is mainly returned to the environment.

Table 6: Licensed allocations of water in the mining sector, 2008

WRL Code	WRL Name	Ground-water (GL)	Surface Water (GL)	Total (GL)	Ground Water (%)	Surface Water (%)	Total (%)
CAMG	General camp purposes	0	0	0	0.0%	0.0%	0.0%
CAMP	Mining camp	12	1	12	1.6%	2.9%	1.6%
CAMS	Campsite water supply	2	0	2	0.2%	0.0%	0.2%
DAMP	Dampening	0	0	0	0.0%	0.0%	0.0%
DEWM	Dewatering for mining	268	0	268	36.1%	0.0%	35.0%
DEWR	Dewater	106	0	106	14.2%	0.0%	13.8%
DUST	Dust suppression	82	1	82	11.0%	2.7%	10.7%
EXPD	Exploratory drilling	2	0	2	0.3%	0.0%	0.3%
EXPL	Exploration	0	0	0	0.0%	0.0%	0.0%
EXPP	Exploration & test pump	0	0	0	0.0%	0.0%	0.0%
GEOT	Geotechnical investigation	0	0	0	0.0%	0.0%	0.0%
HCRI	Hydrocarbon well injection	0	0	0	0.1%	0.0%	0.1%
MINE	Mining	272	21	292	36.5%	94.4%	38.2%
MNEX	Mineral exploration	0	0	0	0.1%	0.0%	0.1%
TAIL	Tailings	0	0	0	0.0%	0.0%	0.0%
	TOTAL	744	23	762	100%	100%	100%

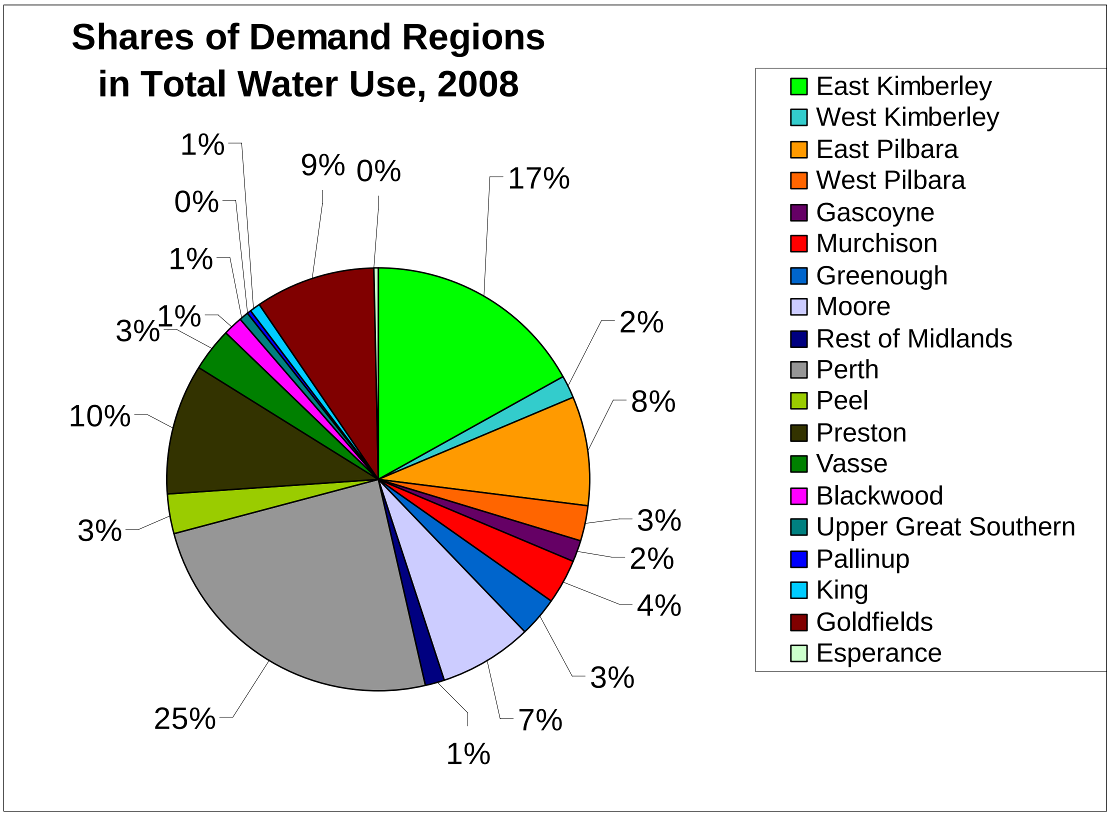
It is notable from Table 6 that dewatering represents about a half of all licensed mining use, and that groundwater accounts for over 97% of the mining use.

Regional Distribution of Water Use in 2008

The Metropolitan Area (Perth Demand Region) has the largest use of water in the State, accounting for some 24% of the total, followed by the East Kimberley(17%), the Pilbara (11% combining East and West Pilbara) and the Goldfields (9%). The wheat belt Demand Regions of

Midlands, Upper Great Southern, and Pallinup have very small demands, though they have implications for the operation of the WA Water Corporation's Integrated Water Supply Scheme. The Moore Demand Region lying immediately to the north of the Perth Metropolitan Area is also a significant user, accounting for approximately 7% of the State total in 2008.

Figure 2: Shares of Demand Regions in total water use, 2008 (%)

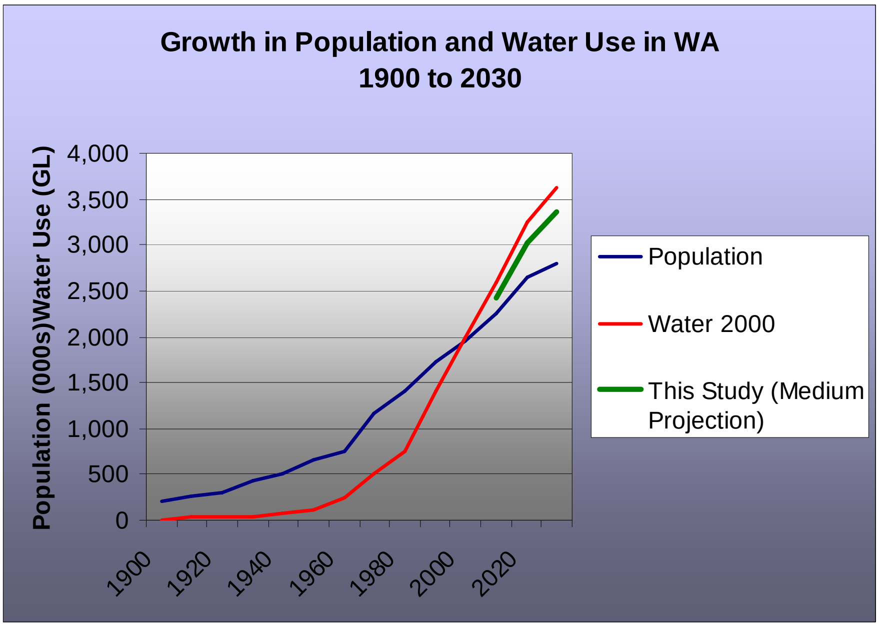


Comparison of 2008 Results with Water 2000 Study Projections

The total use estimate for 2008 in this study is broadly comparable with the projections produced by the Water 2000 Study. Water use has increased from approximately 1,790 GL in 1999-00 to approximately 2,300 GL in 2007-08, an increase of around 28%, or 3.17% per year.

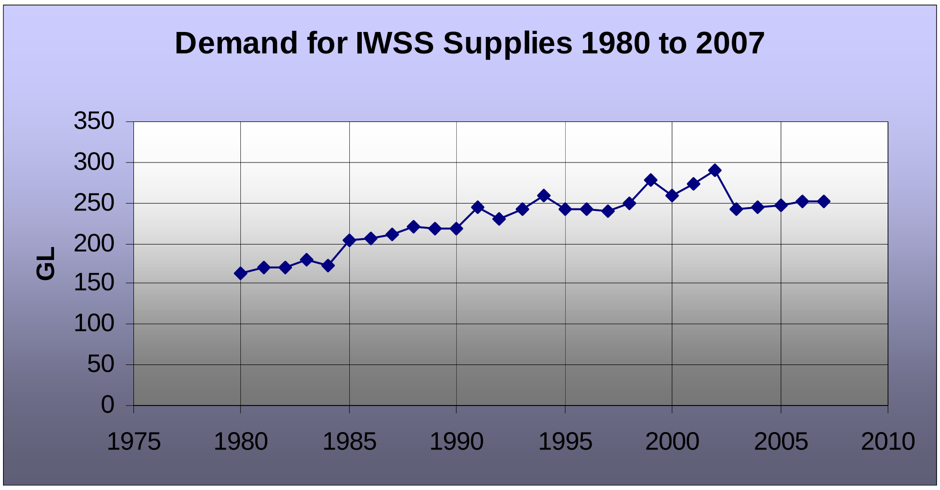
This study has found that the projections of water use undertaken in the Water 2000 study were reasonably accurate in aggregate, but with some significant differences at regional level. Figure 3 shows the overall trend in water use in Western Australia as projected in the Water 2000 Study versus this study's estimates for 2010, 2020 and 2030. It can be seen that this study's projection of water use in 2010 is slightly lower than the level projected in the Water 2000 Study. However, the 2010 total estimated in this study would be higher by some 410 GL if unused allocations are taken into account. It has not been possible to determine the detailed treatment of unused allocations in the Water 2000 Study.

Figure 3: Growth in Population and Water Use in Western Australia since 1900.



As might be expected, greater differences are found at the level of individual regions. The Water 2000 Study incorrectly assumed that Ord Stage 2 would be in place by 2008, leading that Study to over-estimate use in the East Kimberley Demand Region in 2008. Conversely, water use in the south west has tracked on a lower trajectory than was anticipated in the Water 2000 Study. The effect of new water restrictions policies is demonstrated in Figure 4, which traces demand for the Integrated Water Supply Scheme since 1980.

Figure 4: Demand for IWSS supplies 1980 to 2007 (from Water Corporation)



It can be seen that there was an abrupt change in trend after the year 2002, after the 2-day restrictions on household garden irrigation in Perth were introduced. The projections undertaken in the Water 2000 Study - i.e. a few years before the restrictions were imposed - essentially extended the long-term trend, producing a difference of around 80 GL by 2008 between long-term trend and actual outcome.

WATER USE SCENARIOS 2008 TO 2030

The Projection Tool

Four scenarios for future water use in each Demand Region have been developed:

- ***Medium Growth Scenario:*** the future population of Western Australia and each Demand Region follows the path indicated in the Department of Planning and Infrastructure's publication WAT2004 (Department of Planning and Infrastructure, 2005). The current rate of development of the resource-based industries continues until around 2014, after which the rate of growth declines to historical average rates of growth. Water use per unit output or employment remains constant.

- ***High Growth Scenario:*** the resources boom continues for longer, and a high but historically plausible rate of growth for the Western Australian economy is sustained through to the year 2030. Population trends in each demand region are adjusted upwards to accommodate industry requirements for labour. Considering long-term trends in the Australian and Western Australian economies, any higher growth rate after the year 2020 than is assumed in this Scenario would be unlikely. Water use per unit output or employment is assumed to remain constant.

- ***Low Growth Scenario:*** the resources boom continues until around 2012, but is followed by a more rapid "cooling off" period, with growth rates after 2020 at around the historical lows for Western Australia. Water use per unit output or employment remains constant.

- ***Climate Change Scenario:*** The economic impacts of climate change beyond recent experience begin to take effect after 2020. The eastern margins of the wheat-sheep growing areas suffer productivity declines, oil is substituted for coal in energy production, investment in plantation forests in the south west accelerates sharply in response to greenhouse incentives, and after 2020 there is rising investment in defensive expenditures, particularly in areas affected by increased tidal risks. Water use per unit output increases in the Demand Regions where declining rainfall and/or increasing temperatures are expected.

Volume 3 gives the assumptions fed into the economic model to implement these scenarios. Annex C gives a brief outline of the economic model.

Indicators

The water use of any industry in a region can be expressed as the product of three factors:

- An "indicator" of water use. Three indicators are available from the economic model: (i) industry ***real value added***: this the sum of wages, salaries and profits earned in an industry at constant prices, and is a measure of industry output expressed with dimension $ million; (ii) industry ***employment***, which is an indicator of industry inputs rather than outputs; and (iii) ***population***. As a broad generalisation real value added tends to increase at a faster rate than employment or population as a result of productivity improvement. For some industries trends in employment may not be a good indicator because productivity improvements tend to reduce employment per unit of physical output over time even though output and the use of inputs such as water may be increasing. Population growth rates have been used as an indicator of household demand.
- The potential rate of growth in the indicator into the future: expressed as a percentage rate of growth each year into the future. Multiplying the Base Year indicator value by the series of future growth rates produces an estimate of future levels for the indicator.
- A coefficient that relates the water use estimate to the indicator value: expressed as kL per $ million or kL/employee. Base Year coefficients were obtained by dividing Base Year water use in each user group by the corresponding indicator value. Future values of coefficients may be changed to reflect e.g. impacts of climate change on unit water use. For example, in response to climate change a farm that used to use 5 ML/ha for irrigation in the past may need 7ML/ha in future. This will change the water use coefficients for value added and employment.

In the study:

- ***Industry value added*** was chosen as the indicator of trends in water use where projected value added and employment growth rates were broadly similar, and where previous forecasting experience favoured the use of value added. The industries that satisfy these criteria include mining, process industry and several of the higher-water-using "service industries" such as the construction, power generation, transport, wholesale distribution and leisure industries. These employ production systems which are as water-intensive as some manufacturing and processing industries.

- ***Projected employment*** was used for some industries, based on an analysis of trends between 2000 and 2008, described in Volume 3. These industries included dairies, fabricating industries, and service industries such as Finance, Banking, Public Administration, Health, Education and Personal Services.

- ***Projected population*** was used as the indicator for growth in residential water use from both scheme supply and self-supply. Future household water use from scheme supplies was estimated using population projections by the Department of Planning and Infrastructure (Department of Planning and Infrastructure, 2005). The

Department is currently revising its projections to take account of more recent information. The scenario projections in this report incorporate the Department of Planning and Infrastructure's revised (higher) projection for the Perth Demand Region, but not the rest of the State, for which the assumptions remain based on Department of Planning and Infrastructure (2005). An estimate of per capita scheme water use in each region in 2008 was then derived from data from the WA Water Corporation.

- For the purpose of the projections environmental allocations totalling 5GL in 2008 were assumed to remain constant.

Physical output measures such as areas irrigated, or mine production in tonnes might be considered to offer an alternative to value added or employment as indicators of trends in water use. However, it is difficult to establish data sets and trends in physical output across the complete range of water using activities. Further, any prediction of physical measures will likely rely on some underlying predictive economic model. With further research it might prove possible to obtain more accurate predictors of change in water demand, but at the present time value added, employment and population appear to be the most reliable predictors.

Accounting for Climate Change

Recent Australian and international literature on potential climate change impacts on Western Australian regions has been reviewed. Particularly important sources are the Stern Report (Stern 2006), Cline (2007), the Australian Bureau of Meteorology and CSIRO Australia (2007), an assessment of agricultural impacts by the Australian Bureau of Agricultural and Resource Economics (Gunasekera et al, 2007) and the Garnaut Report Discussion Paper (2008). These sources were read and their implications for potential change in economic structure and unit water demands were assessed. These assessments were then used to formulate a "Climate-dependent" water use scenario. Volume 4 presents a literature review and interpretation of how climate change may affect water demand through structural economic effects or by changing unit water use.

Qualifications and Meaning of the Projections

The scenarios of water use in this study are based on a model that considers plausible trends in value added, employment and population, on a regional basis, and gives an indication of future water use *in the absence of land or water constraints*.

The projections portray growth prospects at broad industry and regional level. The finer the geographic detail the greater will be the potential error in projections.

Where there are constraints to growth of water-using activities these may "frustrate" the economic potential of the industries currently resident in a particular location. This applies particularly to irrigated agriculture. The question then arises as to whether the frustrated increment of growth can be accommodated in an alternative location. An example is frustrated growth potential of horticulture in the Metropolitan Region, where there is a steady transfer of horticultural land to urban use and a reduction in the availability of water. The adjacent Moore Demand Region can provide a substitute source of land and water, so the "unconstrained" economic projections for the two regions might need to be over-written using the judgements of land and water planners about some likely spatial re-distribution of the industry. Alternatively the scenarios might signal the need for new sources of water to be developed and/or imported into the region.

Another qualification is that the model does attempt to anticipate demand management interventions. An example is the imposition in 2002 of restrictions on the use of public water supplies for garden irrigation in the Metropolitan Area. This produced a step-change in the trend of residential water use that could not be anticipated by the assumptions built into the economic model compiled in 1999. Another example is the channel replacement strategy of Harvey Water irrigation cooperative, which reduced system losses substantially, hence changing water demand at source.

The model makes no attempt to anticipate hydrologic variability. For example, since 2000 Darling Range reservoirs have experienced historically low storage levels: to the extent that neither urban nor rural irrigation water suppliers have been able to withdraw as much water as they would wish. Down-side hydrologic variability can be viewed as frustrated economic demand for water.

Finally, while the model can anticipate the impacts of macro-economic and micro-economic trends on existing industries, it cannot "insert" completely new activities. Major new economic development projects may falsify the projections. For example, there is no large paper and pulp industry, nor a cotton industry in Western Australia. Should such industries be introduced they would represent a deviation from the model projections. There are two possible ways of dealing with this: either (i) the model can be re-run at regular intervals such as 5 years, taking account of unexpected developments; or (ii) water planners can use new information on major projects to modify model projections on the basis of best available knowledge. In practice a combination of the two approaches may be needed.

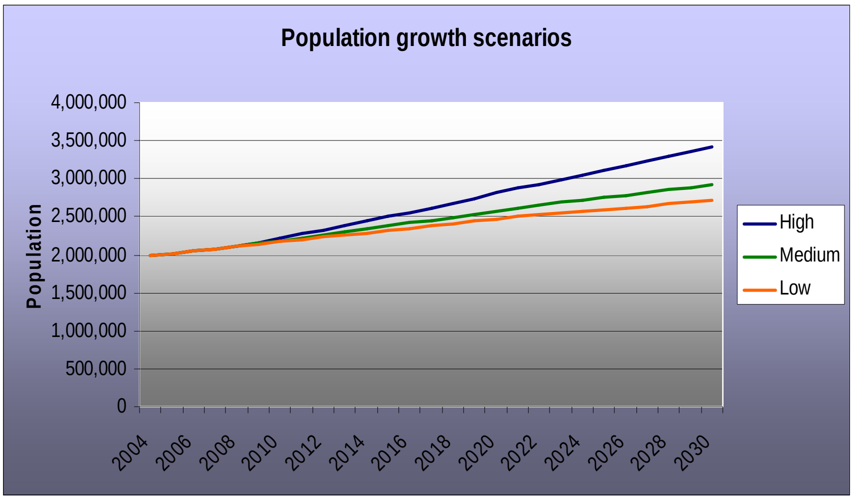
The case is different where an industry is already large, such as the iron ore industry in the Pilbara Demand Region. Here, the level of activity will respond in the model to projected growth in international demand, and large new iron ore mines may or may not invalidate model projections. The key question will always be: if such-and-such major new project goes ahead, will it falsify the model projections? The art of plausible scenario generation must employ a mix of economic theory, well-grounded statistics and judgement on the part of the user. For this reason the *Demand Scenario Modelling Tool* includes a facility for the user to "overwrite" model projections.

Results

Population

Figure 5 shows the growth of the State's population under the High, Medium and Low Growth Scenarios. Note that the Medium Growth Scenario uses the projections of the Department of Planning and Infrastructure (2005) for all regions except Perth, for which the Department of Planning and Infrastructure's revised figure was used. Revised estimates for other regions were not available at the time of this report.

Figure 5: Alternative WA population growth scenarios



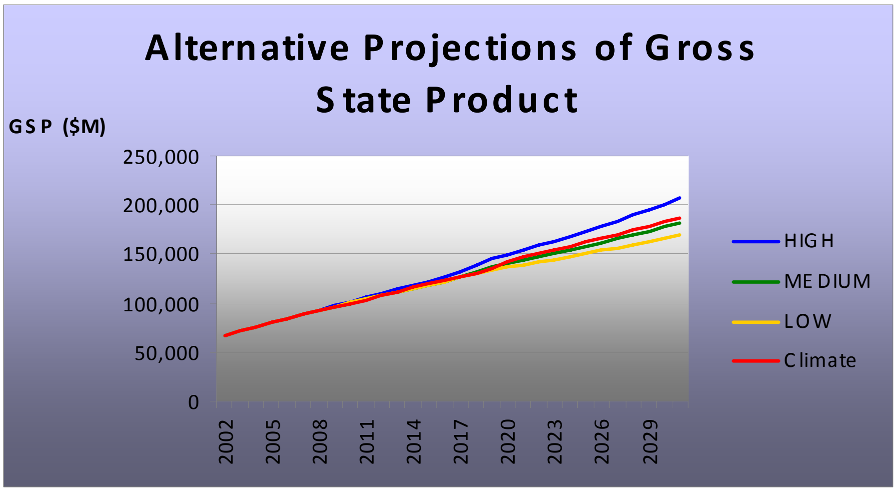
Economic Growth

The assumptions for Gross State Product are shown in Figure 6. The graph suggests continuous growth, with a period from around 2013 to 2018 experiencing a slightly lower rate of increase. The High Growth Scenario results in Gross State Product in 2030 being approximately 13% higher than in the Medium Growth Scenario. The Low growth Scenario produces a Gross State Product some 7% lower than the Medium Growth Scenario, giving an overall range of around +/- 10% around the midpoint between the High and Low growth estimates.

It is notable that the projections in this report were compiled before the global financial crisis in July-August 2008. Does this invalidate them? While it is clear that the growth in output, employment and capital investment in Western Australia will be affected in the short term – say two years – it is by no means clear whether world demand and the Western Australian economy will rebound, in a fashion that could compensate for depressed growth in 2009 and 2010. It should also be emphasised that despite the projected "boom" conditions for 2008 to 2013 that were incorporated in these projections, the modelled growth rates for key commodities for that period were nevertheless significantly lower than what occurred between 2004 and 2008.

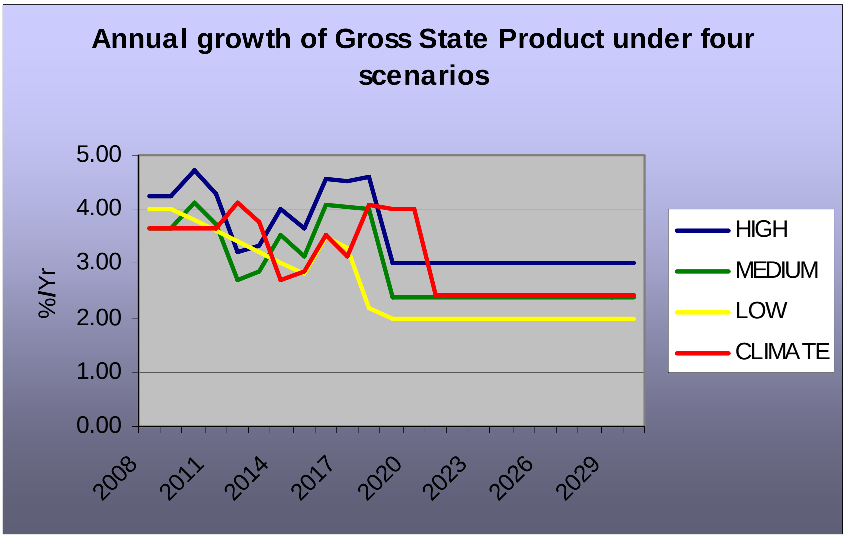
Gross State Product under the Climate-dependent scenario turns out to be slightly higher than the Medium Growth Scenario. Our interpretation of this result is that the assumed investment in defensive expenditures stimulates economic growth after 2020, as compared with the Medium Growth Scenario.

Figure 6: Alternative projections of WA's Gross State Product 2008-2030



The slow-down in 2013 to 2018 is shown more clearly in Figure 7. Note that this projection is coming off a period of exceptional growth in the State economy between 2003 and 2008, so the growth rates decline fairly rapidly until around 2020.

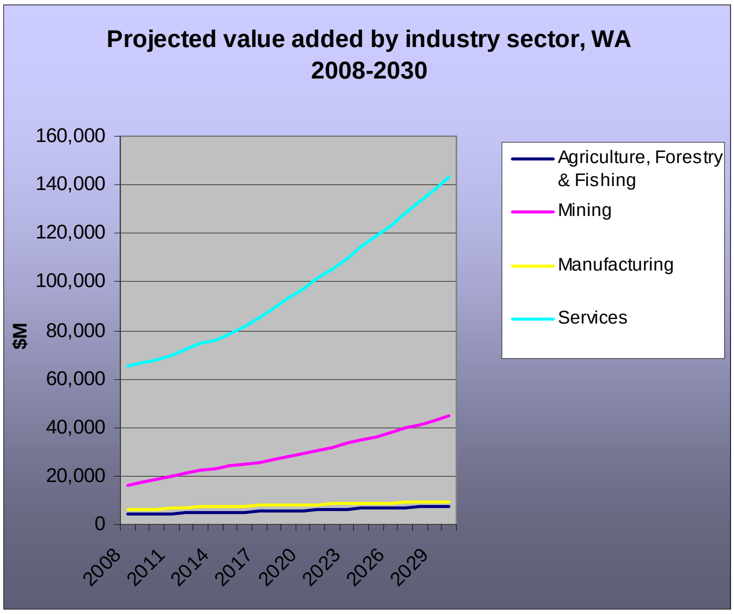
Figure 7: Assumed annual rates of change in State GDP (%/Yr)



Composition the WA Economy

The projections depict a Western Australian economy that will be increasingly driven by the resources sector, as is illustrated in Figure 8. Services continue to be the largest sector in terms of value added and employment. Moderate growth is projected for agriculture and manufacturing, including heavy industry processing activities.

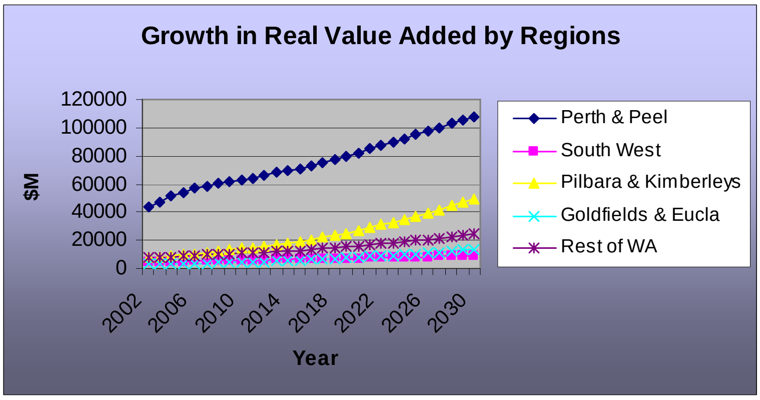
Figure 8: Projected value added by industry sector 2008 to 2030



Regional Distribution of Economic Activity

The resulting size of WA's regional economies is summarised in Figure 9.

Figure 9: Growth in real value added by regional groupings



It is seen that Perth and Peel are projected to continue to attract the greater part of the State's economic growth, followed by the Pilbara and Kimberleys. The Goldfields, Eucla and the South West remain relatively small economies having moderate growth.

The Water Use Scenarios

Table 7 summarises the results obtained for Western Australia's total water use under the four demand scenarios.

The results suggest that total water use could rise from 2,280 GL in 2008 to a maximum of 3,892 GL in 2030 under a High Growth Scenario or to a minimum of 2,865 GL under the Low Growth Scenario. The Medium Growth Scenario produces an estimate of 3,339 GL in 2030.

The Climate Change Scenario produces an outcome that is intermediate between the Medium Growth and High Growth Scenarios, with a 2030 projection of 3,492 G for the State as a whole. This result is obtained for two main reasons: (i) unit water use rates are assumed to increase in response to reduced rainfall and increasing temperature and evapotranspiration in the western regions from Gascoyne to Peel, driving up water use; and (ii) our assumption of steadily increasing defensive expenditures between 2020 and 2030 has the effect of stimulating economic growth in much the same way as a public works program, as compared with the Medium Growth Scenario. This is despite an assumption of somewhat reduced exports from Western Australia in the Climate-dependent Scenario.

The table shows how growth rates are assumed to decline substantially in the latter part of the projection period. It can also be seen that all User Sectors grow, but to different extents. Highlighted results include:

- Aside from the small fishing industry, the mining and energy resources sector has the highest growth rates. We regard this as still the most realistic long-term projection despite the recent global financial and economic crash.
- The only negative growth is for irrigated agriculture under the Low Growth Scenario.
- One feature of the High Growth Scenario is a substantially increased rate of ownership of private household bores between 2008 and 2020
- Household demand for scheme supplies grows at constant per capita rates under all scenarios, the only difference being in the assumed population levels under the various scenarios. Any upward drift in per capita water use would produce higher consumption under all scenarios.

Table 7: Water use projections under four Scenarios 2008-2030 by User Sector

(a) Volume (GL)

	User Sector	MEDIUM DEMAND			HIGH DEMAND			LOW DEMAND			CLIMATE-DEPENDENT DEMAND		
		2008	2020	2030	2008	2020	2030	2008	2020	2030	2008	2020	2030
1	Agriculture	812.5	1,024.8	1,058.5	812.5	1,104.0	1,227.8	812.5	788.7	706.1	812.5	1,071.8	1,157.3
2	Licensed Rural Domestic & Stock	42.8	54.3	60.6	42.8	56.8	67.0	42.8	52.0	56.1	42.8	58.9	70.5
3	Unlicensed Rural Domestic & Stock	82.8	109.8	126.0	82.8	115.0	139.3	82.8	104.8	116.3	82.8	109.8	126.6
4	Fishing & Forestry	12.3	18.0	20.0	12.3	21.0	26.0	12.3	16.4	16.8	12.3	14.8	15.2
5	Mining	619.3	891.9	1,064.2	619.3	943.6	1,195.1	619.3	796.1	1,062.8	619.3	890.1	1,059.9
6	Manufacturing and Processing Industry	146.3	191.1	193.8	146.3	213.1	244.6	146.3	173.4	161.4	146.3	190.3	192.1
7	Service Industries	127.4	159.6	188.4	127.4	175.5	221.4	127.4	149.3	168.6	127.4	153.8	172.4
8	Households (PWS)	242.5	293.4	330.6	242.5	319.1	385.8	242.5	281.5	306.4	242.5	311.9	371.8
9	Household Bores	124.5	158.6	182.4	124.5	212.7	265.6	124.5	150.8	168.1	124.5	171.5	211.4
10	Parks, Gardens, Sport etc	75.2	101.7	121.0	75.2	107.9	126.9	75.2	94.7	107.3	75.2	102.2	121.3
	TOTAL	2,285.6	3,003.3	3,345.4	2,285.6	3,268.9	3,899.5	2,285.6	2,607.8	2,870.1	2,285.6	3,075.0	3,498.6

(b) Growth Rates (%/Year)

User Sector		MEDIUM DEMAND		HIGH DEMAND		LOW DEMAND		CLIMATE-DEPENDENT DEMAND	
		2008-20	2020-2030	2008-20	2020-2030	2008-20	2020-2030	2008-20	2020-2030
1	Agriculture	1.96	0.27	2.60	0.89	-0.25	-0.92	2.34	0.65
2	Licensed Rural Domestic & Stock	3.25	0.86	4.56	1.81	2.42	0.23	1.56	0.23
3	Unlicensed Rural Domestic & Stock	3.09	1.48	3.57	1.99	2.11	2.44	3.07	1.47
4	Fishing & Forestry	2.25	0.12	3.18	1.15	1.43	-0.60	2.21	0.08
5	Mining	1.90	1.39	2.71	1.96	1.33	1.02	1.58	0.96
6	Manufacturing and Processing Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	Service Industries	1.60	1.00	2.31	1.59	1.25	0.71	2.12	1.48
8	Households (Scheme Supply)	2.55	1.45	3.05	1.36	1.93	1.05	2.59	1.44
9	Household Bores	2.00	0.92	2.40	1.38	1.64	0.63	2.71	1.51
10	Parks, Gardens, Sport etc	2.04	1.17	4.57	1.87	1.61	0.91	2.70	1.76
TOTAL		20.64	8.66	28.95	14.00	13.47	5.47	20.88	9.58

Table 8 shows the breakdown of State demand increments under the Medium Growth Scenario as between individual industries and other users. By far the largest additional demand comes from the mining sector, both ferrous and non-ferrous (450 GL), followed by irrigated agriculture (245 GL), and household demand for scheme supply (88 GL). Domestic bores produce an additional demand increment of some 58 GL. Both the residential public water supply and domestic bore demand assumptions assume that household consumption grows no faster than population. Demands for irrigation of parks and gardens add another 46 GL to expected demand under the Medium Growth Scenario. Negatives in the table denote projected declines in use: most notably in the dairy industry.

Table 8: Demand increment by User Sector, 2008-30: Medium Growth Scenario, Western Australia

No.	Industry/User Group	GL	No.	Industry/User Group	GL	No.	Industry/User Group	GL
1	GrainLivestock	-1.4	21	Fruit & Veg	0.1	41	WholesaleTrade	0.4
2	BeefCattle	47.5	22	Other Food &Tobacco	0.9	42	Retail Trade	13.6
3	DairyCattle	-12.1	23	Beverages	1.4	43	Mech & Other Repairs	0.1
4	Pigs	0.6	24	TextilesClothing Footwear	0.3	44	Hotels & Cafes	2.6
5	Poultry	0.9	25	Sawmill Products	7.8	45	Transport & Communications	4.2
6	Cotton	0.2	26	OthWoodProds	0.2	46	Finance/Business	-0.4
7	Grapes	9.5	27	Pulp Paper & Printing	3.7	47	Ownership of Dwellngs	0.0
8	Vegetables	51.6	28	Petrol & Coal Products	0.8	48	Government & Defence	0.8
9	Other Hortcltr	61.6	29	Chemicals	6.3	49	Education	6.3
10	Sugar Cane	62.3	30	NonMetMinPrd	0.7	50	Health	7.5
11	Oth Agr Serv	25.3	31	Iron & Steel	9.0	51	Welfare	3.1
12	Forestry	1.1	32	Basic Non-ferrous metals	9.4	52	Parks, Gardens & Liesure	45.7
13	Fishing	6.6	33	Metal Products	3.5	53	Other Services	3.2
14	Coal	-0.6	34	Transport Equip	-0.1	54	Population	88.1
15	Oil & Gas	3.6	35	Photographic Equipment	0.2	55	Domestic and Stock	14.0
16	Iron Ores	210.2	36	Other Equipmt	-0.1	56	Environmental Allocations	0.0
17	Oth Metal Ores	43.9	37	Manufacturing nes	0.2	57	Not Specified	2.2
18	Other Mining	187.7	38	Electricity & Gas	0.2	58	Licensed Rural Domestic	1.6
19	Meat Products	3.0	39	WaterSewerage Drainage	0.0	59	Household Bores	57.9
20	Dairy Products	0.1	40	Construction	19.6	60	Unlicensed D&S	43.2
							Total	1,059.0

Demand for Scheme Supplies

The model calculates the likely demand for scheme water supplies on the assumption that the proportion of total demand in each of the 60 industry groups in each of the 19 Demand Regions that is met through a scheme supply will remain the same as in 2008. In other words, the model anticipates the impacts of structural economic change and demographic shifts on the demand for scheme water, but not any changes involving substitution of scheme water for self-extracted water or vice versa.

Table 9: Projected urban scheme demands: Medium Growth Scenario 2008-30 (GL)

	Demand Region	2008	2020	2030
1	East Kimberley	5	6	8
2	West Kimberley	10	14	17
3	East Pilbara	16	18	20
4	West Pilbara	14	17	18
5	Gascoyne	6	6	7
6	Murchison	0	0	0
7	Greenough	15	18	20
8	Midlands	8	9	10
9	Moore	3	4	4
10	Perth	238	296	336
11	Peel	9	12	14
12	Preston	10	11	12
13	Vasse	6	8	9
14	Blackwood	2	2	2
15	King	6	7	7
16	Pallinup	2	2	2
17	Upper Gt Southern	4	4	4
18	Esperance	3	3	3
19	Goldfields	3	3	3
Total Urban Scheme Water Use		**360**	**440**	**496**

The Medium Growth Scenario is for an average annual rate of growth in urban scheme demands of 1.33% per year between 2008 and 2030 it is stressed that very conservative assumptions were made implying constant per capita residential use throughout the period. The comparable growth rate under the High Growth Scenario is 1.7% per year.

Table 10 shows the expected growth of irrigation scheme demands to 2030. The rates of growth in irrigation scheme demand are similar for Peel, Preston and East Kimberley. Absolute growth is highest in the East Kimberley Demand Region, but still at a moderate 1.1% per year. This scenario does not include full development of the Ord River Stage 2 Project, which could add another 300 GL or more to use in the East Kimberley.

Table 10: Projected irrigation scheme demands: Medium Growth Scenario 2008-30

	Demand Region	2008	2020	2030
1	East Kimberley	295	379	378
2	West Kimberley	0	0	0
3	East Pilbara	0	0	0
4	West Pilbara	0	0	0
5	Gascoyne	13	16	17
6	Murchison	0	0	0
7	Greenough	0	0	0
8	Midlands	0	0	0
9	Moore	0	0	0
10	Perth	0	0	0
11	Peel	8	9	10
12	Preston	85	96	99
13	Vasse	0	0	0
14	Blackwood	0	0	0
15	King	0	0	0
16	Pallinup	0	0	0
17	Upper Great Southern	0	0	0
18	Esperance	0	0	0
19	Goldfields	0	0	0
Total Irrigation Scheme Use		**401**	**500**	**504**

Regional Trends

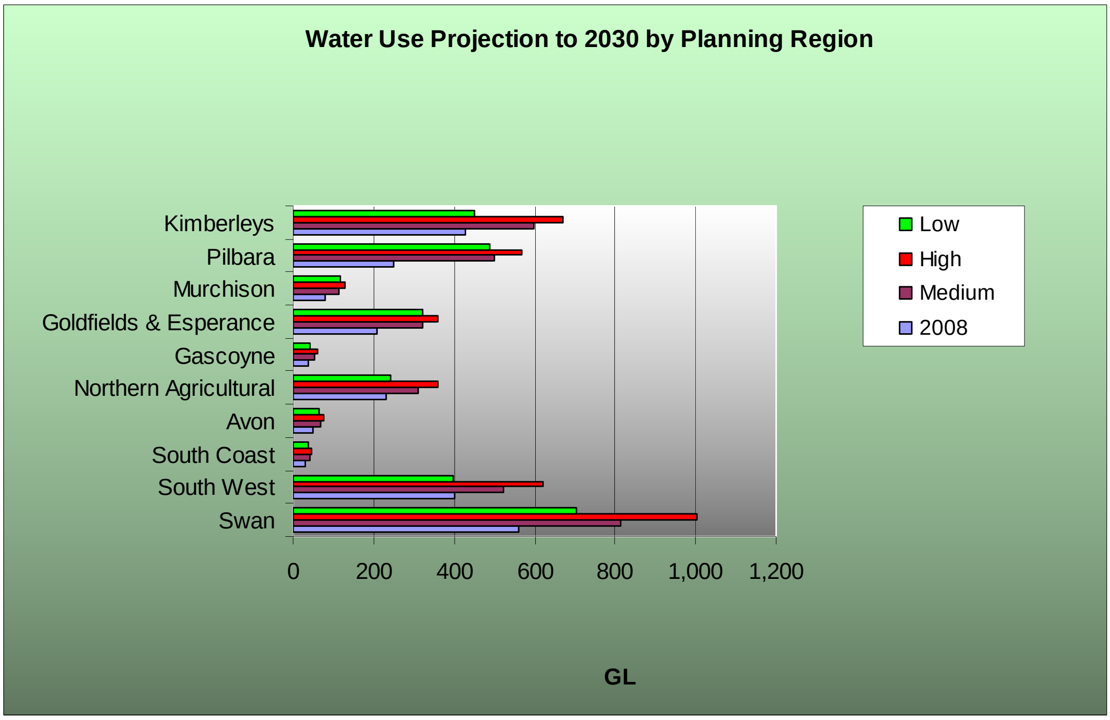
Figure 10 shows the results for total water use in each region under each scenario. For ease of interpretation the Demand Regions have been amalgamated into WA Planning Regions in the Figure.

It is striking that the Perth-Peel Planning Region heads the expected growth, despite the relatively conservative assumptions we have made about per capita residential demand being kept constant under each scenario (though the size of the population varies between the scenarios).

The other two Planning Regions where water use would increase substantially under all scenarios are the Pilbara and Kimberley.

In the case of the Pilbara it has been assumed that demand for iron ore and output levels will continue to increase beyond 2020. Other resource-based industries are also projected to grow in this region. Approximately a half of the mining component of demand can be expected to come in the form of mine dewatering. In fractured rock environments this demand is largely self-fulfilling, and the provision of water is not an issue. However, the destination of discharged waters is an issue for environmental managers. The growth of this region will present issues for scheme water supplies, which are likely to be met from either coastal plain groundwater or desalinated sea water.

Figure 10: Water use by Planning Region under High, Medium and Low Growth Scenarios



Note: composition of Planning Regions in terms of Demand Regions:

- Kimberleys = West Kimberley and East Kimberley
- Pilbara = West Pilbara and East Pilbara
- Murchison = Murchison
- Goldfields and Esperance = Goldfields and Esperance
- Gascoyne = Gascoyne
- Northern Agricultural = Greenough and Moore
- Avon = Midlands
- South Coast = Blackwood, King, Upper Great Southern and Pallinup
- South west = Preston and Vasse
- Swan = Perth and Peel

In the Kimberleys the scenario projections, being based on economic modelling of the growth potential of existing industries, may understate the eventual outcome if the Ord Stage 2 Project reaches its full potential.

The Goldfields and Esperance Planning Region is projected to experience continued growth in water demands. Much of the demand is for dewatering of gold and base metal mines in fractured rock environments. However, the region is not well endowed with adequate groundwater of good quality. Thus the continued growth of resource-based activities will generate a local scheme water demand that must be met from inter-regional transfers or locally-desalinated water.

The South West Planning region has generally slower growth in water use than in other regions, mainly because mining is not so strongly represented in their economies. The projections in this group of regions may appear to contradict recent trends, which have shown little if any growth in water use. It has to be emphasised that the projections take account of potential demand trends according to a forward-looking economic model. Recent history of water use has been influenced by two factors: (i) Harvey Water's channel replacement strategy, linked to its water trade to the Water Corporation, and (ii) historically low water storages. It is also notable that the ABS records significant growth the area irrigated as reported by farmers, as compared to the 1990s.

The Gascoyne, Avon and South Coast Planning Regions all have relatively small water demands, and economic and demographic growth expectations are more restricted. That is not to say that these regions can be ignored in water planning. In each case there are serious challenges for water managers, and the water demand-supply balance is quite critical for some communities.

The following section considers water demand and supply balances in the light of the scenarios for water use.

FUTURE WATER DEMAND VERSUS AVAILABILITY

Definition of Water Availability

Over the years there has been a shift in the criteria used to derive water allocation policies. In 1985 water availability was defined in terms of "Mean Annual Flow" and "Divertible Yield": namely the stream flow or aquifer yields respectively that could be practically and economically developed. In the Water 2000 study two further concepts were added, namely "Sustainable Yield", meaning the amount of water that could be made available for human use after allowance for environmental needs; and "Current Allocation" the amount of water already allocated, even if it was not fully used. In this study recently established "Allocation Limits" for Western Australian water resources are taken as the measure of resource availability. These limits incorporate additional criteria including uncertainty about future yields and uncertainty about competing demands in future. It is stressed that there will be ongoing reviews of allocation limits.

Estimates were made of the difference between projected water demands and the amount of water assessed as likely to be available in each region, taking account of the "flow-on" effects of inter-regional transfer demands. For example, if Perth traditionally exports water to the Goldfields and imports water from Peel and Preston, an increase in demand for water in the Goldfields will have the effect of also increasing the demand of Perth for transfers from the other to regions. The table takes account of these "transfer demands" by including the projected exports as a part of water demand in the exporting region.

In developing these estimates groundwater availability was taken as the current aggregate Allocation Limits in each Demand Region. Surface water availability was based on a discussion with staff of the Department of Water about the previously published (Water 2000 Study) "Sustainable Yields" and the practicality of surface water development in each region, taking account of the engineering tractability of dam sites, water quality and environmental constraints. Nevertheless, it is stressed that the Department is continuing to review allocation limits, and the interpretation of feasible resource development levels is the author's responsibility. The prospective demand-supply balances reported here will be revised when the Department's resource assessments are complete and new runs of the Water Demand Scenario Modelling Tool are undertaken. The following paragraphs summarise our findings on the basis of the preliminary estimates of resource availability that were available to us.

Perth-Peel

The situation in Perth can be considered to be the most serious of all Demand Regions.

Approximately 50 GL of the total licensed allocation (of 477 GL) is currently un-utilised. But this apparent "surplus" does not take account of environmental constraints on groundwater abstraction, and the severely depleted hills storages. The surplus is simply an over-allocation in relation to the true resource availability, due to the fact that surface water allocation limits have not yet been adjusted to reflect declining rainfall, runoff and groundwater recharge.

The Demand Region enters water deficit by 2020 under all scenarios. Even under the Low Growth Scenario there is still an absolute deficit of some 30GL by then. By 2030 the deficit is as much as 390 GL under the High Growth and 338 GL under the Climate-dependent Scenario.

The situation appears better if the resources of the Peel Demand region are taken into account. Nevertheless, in this case Perth-Peel combined would still experience water deficits of 80 to 300 GL by 2030 under the Medium and High Growth Scenarios respectively.

These results have to be interpreted against a projected water use for irrigated agriculture in the Perth-Peel Planning Region that is unlikely ever to be realised. In the scenarios irrigated agriculture grows from a base of 103 GL in 2008 in the two Demand Regions to 150 GL under the Medium Growth Scenario and to 180 GL approximately under the High Growth Scenario. As water is not available for this expansion it appears inevitable that irrigated agriculture will have to substantially relocate to other Demand Regions if the total quantity of irrigation in the south west is to be maintained. Even so, the emerging deficits for Perth and Peel Demand Regions under the various scenarios are well in excess of current irrigation usage, so even a complete relocation of irrigated agriculture could only be a part of the solution.

Pilbara

Emerging water deficits of up to 120GL under the High Growth Scenario for the East Pilbara Demand Region are a sign of good long-term prospects for the iron ore industry. If economic growth proceeds as per the scenarios, Allocation Limits are likely to be increased to cope with mine dewatering requirements. Our assessment if that likely growth of population, industry and commercial demands in the East and West Pilbara Demand Regions, i.e. the demand for urban scheme supply, can be met by groundwater and/or desalination. The eventual mix of these two options will be determined by their relative costs.

Goldfields

There is a large existing water deficit in the Goldfields Demand Region reflecting a situation where allocations are being exceeded by the mining industry, even assuming 80% utilization, and need to be adjusted. Nevertheless the Aggregate Allocation Limit for groundwater in this Demand Region is substantially greater than the current level of allocations. The principal concern should be with alternative ways of providing for long-term scheme supply demands, especially as this region obtains its water from the Perth Demand region, which is clearly under stress.

Wheat Belt Regions

These Demand Regions (Pallinup, Upper Great Southern and Midlands) have been in water "deficit" for many years, and have obtained water through the IWSS and from self-extraction, mainly farm dams. The scenarios suggest relatively small growth in demands. Nevertheless, the stresses on the water resources of the west coast and south coast regions implies that every effort needs to be made to find ways of limiting the demand for water imports to these wheat belt regions.

South Coast

While apparently in "surplus", the south coast regions, and particularly the King Demand Region, face numerous challenges given the limited groundwater resource and the marginal quality of many of the surface resources.

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ANNEX A: COMPOSITION OF THE WATER DEMAND REGIONS IN TERMS OF ABS STATISTICAL AREAS

WATER DEMAND REGION		ABS STATISTICAL AREAS
1	East Kimberley	Ord SSD
2	West Kimberley	Fitzroy SSD
3	East Pilbara	Pilbara SD minus Fortescue SSD
4	West Pilbara	Fortescue SSD
5	Gascoyne	Gascoyne SD
6	Murchison	Carnegie SD
7	Greenough	Greenough River SD
8	Midlands	Midlands SD minus Moore SSD
9	Moore	Moore SSD
10	Perth	Perth SD
11	Peel	Murray SLA
12	Preston	Preston SD minus Capel(A) SLA and Capel(B) SLA
13	Vasse	Vasse SD plus Capel(A) SLA and Capel(B) SLA, plus Nannup SLA
14	Blackwood	Manjimup SLA
15	Pallinup	Pallinup SSD
16	King	King SSD
17	Upper Great Southern	Upper Great Southern SSD
18	Esperance	Esperance-Ravensthorpe SLA
19	Goldfields	Lefroy SD

The ABS acronyms in the table above have the following meanings:

- SD: Statistical Division
- SSD: Statistical Sub-division
- SLA Statistical Local Area

ANNEX B: MONASH-TERM MODEL

This Annex gives an overview of the MONASH-TERM model.

The Centre of Policy Studies at Monash University provided indicative future growth rates for value added, employment by industry and region, and for population to the year 2030.

The model employed in this study is similar to national CGE models such as MONASH (Dixon and Rimmer 2002). In this model, each industry selects inputs of labour, capital and materials to minimise the costs of producing its output. In the latest version of the model each commodity is produced by an industry in a region, and commodity users have many sources of supply (each region in the chosen aggregation plus imports). Unlike previous versions of the model, which postulated a single government and a single household sector, this version has a national government, two state governments (in this application, Western Australia and the rest of Australia) and a household sector in each region.

The model is suitable for examining the impacts of “shocks” that may be region specific. For example, the current resources boom in WA may be regarded a “shock” that fundamentally changes economic relationships in the State economy. For a detailed description of the economic model see Horridge, Madden and Wittwer (2005).

The model produces estimates of value added (output) and employment annually between 2008 and 2030 in three WA economic regions, namely “Perth” (the Metropolitan Region), “FarmWA” (the South West Division from approximately Geraldton to Esperance), and “MiningWA” (the remaining regions lying to the north and east . The rest of Australia is represented as a single region. These regions are linked by trade. The model imposes a fixed exchange rate and free trade between regions, and common external tariffs. In this sense, it remains a national model, rather than international. Behavior in foreign markets is determined outside the model (i.e. exogenously).

Results are next mapped onto the 19 Water Demand Regions. To achieve this, the model includes a representation of sub-statistical divisions within Western Australia. For example, FarmWA solutions are used to infer industry and regional results for Vasse, Peel, Blackwood, Preston, King, Pallinup, Upper Great Southern, Greenough, Midlands and Moore Demand Regions. Similarly, results for Goldfields, Eucla, Gascoyne, Carnegie, West Pilbara, East Pilbara, West Kimberley and East Kimberley are inferred from the “MiningWA” economy. The main source of data for these regions was the 2001 Census, which included 3-digit ANZSIC industry employment at the statistical local area level. ABS prepares agricultural statistics at the statistical division level, which is one level higher than the sub-statistical division representation in this version of the model. Note that some industries are designated as “local”. These are utilities and most service industries excluding wholesale trade. Local industries do not have the same percentage change in output as in the parent economic region. Rather, the local industry outputs vary. That is, local incomes affect local industries, so that some local industries are faster-growing and some slower-growing than the average in the parent region.

ANNEX C: WATER BALANCE EQUATIONS

Water Use Estimate for Industry i in Region r:

$$Wu_{ir}= LicGW_{ir}+ LicSW_{ir} + Ulic_{ir} +Sh_{ir}*[PWS_r+Imp_r- Exp_r+ Mf_{r+} Reu_{r-} UPA_r]$$

Where:

Wu= water use
LicGW = licensed groundwater abstraction
LicSW = licensed surface water abstraction
Ulic = unlicensed abstraction
Sh = a proportion
PWS = public water supplied
Imp = water imported to the region
Exp = water abstracted in the region but exported to another region
Mf = water manufactured for use in the region (e.g. desalination plant)
Reu = water obtained from a water or wastewater re-use facility
UPA= unused public water supply allocations
r and i subscripts refer to region and the ANZSIC industry group respectively

Note that in projecting total demand for water in a region the likely demand for export of water from a region is taken into account as well as demands from activities within the region. For example, the Goldfields and Agricultural Water Supply Scheme now contained within the Integrated Water Supply Scheme, obtains water from storages located in the Perth Demand Region. The method of projection, using matrix algebra, provides an indication of how changes in the population and economies of these receiving regions might affect demand on the producing region*, if the pattern of water production remains similar to the current situation*. It remains for the user of the Water Demand Scenario Modelling Tool to assess whether the future demands can continue to be supplied in a similar fashion to the present. No attempt is made to model optimal patterns of production and distribution.

Water Availability Estimate for Region r:

$$Wav_r = GW_r + SW_r +Imp_r- Exp_r+ Mf_r + Reu_r$$

Where:

Wav_r = total water available for use in a region
GW_r = sum of groundwater allocation limits
SW_r= sum of surface water allocation limits
The other terms are as previously defined.

At the level of the whole State, inter-regional imports and exports cancel each other: i.e. they sum to zero.

Note that the current approach of the Department of Water is to set allocation limits in a way that reflects expectations of development up to the level that would trigger an environmental assessment by the Environmental Protection Authority. Most major projects require environmental assessment. The Department has published allocation limits for groundwater, but not for surface water. However, in considering surface water the State can reasonably be divided into the south west, where surface waters are already at the limit of their allocations, and the Kimberley where only a small proportion of surface flow is currently harvested.

The ***Balance*** between water availability and water demand in a region is therefore:

$$Br = Wav_r - \Sigma Wui_r$$

Estimation Methods

Licensed self-extraction

Data from the Department's Water resources Licensing (WRL) data base identified current allocations in 2008. Where possible (i.e. where the WRL code agreed with an ANZSIC code) these were translated directly from WRL into the ANZSIC codes. Where the WRL code contained more than one ANZSIC code the licensed volume in each region was "spread" across the constituent ANZSIC codes using an appropriate weighting. Mainly, the weighting was based on relative employment in the constituent ANZSIC codes, but for irrigated agriculture areas irrigated were used, where available. Licensed abstraction was then added to any water supplied by a scheme supplier.

Irrigation Cooperatives

There are three irrigation cooperatives in Western Australia, namely (i) Harvey Water, which serves the Waroona Irrigation Area in the Peel Demand Region, and the Harvey and Collie Irrigation Areas within the Preston Demand Region; (ii) Gascoyne Irrigation Cooperative near Carnarvon; and (iii) the Ord River Irrigation Cooperative in the East Kimberley Demand Region. The cooperatives operate as bulk distributors of water, and are treated as scheme suppliers in this report. For these entities it was necessary to allocate the aggregate volumes licensed across ANZSIC-defined producer groups using ancillary information on irrigation uses within each irrigation area. Sources included: Harvey Water website, Ord River Management Plan (Department of Water, Dec 2006), and Brennan (2006).

Unlicensed Rural Domestic and Stock Uses

Large areas of the State are "un-proclaimed". In these areas water is abstracted under the *Rights in Water and Irrigation Act* 1905, and is not licensed. Estimates were developed of total stock water use using the number of livestock from the 2006 Agricultural Census (Australian Bureau of Statistics, 2008) and typical water requirements per head supplied by the WA Department of Agriculture and Food (R. Loh, pers. Comm; and Marwick, 2007). A statistical analysis was then undertaken to determine how much of the total livestock water requirement in each region could be met from licensed abstraction. This was deducted from the total livestock requirement. The balance was then divided between licensed abstraction for stock watering purposes (as determined from WRL licenses) and unlicensed abstraction.

Water Used in Mining

Water use in mining has been considered in terms of (i) licensed abstraction and (ii) actual use including de-watering. The WRL codes do not translate into ANZSIC codes for mining industries. Employment data was used to spread licensed allocation to mining in a region across e.g. iron ore, non-ferrous metals, etc.

Licensing data for 2008 were obtained from the WRL data base. Indicative estimates of actual use (i.e. less than licensed use) were prepared using confidential data from investigation by the Department in the Pilbara, and discussions with Departmental staff .

There has been some debate about the treatment of dewatering in water use scenarios. As the product of dewatering is returned to the environment, some argue that this component of mine water use should be excluded (see for example Economic Consulting Services, 2007). However, as the dewatering is quite clearly an abstraction it is relevant to Department of Water's anticipation of water demands.

Household Scheme Supplies

Data from the WA Water Corporation were used to determine residential (i.e. household) supplies. These were then deducted from the total use of the Corporation, and the balance was spread across industrial and commercial users.

Urban Domestic Bores

Since household bore ownership started rising in the 1970s there have been periodical surveys of the levels of ownership in Perth and elsewhere in the State. Recent surveys include those undertaken by the Australian Bureau of Statistics (2003 and 2006). For a longer-term view see the Perth Domestic Water Use Study Metropolitan Water Authority, 1985).

For this study, an estimate of bore ownership in Perth was made based on ownership from the Australian Bureau of Statistics survey in 2006 and population growth since then. It is thought that recent rates of bore installation may have fallen from the high levels experienced up to 2006 as a result of the introduction of restrictions on the time of use of domestic bores by households, in line with similar restrictions on the use of the scheme supply.

Industry and Commerce

Industrial and commercial uses in 2008 were estimated by combining licensed self-extraction from the WRL data base with an estimate of scheme water supplied. This was based on a two-stage estimation procedure. Firstly the total amount of scheme water distributed was obtained from Water Corporation data (also covering AqWest and Bunbury Water). Then the amounts distributed to individual ANZSIC groups were estimated using a system of weights based on employment data and water use per employee calculated from the Australian Bureau of Statistics Water Account (Australian Bureau of Statistics, 2006).