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

Water for the Future – South West groundwater areas management plan

Final report to the Department of Sustainability, Environment, Water, Population and Communities

Looking after all our water needs

Department of Water

October 2010

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October 2010

ISBN 978-1-921789-33-5 (online)

Disclaimer

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Acknowledgements

This project was supported with funding assistance from the Australian Government's Water for the Future – Water Smart Australia program.

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1 Introduction

1.1 Background

This report is one of four reports on projects funded under the Australian Government's 'Water for the Future' program (originally 'Water Smart Australia') and designed to improve our knowledge in four priority areas – the South West groundwater areas, the Pilbara, the Gnangara mound and the Collie catchment.

This report, on developing a second management plan for the South West groundwater areas, represents the final commitment under the Water for the Future funding deed for the South West groundwater areas project. It describes the work undertaken in this project and compares what was achieved to the original goals. There were four 'project activities' carried out under the schedule 9 of the agreed deed. They are:

- groundwater investigations and modelling
  - undertaking hydrogeological and hydrological investigations
  - developing local area models for the Swan Coastal Plain and the Blackwood River
  - licence assessment, monitoring and compliance work
- determining comprehensive ecological, social and cultural water requirements
- developing decision-support tools and management systems
  - a methodology for quantitative determination of social water requirements
  - a methodology for economic evaluation of allocation options
  - a methodology for obtaining community preferences on allocation options through a multi-objective planning process
- significance of interceptors (plantation water use)

Figure 1 shows which of these Water for the Future activities are relevant to each of the three main stages in the water resource planning process.

1.2 The South West groundwater areas

The South West groundwater areas (SWGA) include the proclaimed groundwater areas of Bunbury, Busselton–Capel, and Blackwood plus the southern part of the South West Coastal groundwater area, covering approximately 8250 km^2. They include two portions of unproclaimed areas (Karri–Blackwood and Karri–Bunbury groundwater subareas). This means that taking of water from groundwater resources from these areas is not subjected to licensing under the existing water legislation unless water is taken from artesian groundwater resources. All other groundwater areas are proclaimed, which means that taking of water from all available resources is subject to licensing.

The groundwater resources located in the South West groundwater areas are the Superficial, Leederville, Yarragadee, Lesueur Sandstone, Sue Coal Measures, Cattamarra Coal Measures and fractured rock aquifers. The area is defined to include surface water expressions of groundwater (that is, wetlands or riverine base flows) where these are dependent on groundwater, and any management decisions regarding groundwater must consider these situations.

The South West is experiencing climate change resulting in less recharge from rainfall reaching the groundwater system every year. There has also been growth in the number of people living in the area, as well as in commerce and local industries. All rely on secure water supplies. Currently around 4000 industries, landowners and domestic bore users rely on the groundwater resources in the area.

The project area covers the important Yarragadee aquifer as well as other groundwater resources, including the Leederville and Superficial aquifers. The water levels in some of these aquifers are decreasing due to reduced rainfall and higher abstraction. In some of the northern aquifers the recycling of salt through irrigation is having an impact on groundwater quality.

The environment in the South West is highly valued by the community as well as being recognised for its outstanding biodiversity. The area has some important features, such as some of the Blackwood River tributaries and important coastal plain wetlands and lakes, that have been identified for careful management. Currently the environment is sustained by the existing water level regime, but increased abstraction on top of the predicted reductions in rainfall could result in future adverse effects.

1.3 Projects in the South West groundwater areas

To manage the South West groundwater areas system to an environmentally sustainable level of extraction in response to the change in water availability and demand, the Department of Water initiated two major projects.

The first was the *South West groundwater areas allocation plan*, which was developed and is being implemented to:

- maintain security of supply for consumptive use by setting and licensing to allocation limits
- increase water use efficiency
- increase protection of wetlands from direct impacts of abstraction.

The second was this project completed under the Australian Government's Water for the Future program. Information gathered and products delivered through this program will be used to refine the three main strategies on which a second South West groundwater areas allocation plan will be based. These strategies are:

- to maintain security of supply by:
  - improving our understanding of the aquifers, including the connectivity between aquifers, to define the hydrogeological boundaries for

consumptive pools, to set an environmentally sustainable level of extraction from consumptive pools, and to set an appropriate timeframe for periodic allocations from each consumptive pool

  - developing policy and processes to ensure abstraction is at sustainable levels

- to increase water-use efficiency by:
  - increasing the accuracy of current use data
  - managing licences
- to improve protection of wetlands and waterways from the direct effects of groundwater abstraction by:
  - improving our understanding of the susceptibility of wetlands to climate change so that they can be maintained in a satisfactory state or managed to make a transition to new states
  - improving our understanding of connectivity between surface and groundwater and between different aquifers in priority surface water systems where water abstraction by users is high and where the system is known to have very sensitive ecology

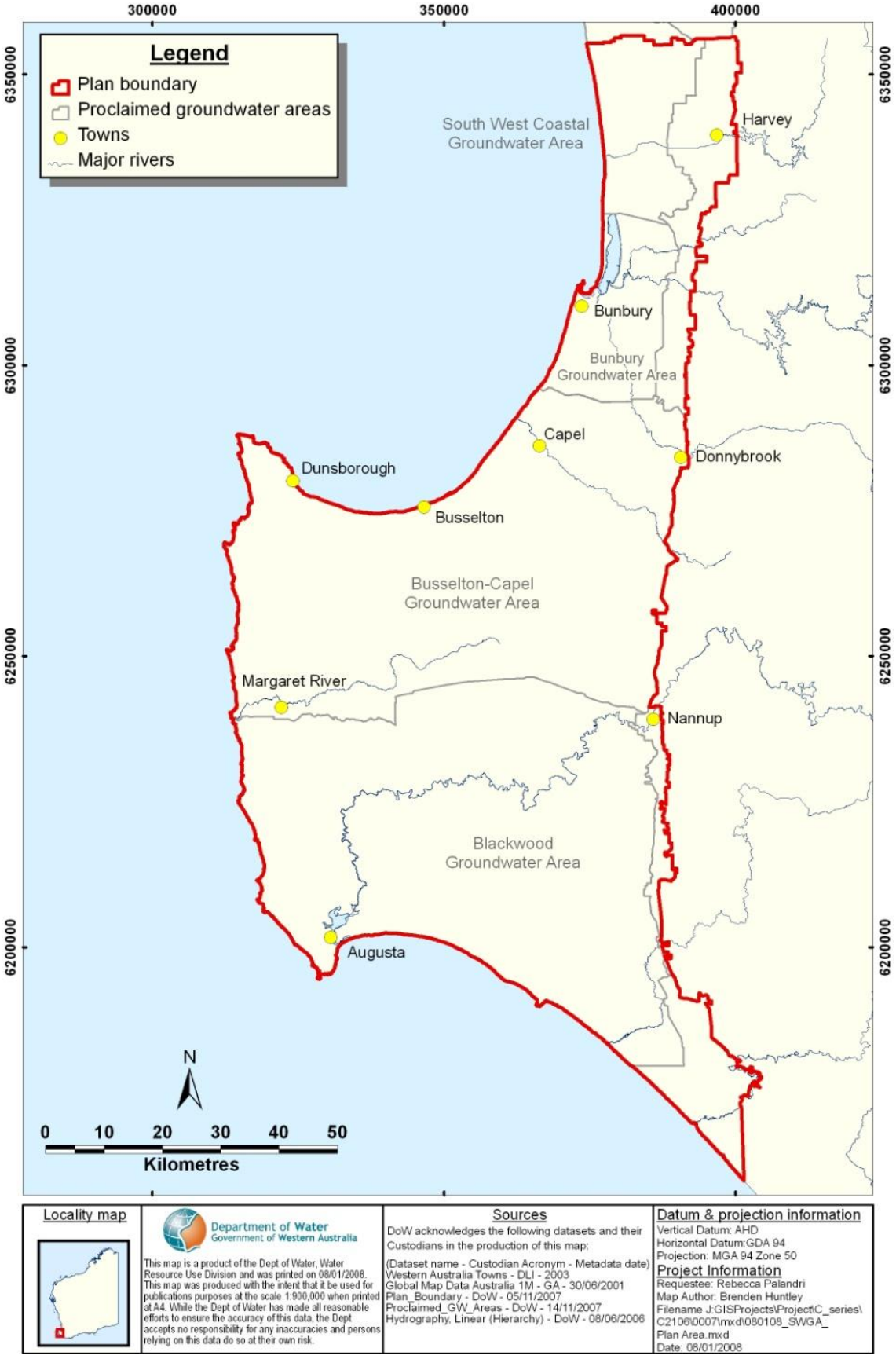

Figure 1 Location of the South West groundwater areas covered by the project

2 How was the WFTF project for South West groundwater areas implemented?

2.1 Mapping WFTF milestones (Schedule A18) to WFTF project activities (A9)

The project was divided into four main components described as project activities in schedule 9 of the deeds. Each project activity was achieved by completing specific milestones as described in schedule 18 of the deed. The deed specified agreed timelines by which each milestone had to be completed over the three year project. The table below gives details of the project activities and their related milestones.

Table 1 Mapping milestones to project activities

Project activities	Related milestones
Groundwater investigation and modelling	*Milestone 1 – SGS Investigation and Assessment* 1.1 – Completion of Stage 1 – Investigation and installation of monitoring for SGS 1.2 – Completion of access permissions, drilling, testing and monitoring network installation 1.3 – Completion of groundwater and sediment sampling and analyses (Phase 1) 1.4 – Completion of groundwater and sediment sampling and analyses (Phase 2) *Milestone 2 – SGS – GW Interaction (Hydrology)* 2.1 – Completion of Stage 1 of HECRAS and RAP Modelling of Blackwood and tributaries 2.2 – Completion of stage 2 – HECRAS and RAP Modelling of Blackwood and tributaries 2.3 – Completion of Stage 3 – HECRAS and RAP Modelling of Blackwood and tributaries *Milestone 3 Groundwater Assessment* 3.1 – Completion of petrophysical analysis of geophysical logs and core analysis 3.2 – Completion of 3-D geological modelling of the SP Basin 3.3 – Completion of the Swan Coastal Plain local scale assessment and modelling 3.4 – SWAMS model upgrade and use *Milestone 4 – SW Groundwater Investigation* 4.1 – Completion of site approvals and access 4.2 – Mobilisation and commencement of drilling investigations 4.3 – Completion of drilling investigations *Milestone 8 – License assessment, monitoring and compliance* 8.1 – Completion of Stage 1 – monitoring / management framework systems support and development 8.2 – Completion of Stage 2 – monitoring / management framework systems support and development 8.3 – Completion of Stage 3 – monitoring / management framework systems support and development
Determination of comprehensive ecological, social and cultural water requirements	*Milestone 5 – Environmental Water requirements* 5.1 – Vegetation assessment 5.2 – Other ecological investigation
Development of decision-support tools and management systems	*Milestone 6 – Social/ Cultural Water requirements* 6.1 – Completion of social water requirements 6.2 – Completion of cultural water requirements
Significance of interceptors (plantation water use)	*Milestone 7 – Economics and demands* 7.1 – Completion of interception and accounting policy (plantations) 7.2 – Completion of self-management process

2.2 How WFTF project activities relate to the water allocation planning process

The current allocation plan for the South West groundwater areas is enabled under the existing legislation, the *Rights in Water and Irrigation Act 1914*. Licences to take water are the regulatory instrument.

In order to build on the 2009 allocation plan, we need to improve our understanding of the groundwater systems and the implications of different management options for them. The activities undertaken through the Water for the Future investment were designed to gather further knowledge to be used when we review and update the allocation plan. It is anticipated that this will be done under forthcoming new water resource legislation and will formally commence in 2010–11.

Without the support of the Water for the Future the department could not have undertaken the next stage of water allocation planning in the South West groundwater areas with the confidence that we were making a big step forward in improving the management of this system.

Four Water for the Future project activities as described above were completed over the three years project. Each of the project activity will inform different stages of the planning process as shown in Figure 2 below.

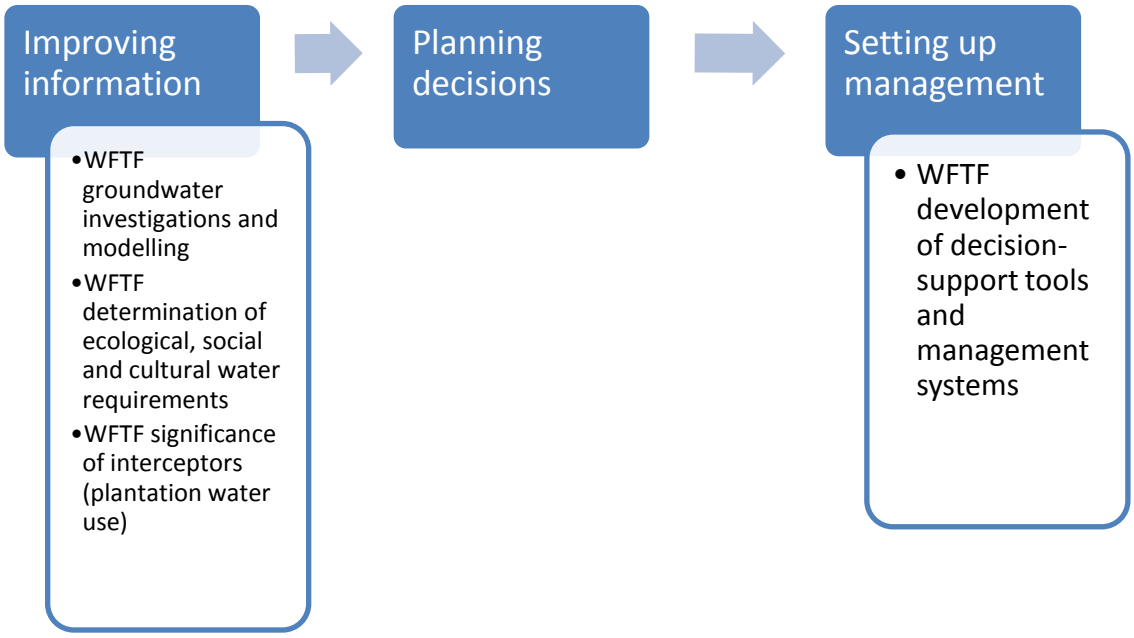

Figure 2 How Water for the Future project activities relate to the water allocation planning process

3 Statement against project activities (Schedule A9)

Activity 1: Groundwater investigating and modelling

Background

This project activity was set up in three main parts:

- undertaking hydrogeological and hydrological investigations
- developing local area models for the Swan Coastal Plain and the Blackwood River
- licence assessment, monitoring and compliance work.

It was intended to improve the conceptual understanding of the water systems in the South West region by investigating areas where water intake is high and where there is a significant lack of water information. Results from investigations have been incorporated into the regional model (South West aquifer modelling system) to refine the parameters on a regional and local scale.

Work conducted and products developed

The project activity was achieved by completing work set up under milestones 1, 2, 3, 4 and 8 of the agreed deed. (see Table 1).

Description of the work conducted and products delivered against these milestones are individually described below.

Milestone 1 – Shallow Groundwater systems (SGS) investigation and assessment

The scope of work for the milestone was designed to provide an improved understanding of Shallow Groundwater Systems (SGS) in the South West Groundwater Areas (SWGA). The work focused on the acquisition of new groundwater data and transforming existing hard-copy groundwater data to digital data. Subsequent use and assessment of this data will provide a greater understanding of SGS.

The work conducted under this milestone was divided into six sub-projects:

1 Swan Coastal Plain Superficial aquifer stratigraphic drilling program

2 Groundwater Dependent Ecosystems drilling program

3 Acid Sulfate Soils investigation program

4 State Reference Network - WIN data cleansing

5 Form L - WIN data update

6 Non-point source - WIN data update

Swan Coastal Plain Superficial aquifer stratigraphic drilling program

The Department of Water uses a regional-scale numerical model called South West Aquifer Modelling System version 2 (SWAMS v2) and the Eastern Scott Coastal Plain (ESCP) local-scale model for modelling the groundwater resources of the SWGA. These models predict the volumes of groundwater stored in the aquifers that comprise the groundwater resources of the SWGA. They also broadly predict the impacts of simulated climate change and groundwater abstraction on groundwater levels at important ecological, cultural/social sites and other groundwater user abstraction points.

In the SWAMS v2 model the superficial formations are modelled as one layer with no vertical or horizontal discretisation to simulate the highly variable nature of the lithological units comprising this aquifer. Groundwater abstraction in the SWGA is concentrated on the Swan Coastal Plain. Improved prediction of impacts on the Swan Coastal Plain due to climate change and groundwater abstraction required development of a high resolution local-scale model coupled with comprehensive hydrogeological and environmental monitoring.

The Swan Coastal Plain superficial aquifer drilling program provided the data required to develop this model. A local-scale model between Dunsborough and Bunbury covering the Swan Coastal Plain was developed as part of Milestone 3.3.

The objectives of the Swan Coastal Plain superficial aquifer drilling program were to drill 5 transects across the Swan Coastal Plain between Dunsborough and the Capel River (Figure 1). The lateral extent and thickness of the lithologies comprising the superficial formations and the contact with the underlying Leederville formation was defined. Confirmation of the Leederville contact was evidenced through palynological sampling. Plugs of the drilled core were analysed for liquid permeability (vertical and horizontal), effective porosity and irreducible water content. These results were used to define parameters for the local-scale model. Monitoring bores were constructed at each of the coring sites. Water level loggers were also installed at each site. The high-resolution time series water level data collected will be used to calibrate the local-scale model, which provided a greater understanding of the recharge characteristics and seasonal water-table trends of the superficial aquifer. Groundwater quality sampling provided data for the future management of water resources.

Groundwater-dependent ecosystems drilling program

The SWGA is an important region within an internationally recognised biodiversity hot-spot with wetlands sited along bird global migratory routes and has ecosystems that include endemic flora and fauna species. The water regimes for groundwater-dependent Ecosystems (GDEs) within the SWGA are highly variable and depend on a number of factors including geomorphology, climate, supporting aquifer characteristics and land use activities. Management of the SGWA water resources required the identification of GDE values, understanding of related water regimes and the determination of recommended ecological water requirements (EWRs).

Groundwater-dependent vegetation sites of high-conservation value had been previously identified in 2006. Investigations were initiated as a subset of these. Vegetation monitoring transects were established to collect baseline data and are annually monitored to record vegetation health and changes in species composition. In 2007, shallow monitoring bores were installed at twelve of these wetlands. Water levels are monitored monthly and water-level loggers have been installed at each of these sites.

The GDE drilling program was designed to provide an improved understanding of the water regimes supporting a variety of GDEs on the Swan and Scott coastal plains. At sites where no drilling has occurred, shallow monitoring bores and deeper piezometers were installed. At some sites where previous drilling and shallow bore installation had occurred, a deeper piezometer was drilled and installed. High-resolution time-series groundwater-level data collected by water-level loggers are providing recharge/discharge relationships of the superficial aquifer with rainfall and the underlying aquifer.

Cores retrieved from the drilling provided data regarding depth of root penetration and lithological characteristics of the sedimentary profile. Plugs of core were analysed for liquid permeability (vertical and horizontal, effective porosity, irreducible water content, water retention characteristics, bulk density, particle size distribution and unsaturated hydraulic conductivity). Palynological analyses have evidenced regional stratigraphic correlations.

At selected wetlands capacitance probes were installed to measure the water content in the unsaturated zone. Data was collected to establish the relationship between rainfall and recharge by tracking the wetting front during early winter. Extraction of water by plants from soil layers was calculated to quantify evapotranspiration rates and vertical patterns of extraction. This will indicate the water requirements of wetland vegetation and the degree of groundwater dependence over a range of climatic conditions and vegetation types.

At some sites, water stress of different plant species was measured to determine relative rooting depths and vulnerability to water table drawdown. Several access tubes were installed at each of these sites and the spatial distribution of soil moisture was measured each time plant water stress was measured. By measuring water stress of different plant species, their rooting depths and relative groundwater dependence can be inferred. This will determine the plant species to be monitored as indicators of ecological change due to changes in water regimes. This will be included in the Milestone 5 reports.

Assessment of the data collected from this investigation will aid the determination of in situ ecological water needs for each of these sites and be extrapolated to other sandy sites in the region.

Acid sulfate soils investigation program

Acid Sulfate Soils (ASS) are widespread on the Scott Coastal Plain and have been identified along the coastal strip of the Swan Coastal Plain within the SWGA.

Oxidation of these ‘soils’ through disturbance including dewatering, drainage, excavation and exposure to nitrate (from fertilisers and other nutrient sources) can result in the generation of acid and the subsequent release of metals and metalloids (e.g. arsenic, antimony) into groundwater. ASS presents a hazard to the quality of groundwater and it’s receiving environments. An improved knowledge of the location of ASS in the landscape, buffering capacities of ASS host and adjacent materials, and local water regimes is essential for the management of the risk that ASS oxidation poses to the environment, including surface water sources.

Estuarine areas on the Swan Coastal Plain have also been defined as high risk, with the remainder falling in the moderate risk category. Work to date has comprised preliminary soil sampling along the coastal plain areas with no work to date carried out on the Blackwood Plateau. Improved knowledge of the occurrence of potential ASS (PASS) is necessary due to the potential impact from groundwater abstraction, climate change and changing land use development. The project:

- Increased the intensity of regolith investigation sites on the coastal plains to enable improved resolution of ASS hazard mapping for improved water use management and land use planning.
- Conducted PASS surveys on the Blackwood Plateau in areas of environmental and social significance that are likely to be impacted by future groundwater abstraction – particularly the groundwater dependent ecosystems in the general area of the Blackwood River and the area of discharge from the Yarragadee Aquifer.
- Conducted deeper investigations to identify whether ASS hazard occurs extensively in deeper layers of water tables within the superficial aquifer;=.
- Undertook collaboration work with water resource modelling systems to identify areas where declines in shallow groundwater regimes are likely to occur from land and groundwater use activities.

The Acid Sulfate Soils investigation program provided an improved coverage of ASS sites across the Swan and Scott coastal plains. Drilled core from the Swan Coastal Plain superficial aquifer and SWGA-SGS – Groundwater Dependent Ecosystems drilling programs provided lithological data and core for ASS analyses. Profiles of core of the superficial aquifer were analysed to assess the occurrence of ASS especially in deeper parts of the aquifer. Current ASS hazard maps are being updated. Where the data coverage is dense enough, depth to ASS contour maps will be generated. These then will be compared to outputs from groundwater resource models and areas of high risk of ASS oxidation will be delineated. Where possible, trigger groundwater levels for EWRs were determined considering the potential for ASS oxidation.

State reference network - WIN data cleansing

The Western Australian surface-water, groundwater, water allocation and licensing data is stored in three departmental corporate databases - DWAID (Divertible Water Allocation Inventory Database), WRL (Water Resource Licensing) and WIN (Water

Information System). WIN data includes bore construction details, water level and water quality. WIN is the amalgamation of five databases. Some of these databases housed common information or information that had little quality assurance. This led to some sub-standard quality data or duplicated data being migrated to, and subsequently stored in, WIN.

Water resource modelling and water quality trend analysis uses WIN data. SWAMS v2 uses data collected from monitoring bores that make up the State Reference Network (subsequent to the inception of this project the State Reference network has been renamed the Groundwater Assessment network) and is complemented by data from privately owned bores (see details pertaining to the SWGA-SGS – Form L - WIN data update sub-project below). Inaccurate data compromises the validity of both model outputs and water quality trend analyses.

The Department of Water has maintenance and decommissioning schedules for the bores comprising the State Reference Network. Inaccurate data can however compromise efficiency of bore-component purchase and bore maintenance schedules.

The State Reference Network - WIN data cleansing sub-project was designed to clean groundwater data specifically related to the SWGA. The objectives of this sub-project were to provide accurate bore construction details, water levels and groundwater quality of bores located within the boundaries of the SWGA. This data was evidenced and subsequent documentation became accessible via the Department's electronic document storage database (TRIM). This provided the basis for ongoing digital documentation for changes regarding the maintenance and groundwater data collection for each bore. This information is then readily available for updating the Government of Australia's Bureau of Meteorology (BOM) database and consequently available to the public both state-wide and nationally.

Ultimately, this sub-project provides a cost-model for the cleansing of all groundwater data stored in WIN. The cleansing of all groundwater data stored in WIN using the protocols established in this sub-project will subsequently provide the basis for the chain-of-custody for information evidencing groundwater models developed by the department.

Form L - WIN data update

AQWABASE was developed to store bore location, construction, water levels, and groundwater supply and groundwater quality data. Data was sourced from State Reference Network bores, drillers' logs (called 'Form Ls') for licensed and some unlicensed bores, government agency environmental/contamination investigation bores, and public water-supply production and observation bores. Prior to the migration of data from AQWABASE to WIN, all data capture and import into AQWABASE ceased. Since the launching of WIN in 2000, very little licensed and unlicensed bore data had been added.

Groundwater resource modelling, assessment and groundwater level and quality trend analyses use WIN data. Modelling of the SWGA groundwater resources mainly

uses data collected from monitoring bores that comprise the State Reference Network, but is complemented with data from other sources. One important data source is the Form Ls (drillers' logs).

The Department of Water provides a number of services to the community including the provision of advice regarding water quality, bore construction and probable depth to water. Delivering up-to-date information is crucial if informed decisions are to be made regarding the viability of drilling and installation of privately-owned bores, and ensuring that screens are constructed within the aquifer specified by the department.

The objective of this sub-project was to update WIN with Form L data. This data has been digitally captured and is also be accessible via the department's electronic document storage database (TRIM). Access to the digital Form L stored on TRIM is now available via the department's GIS platform. This tool will provide department licensing officers and other staff members ease of access to digital documentation that was previously only available on hard-copy files. The Form L data in digital format will improve groundwater models, allocation and licensing decisions and surveys, and service provided by the department to the wider community.

Non-point source - WIN data update

Anthropogenic-disturbed landscapes can result in the contamination of surface and groundwater resources through a number of mechanisms including agricultural-related inputs (e.g. manure, fertilisers and pesticide/herbicide application), drainage and groundwater abstraction (e.g. changing in oxidation/reduction conditions, inducing salinisation), industrial and manufacturing activities, and urbanisation.

The management of potential localised sources (point-sources) of contamination to groundwater resources is managed through operating strategies attached to groundwater licenses. Diffuse (non-point source) groundwater contamination can account for most of the contamination in a region. For example, elevated nitrate concentrations in groundwater can occur over large areas where there is a high density of septic tanks or the widespread intensive use of fertilisers.

The management and monitoring of non-point source contamination requires comparison of regional groundwater quality surveys with baseline data. In the mid-1990s a survey of non-point source groundwater contamination in the Perth Basin was conducted. Bores that were screened within 10 m of the water table were chosen. Where there were no state-owned bores, private bores with well-documented construction data were used. In the SWGA, bores on the Swan and Scott coastal plains were at 5 to 10 km spacing and at a much broader spacing on the Blackwood Plateau.

The objective of this sub-project was to data capture the SGWA field measurements and laboratory analyses from this baseline survey and store this data in WIN. This provided a snapshot of groundwater quality in a digital form, which is now available for comparison with subsequent surveys.

Milestone 1 findings

- Rotary sonic drilling technology was trialled during this project and is now seen as a useful tool for core collection where detailed lithology and intact core samples are required. This technology has subsequently been used for other Department of Water projects.
- Most technical aspects of this project were managed and resourced using Department of Water personnel. Departmental hydrogeologists and environmental scientists were employed to log and sample cores, interpret geology etc. These people now have an increased familiarity and understanding of shallow stratigraphy shallow hydrogeological processes and ASS of the Southern Perth Basin, That knowledge resides within the department as a consequence of this work being done in-house ensuring continuity for the next phase of planning.
- The stratigraphic drilling program has provided geological data of the superficial formations at a much higher resolution than previously available. This will underpin future (Superficial Aquifer) allocation decisions on the Swan Coastal Plain for the area between Dunsborough and Capel through the development of the LAM (Milestone 3.3) and the subsequent SWAMS upgrade.
- Installation of water-level loggers at all of the sites where bores were constructed provides the means to collect time-series water-level data. Analysis of seasonal and longer-term trends will result in improved understanding of the hydrogeological system. That improved understanding will advise future management of and provide a means of monitoring the Superficial Aquifer.
- The GDE drilling program and other associated activities will result in the development of trigger values at selected sites – monitoring aquifer performance against these trigger values is part of a strategy developed to improve the management of water resources and GDE health within the SWGA.
- The ASS investigation program will assist decisions regarding short and long term groundwater abstraction/surface diversion. By coupling the ASS information with water-level data, land-use activities can be assessed in the context of risk of oxidising potential acid sulphate soils.
- The Form L project will provide a GIS tool which will improve services to the wider community and facilitate licensing decisions. Because this data is now also available it can be used in the modelling of groundwater resources of the SWGA.

Milestone 1 products

Milestone number	Milestone detail	Product status	Products
1	1.1 – Completion of Stage 1 - investigation and installation of monitoring for SGS	Completed	• Installation of monitoring system
	1.2 – Completion of access permissions, drilling, testing and monitoring network installation	Completed	• Completion of test drilling, sampling and monitoring network installation
	1.3 – Completion of groundwater and sediment sampling and analyses (Phase 1)	Completed	Provided with Nov09 progress report: • 1.2 & 1.3 Bore completion report – HR287 • 1.2 & 1.3 SGS Drilling Activity Report • 1.3 Bore Completion Report – HR289 Note that work was complete by May 09, but BCR takes 6-12 months to complete
	1.4 – Completion of groundwater and sediment sampling and analyses (Phase 2)	Completed	• Bore Completion Report for final phase of drilling HR296

Milestone 2 – Shallow groundwater systems (SGS) – groundwater interaction (hydrology)

The Blackwood River cuts through one of the few small areas in the whole South West where the Yarragadee Formation is exposed at the land surface. The hydrological characteristics of the aquifer means that groundwater abstraction, particularly cumulative effects, from these distant areas has the potential to impact the summer flows in the Blackwood River and some of its tributaries. The Blackwood River and its tributaries contain ecologically and socially important groundwater dependent ecosystems (GDE). To manage groundwater resource use and protect these GDEs the department requires a sound understanding of the system dynamics to develop management tools. This project satisfies both of these management desires.

The lower Blackwood River discharges flows from the extensive Yarragadee groundwater system. To support its resource planning, the Department of Water has been monitoring flow dynamics in the Blackwood River with the aim of identifying the extent of the Yarragadee discharge zone (YDZ) and to quantify groundwater contributions to river flow, especially during the low flow period between December and May. This work included flow gauging, discrete discharge measurements, water quality sampling, and ecological research.

The Blackwood River in the study area includes a number of long, deep pools (4 m deep in places) upstream of well defined rock out crops. These pools are permanent summer habitat for a range of aquatic fauna especially native fish and macro-

invertebrates. The summer permanency is dependent on groundwater discharges from superficial and deeper aquifers.

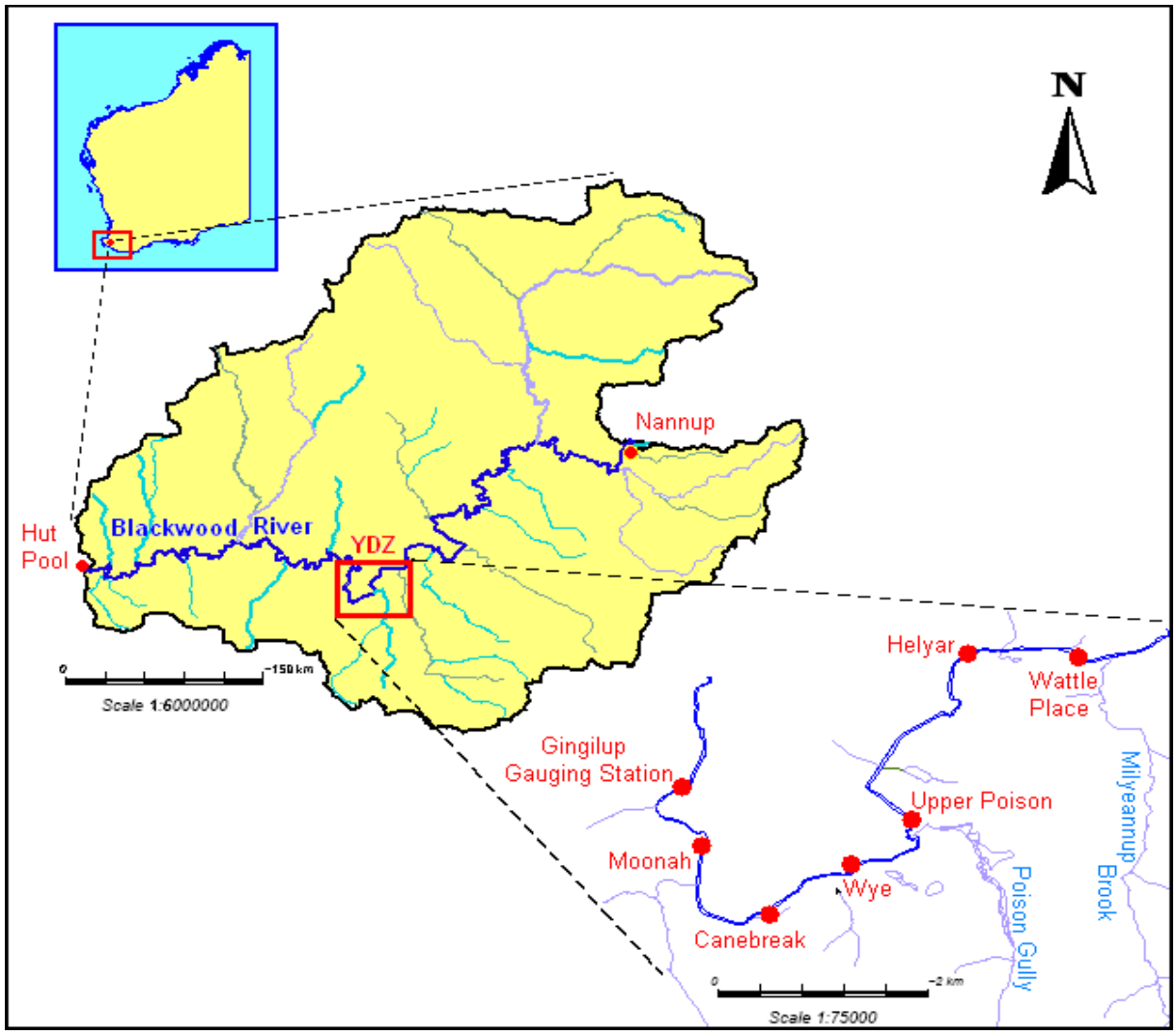

Figure 3 The study area – Yarragadee discharge zone (YDZ) from the confluence of Milyeannup Brook to the Gingilup gauging station on the lower Blackwood River.

This project developed an hydraulic model of the groundwater gaining reach of the Blackwood River. This model will be used to identify flow rates that achieve ecological thresholds for environmental flow studies. This information would then be used in identifying and environmental flow regime and the sustainable yield of the areas surface and groundwater resources.

The department engaged consultants to:

- Develop a conceptual hydrogeological model of the Blackwood system.
- Analyse rainfall-groundwater-surface water relationships.
- Develop management triggers.

Throughout 2007, 2008 and 2009 the department undertook extensive fieldwork on the Blackwood River to collect the data required to develop the hydraulic model.

The hydraulic model was created using the HEC-RAS (Hydrological Engineering Centre, United States Army Corps of Engineers, River Analysis System) modelling package in May 2010, after inputting the 2009-10 low flow data from the Blackwood. The HEC-RAS model was then imported to the river analysis package.

Milestone 2 findings

The hydraulic model is now developed and can be utilised for allocation planning processes. Importantly, the model can be updated and improved as the department collects more data in the study area.

- The hydraulic model was loaded into the river analysis package (RAP) and will be used to identify flow rates that achieve ecological thresholds for environmental flow studies. Milestone 5.2 has a close association with this project as the flow thresholds determined in the aquatic fauna EWR study will be used in this modelling.
- Water level and flow thresholds for social and cultural values can also be determined through this modelling.
- The results of RAP modelling will be used to identify the environmental flow regime and the sustainable yield of the areas surface and groundwater resources.
- The department is currently undertaking a long term investigation of the surface-groundwater interactions on the Blackwood River. Development of these relationships will be utilised in the models created in this project to help set allocation limits for groundwater use.

Milestone 2 products

Milestone number	Milestone detail	Product status	Products
2	2.1 – Completion of Stage 1 of HEC-RAS and RAP Modelling of Blackwood and tributaries	Completed	
	2.2 – Completion of Stage 2 – HEC-RAS and RAP Modelling of Blackwood and tributaries	Completed	• Analysis of Lower Blackwood River Report
	2.3 – Completion of Stage 3 – HEC-RAS and RAP Modelling of Blackwood and tributaries	Completed	• Report on the development of the Black wood River HEC-RAS and river analysis package (RAP)

Milestone 3 – Groundwater assessment

This project allowed for more accurate conceptualisation of the hydrogeological system and investigated the hydrogeology and hydrology to better understand the water resource. Data captured in Milestone 1, 3.1 and 3.2 were used to develop the Swan Coastal Plain sub-regional scale model Milestone 3.3.

Upgrade to the SWAMSv2 model involved the update of the abstraction database, collection of recharge estimation techniques data, collect water quality data, installation of high resolution water level data loggers, and the collection of samples for the Blackwood River surface and groundwater interactions. This data will be used to directly compare with the existing SWAMSv2 parameters and upgrade. Data and model use was aimed at the resource quality characteristics, recharge estimates and the overall water balance.

Milestone 3 has been separated into 7 sub-projects that aim to deliver outcomes for the following project activities under Groundwater Assessment and Modelling.

1. Identification of the thickness, lateral extent, and vertical and horizontal aquifer properties of the Swan Coastal Plain stratigraphy through core drilling from Milestone 1. This has been incorporated into the Swan Coastal Plain local scale model. The data collected included both the Superficial and the top of the Leederville aquifers (Milestone 3.3).
2. Drilling, coring and construction of monitoring bores of the confined aquifers on the Swan Coastal Plain to add stratigraphic and piezometric water level data for ongoing water resource management (Milestone 3.1).
3. Development of the Swan Coastal Plain local scale model. This model provides more accurate predictions of water levels than SWAMS therefore enabling its use as an environmental trigger (Milestone 3.3).
4. Environmental Tracers sampling and analysis of the recharge zones of the Yarragadee and Leederville aquifer to upgrade the estimates in the SWAMS model. This provided insight into the vertical movement of water between aquifers. Data collected used as a groundwater signature correlated to the Blackwood River discharge although sampling of the Blackwood River posed problems with the selected isotopes (Milestone 3.4 a and 3.4b).
5. Water quality analysis of selected bores across the SWAMS model area were made to ensure licence assessment and monitoring is compliant to the licence conditions. Data collected provides an analysis of the changing water environments and adds value to impending environmental condition and management (Milestone 3.4 a and 3.4b).
6. Upgrade of the abstraction database to reflect the current abstraction data and upgrade this into the SWAMS model (Milestone 3.4 a and 3.4b).
7. Develop a 3-D geological model of the SWAMS model area. This has enabled a stratigraphic horizon upgrade of the SWAMS model and a visualisation product that can be used in water allocation and licensing assessments (Milestone 3.2).

Milestone 3 findings

- Construction of the two Yarragadee monitoring bores will provide long term aquifer response to cumulative abstraction. This will give an idea about the impacts of over abstraction versus net recharge volumes. Also they will provide an indication of the hydraulic gradient toward the coast that will be used to predict current and future potential salt water interface intrusion landward.
- The 3-D geological model will provide many benefits to resource management. These are conceptual geology, hydrogeology and facies interpretation that will help licensing officers interpret the hydrogeology of a licence application, develop techniques for assessing the recharge through the Leederville aquifer on the Blackwood Plateau, export surfaces for groundwater flow modelling, continually update the model to reflect new data like seismic, and a visual guide through the conceptual geology.
- The Swan Coastal Plain model will give a more accurate and detailed impression of the water table and the drawdown impacts of regional cumulative abstraction. This will be used in allocation planning particularly the GDE assessments.
- The upgrade of the SWAMs model data collection and analysis will benefit future allocation planning by providing a better understanding of the regional water levels at a high resolution, better estimates of the recharge spatially, an understanding of the Blackwood River and its interaction with groundwater, understanding of the environmental water requirements of the Blackwood River, further understanding of the resource condition temporally, better understanding of the aquifers isotopic signature which will help in identifying aquifer leakage and interaction, indication of evapotranspiration spatially and an understanding of the unsaturated and saturated zones processes that dictate GDE health and net recharge processes.

Milestone 3 products

Milestone number	Milestone detail	Product status	Products
3	3.1 – Completion of petrophysical analysis of geophysical logs and core analysis	Completed	• Bore completion report – HR287
	3.2 – Completion of 3-D geological modelling of the SP Basin	Completed	• Confined aquifers Petrel model
	3.3 – Completion of the Swan Coastal Plain local scale assessment and modelling	Completed	• Swan Coastal Plain local scale assessment report and modelling
	3.4 – SWAMS model upgrade and use		
	3.4a – Completion of Stage 1 - SWAMS upgrade	Completed	• SWAMS model upgrade and use – data collection, methods and analytical results (HR 305) – DRAFT
	3.4b – Completion of Stage 2 - SWAMS upgrade		

Milestone 4 – South West groundwater investigation

The aim of this milestone is to improve understanding of groundwater resources across the SWGA. This involved a reconnaissance investigation program with new monitoring bores installed at five sites.

A groundwater investigation program was developed and implemented to address a number of knowledge gaps related to groundwater resources in the South West. The program was focused at two high priority areas: Bunbury saltwater interface and Busselton - Capel Yarragadee aquifer.

Bunbury saltwater interface monitoring

Groundwater abstraction from the Yarragadee aquifer in the Bunbury Groundwater Area is approximately 6.5 GL/yr and is expected to increase to about 13 GL/yr by 2030. There is evidence of increasing groundwater salinity within the Yarragadee aquifer near the Bunbury coast. In order to provide information to manage the saltwater-freshwater interface, a purpose-built interface monitoring bore in Bunbury was installed.

A 200 m deep, blank (unscreened) bore at the corner of Ocean Drive and Scott Street was constructed solely for monitoring the interface using induction logging. Induction logs provide a continuous measurement of the conductivity of the formation, which can be directly related to the salinity of groundwater. The induction tool measures the conductivity remotely by measuring the induced response to an electromagnetic signal. The logging bore was filled with very fresh water (i.e. rainwater) to minimise the impact of the borehole fluid on the induction logging tool.

The bore was constructed with 63 mm ID FRP bore casing and grouted to seal off any sub-aquifers separated by shale units. This diameter is considered to be smallest that will comfortably allow the logging tool to be run. There was a need to minimise the borehole size because the grout (an insulator) and borehole fluid (fresh water) would attenuate the induction signal.

Gamma and resistivity logs were run after the hole was drilled prior to the installation of the casing. The logs were used to interpret the formations drilled and ensure that the fresh water – saltwater interface was penetrated.

Results from the investigation will provide the Department of Water with valuable information regarding long-term monitoring of the fresh water – saltwater interface near Bunbury and along the state’s coastline.

Busselton-Capel Yarragadee aquifer investigation

The Yarragadee aquifer in the Busselton-Capel area required a more comprehensive monitoring network. This area is extensively used for public water supply and irrigation. There are over 44 GL/yr of licensed allocations, 44 GL/yr of public water supply reserve commitments and 5 GL/yr of pending licence allocations in this area from the Yarragadee aquifer.

Prior to this investigation, there were no purpose-built, Department of Water monitoring bores in the Yarragadee aquifer between the Quindalup and Cowaramup lines (approximately 23 km apart) and between the Quindalup and Boyanup lines (approximately 19 km apart). Consequently, there was a need to develop a more comprehensive monitoring network in the Yarragadee aquifer.

The investigation consisted of the construction of four new Yarragadee bores to the south-east of Busselton. These bores were selected at sites (BN6, BN20, BN32 and BN34) that had existing Leederville bores with long groundwater monitoring records.

The new bores were positioned to intersect a reasonable thickness of the Leederville and Yarragadee Formations (both units 2 and 3). Each monitoring bore was installed including reaming to 175 mm and installing 101 mm ID FRP casing. A full suite of geophysical logs were run after the bore was reamed, including gamma, resistivity, sonic, seismic velocity and caliper. Each bore was screened based on stratigraphic and geophysical log interpretations, and was developed with a water sample collected for water chemistry analysis.

The new data collected will contribute to better understanding of aquifer parameters, which will lead to an improved conceptual model and better calibration of the SWAMS (Southwest Aquifer Modelling System) model. The bores will also provide valuable, long-term monitoring data to assess aquifer performance and sustainability of ongoing groundwater abstraction and resource development.

Milestone 4 findings

- Possible approach for long-term monitoring of the fresh water – seawater interface along the state's coastline.
- Data will support improvements to conceptual model and better calibration of the SWAMS (Southwest Aquifer Modelling System) model.
- The new bores will address a knowledge gap and provide valuable, long-term monitoring data to assess aquifer response and performance.

Milestone 4 products

Milestone number	Milestone detail	Product status	Products
4	4.1 – Completion of site approvals and access	Completed	
	4.2 – Mobilisation and commencement of drilling investigations	Completed	
	4.3 – Completion of drilling investigations	Completed	• HR 287 – SW Reconnaissance Drilling Bore Completion report

Milestone 8 – Licence assessment, monitoring and compliance

The aim of this milestone was to improve our understanding of current use and compliance of water licences in high risk and fully allocated (C4) or close to fully allocated (C3) subareas and to standardise licensing conditions to better manage the resource.

This milestone consisted of two major sub-projects:

1 Developing standard conditions for Scott Coastal Plain groundwater licences.

2 Developing standard licences guidelines for four industries.

These sub-projects have been developed around a high risk groundwater management area on the Scott Coastal Plain and four large industries that have the potential to impact on water quality of surface and groundwater resources: Mining, Dairy, large irrigators and urban development.

Both projects focused on reviewing and amending existing water licences in C3 and C4 subareas with standardised conditions and water monitoring requirements. Standardised groundwater licensing conditions developed through this project will facilitate a better understanding of groundwater chemistry and the impact of licensing in high risk management areas. These projects also incorporated water use surveys and compliance audits of licences being reviewed and will promote recouping of water where appropriate. At least 60 licences were reviewed and amended for this project.

Review of licences and development of standard conditions considering water quality, water use efficiency, and ongoing management will enable better management of the groundwater resources, whist providing licensees and industry with a transparent and consistent approach to water licensing.

Both projects were undertaken in consultation with the local community and relevant industries. The Scott River Water Users Group were consulted throughout the process of developing the water monitoring standards, which has resulted in an increased understanding of managing the resource by licensees in this area. Similarly, the Dairy Industry, through Western Dairy, and a number of large mining companies were involved with developing water monitoring standards for their specific industries.

Milestone 8 findings

- High risk sub areas and land use activities identified.
- Standard minimum water monitoring conditions and guidelines have been developed.
- These conditions will now form the basis of the minimum requirements for all water licence operating strategies identified as ‘High and Moderate risk’ in the SWGA plan area.

- A risk assessment has been developed through this process as a decision support tool to better identify and manage potential risks to high priority assets in the SWGA boundary.
- This risk assessment and associated management requirements will form a component of the assessment of all new licence applications and renewals. Through this process all amended licences and future licences in the SWGA will be linked to a bring-up system in the Water Resource Licensing database to better manage licence conditions.

Milestone 8 products

Milestone number	Milestone detail	Product status	Products
8	8.1 – Completion of Stage 1 - monitoring / management framework systems support and development	Completed	• Scott River licence review report
	8.2 – Completion of Stage 2 - monitoring / management framework systems support and development	Completed	• Scott Coastal Plain recommended Monitoring and Reporting Programs
	8.3 – Completion of Stage 3 - monitoring / management framework systems support and development		

Activity 2: Determination of comprehensive ecological, social and cultural water requirements

Background

Ecological water investigations were carried out to develop a better understating of the water dependencies of critical assets in the region. This was done in areas where understanding of groundwater dependencies is limited under milestone 5 of the deed. Work done and products developed under this milestone is described below.

Work conducted and products developed

Milestone 5 – Environmental water requirements

There are many critical environmental and social assets in the study area. Many are groundwater dependent. The region also includes many waterways that receive baseflow groundwater discharge that could be affected by groundwater allocations.

Ecological Water Requirements (EWR) investigations have developed a more comprehensive understanding of the water dependencies of the critical assets in the region. The EWR work has expanded across the region focusing on areas where our understanding of groundwater dependencies was limited. Work included:

- Finalisation of groundwater dependent ecosystems (GDE) criteria sites on Western Scott Coastal Plain and northern Blackwood Plateau
- Investigations into GDE criteria sites on the Swan Coastal Plain, including determination of the groundwater dependencies of wetland sites and ecosystems of national and international significance
- Selection of reference or control sites that will assist management of environmental water, adaptive management and, in the future, a system of resource sharing
- Establishment of vegetation transects at final criteria sites to gather baseline information on ecological condition and for ongoing biological monitoring purposes
- Establishment of shallow piezometers at criteria sites in order to link information on water regimes to plant health, as an indicator of ecosystem health, and for ongoing monitoring purposes
- Determination of EWR based on a comparison between the plant species water level range at the site and their overall range
- Significant contribution to a database of plant species water level ranges to aid in the determination of EWR
- Incorporation of EWR information into the numerical groundwater models to enable more comprehensive assessment of sustainable yields, ecological risk assessment of future allocation options, and more informed decision making in regard to environmental water provisions (EWP).

Determination of EWR is crucial to understanding sustainable yield of an aquifer and to eventually determining EWP and allocation limits. This information will be incorporated into the regional model to determine where impacts to critical environmental assets may occur and will enable our water resource manages to develop adaptive management and monitoring strategies to maintain these sites.

The social and cultural water requirements (SWR) investigations were undertaken on the Swan Coastal Plain and southern Blackwood Plateau. This included identification of recreation sites of significance, aboriginal heritage sites of significance and areas of intrinsic and educational value. The information will be a factor along with the EWR work to determine EWP. The information will also enable potential impacts to sites of significance to be determined through the regional model and various local area models.

Milestone 5.1 consists of two complementary projects that cover high conservation wetlands across the SWGA.

- Three annually consecutive vegetation assessments across the management area. The vegetation assessments were intimately linked to the EWR framework project also being conducted under milestone 5.1.
- An ecological water requirements framework for groundwater dependent vegetation communities in the South West. The department utilised investigations funded under Milestone 1 to support this project.

Milestone 5.2 consists of two key projects that cover the Yarragadee aquifer discharge zone (and outcrop areas) in the Blackwood River.

- Ecological water requirements and monitoring strategy for aquatic fauna in the Yarragadee discharge zone of the Blackwood River.
- An acid sulphate survey of the Yarragadee outcrop area on the Blackwood Plateau.

Milestone 5 findings

- Ecological water requirements have been established for key GDE sites across the management area. These have been determined using rigorous hydrogeological and plant-water relations investigations.
- The EWRs that have been established are a key input to the GDE risk assessment that will be undertaken to consider various allocation and climate change scenarios.
- Reviewing the current allocation limits is a key component of the development of the new statutory allocation plan.
- Ecological water requirements determined in this study are also a key input to the department's adaptive management regime. Adaptive management is extremely important in the South West as the high level of groundwater use means that many sub-areas have reached or are close to their allocation limits. Adaptive management (based on well founded management triggers) is the critical management process in this situation and can now be undertaken with confidence because of the knowledge gained from Water For The Future projects.

Milestone 5 products

Milestone number	Milestone detail	Product status	Products
5	5.1 – Vegetation assessment	Completed	• Completed stage 1 Vegetation assessment Blackwood, Plateau and Scott Coastal Plain

Milestone number	Milestone detail	Product status	Products
	5.1a – Completion of Stage 1	Completed	• 2007, Monitoring of groundwater dependant vegetation – Southern blackwood plateau and eastern scott coastal plain, May 2008 • Completed groundwater level trends analysis • 2007, Vegetation monitoring – Swan Coastal plain (Bunbury, Busselton-Capel groundwater areas)
	5.1b – Completion of Stage 2	Completed	• 2008, Vegetation assessment Blackwood, Plateau and Scott Coastal Plain • 2008 Vegetation assessment Swan Coastal Plain
	5.1c – Completion of Stage 3	Completed	• Ecohydrological status and vulnerability of GDE in the southwest • 2009, Monitoring of groundwater dependent vegetation souther Blackwood plateau and Scott coastal plain • vegetation monitoring Swan coastal plain (Bunbury – Busselton –capel groundwater areas)
	5.2 – Other ecological investigation		
	5.2a – Completion of Stage 1	Completed	• Migration pattern of fishes of the Blacwood river and relationships to groundwater intrusion • Completed ASS survey report
	5.2b – Completion of Stage 2	Completed	
	5.2c – Completion of Stage 3	Completed	

Activity 3: Development of decision support tools and management system

Background

This project activity intended to develop and formalise planning tools that provide a formal method for three particular aspects of water allocation planning:

- Methodology for quantitative determination of social water requirements;
- Methodology for economic evaluation of allocation options; and
- Methodology for obtaining community preferences on allocation options through a multi-objective planning process.

The project activity was completed under milestone 6 of the agreed deed. The work conducted and products delivered are described below.

Work conducted and products developed

Milestone 6 – Social and cultural water requirements

This project focused on the social and cultural values related to water and the water requirements to support these values. Social values of interest are 'in-situ' values or the 'non-consumptive' values of groundwater and surface water resources. Information is needed to support the on-going management of water resources through allocation planning.

This project collated existing information on water-dependent social values and water-dependency and conducted research to identify sites and attributes not previously captured.

The department consultants to undertake this project used the information to develop a GIS based management tool that can be used for licensing and allocation planning.

Milestone 6 findings

- The study has identified areas of social and cultural interest that will be followed up with stakeholder consultation in the next round of planning activities.
- The GIS based product is an important tool for licensing officers to identify water dependent social and cultural value sites that may be impacted by groundwater and surface water use.
- Following select stakeholder consultation social and cultural sites will be given social water requirements criterion. These criterion will be used in the next stage of allocation scenario testing using the SWAMS groundwater model.
- The risk assessment undertaken using SWAMS will be a key input to the decision making process to update allocation limits in the South West groundwater areas.
- It is evident from this study that some of the high value social and cultural sites identified in the study coincide with high conservation status GDEs. These sites have the added benefit of being supported by detailed investigations and monitoring, and the department's GDE trigger and response framework.

Milestone 6 products

Milestone number	Milestone detail	Product status	Products
6	6.1 – Completion of social water requirements	Completed	• The social values of the Southwest water resources
	6.2 – Completion of cultural water requirements	Completed	

Activity 4: Significance of interceptors (plantation water use)

The aim of this project activity was to determine the significance of groundwater and surface water interception by plantations to better understand the impact of the rapid development of the tree plantation industry on catchment water balance components such as recharge.

The project activity was completed under milestone 7 of the agreed deed. The work conducted and products delivered are described below.

Work conducted and products developed

Milestone 7 – Economics and demand

The objective of this milestone was to develop departmental policies on accounting for plantations in allocation planning and future licensing . This milestone also aimed at developing a policy on the process for 'self-management' of groundwater resources.

Milestone 7.1

Rapid development of the non-irrigated tree plantation industry in the South West of Western Australia has broad scale implications for catchment water balance, groundwater recharge and groundwater resources. Currently under the *Rights in Water and irrigation Act 1914*, non-irrigated plantations cannot be licensed. This has implications for both the department as the water resource manager and industry where a water licence is deemed to have an economic benefit. A greater understanding of the impacts of significant interceptors on groundwater and development of departmental policy was identified as important for future management in the SWGA.

The project aimed to research the significance of groundwater and surface water interception by plantations through:

- literature review of water use/ evapotranspiration data for plantations
- liaison with other jurisdictions, particularly South Australia, in the management of plantations
- attendance at national workshops on water interception by plantations
- input into CSIRO documents on plantations and their relevance to water allocation
- engagement with the plantation industry and industry consultants, here and in other states, on plantation issues
- Identification of other state and national frameworks, initiatives, legislation and policies relevant to water interception by plantations

- research to quantify water use in important water resource management areas, where existing data is unavailable
- spatial mapping of the current extent of established plantations and development of a database to record and monitor future expansion and removal of plantations
- input of newly acquired data into existing groundwater flow models to provide better prediction of impacts to key environmental assets, especially groundwater and surface water dependent ecosystems and in situ social water values.

The project delivered the 'Strategic Policy: Managing water interception by plantation forestry in Western Australia'.

Milestone 7.2

In 2006 during the consultation process that led to the release of '*A blueprint for water reform in Western Australia'* the concept of increasing the use of cooperative management by self-supply irrigators, to improve water management at the local level was raised. This concept became known as 'self management groups' for self-supply irrigators.

Community interest in self management, particularly among interested self-supply irrigators in the South West region, was strong during this process and the *Government Response to the Blueprint* supported further investigation into the concept. This project undertook a comprehensive review of self management by self-supply irrigators across Australia and overseas in conjunction with community consultation to develop a departmental discussion paper on self management.

A 'self management group' refers to any group of individuals who come together in pursuit of shared aims and objectives. In the context of water resource management it refers to a group of individuals forming an independent entity (e.g. an irrigation service provider) to specifically manage a defined water resource.

The Department of Water investigated the potential for self management by self-supply irrigators and found that currently there was no precedent throughout Australia for self management by self-supply irrigators. A critical limiting factor for self-supply irrigators in forming a self management group is a practical mechanism that will deliver and control water allocations to its members while replacing the need for individual licensing by the department. However, where this barrier can be overcome mutually beneficial outcomes for both self-supply irrigators and the Department are achievable.

'Self managed' irrigation cooperatives, (i.e. irrigation service providers), are centred on either a shared common distribution system or a common discreet/identifiable resource. Such a shared system allows for members to be allocated a share of a bulk licence that can be controlled by the cooperative entity. To date there are no examples of such a structure for self-supply irrigators that could provide the basis for bulk licensing. Without such a 'bulk licence' opportunity there is little incentive for the department to support the formation of an independent group.

However, the department has developed a position statement which could provide guidance to self-supply irrigators who wish to form as an irrigation service provider (ISP). It outlines the prerequisites that need to be met prior to an ISP being proposed and the steps involved to formally establish it.

Further outcomes of the consultation phase has been the development of water user group guidelines to assist groups of commercial water licence holders to form their own independent groups focused on local water resource operational issues within a defined water resource. The formation of such groups will facilitate a more structured approach to engagement between water users and the department. Consultation also highlighted the need to continue the dialogue with water users in developing innovative collaborative partnerships where emerging water resource issues can be addressed in a positive and practical manner.

Milestone 7 findings

- Development of a strategic policy on plantations under the RIWI Act sets the basis for a good policy on plantation water use.
- The strategic policy on plantations will be translated to an operational policy when the new water resource management legislation is in place.
- The current principles and general thrust of the proposed management of plantations is acceptable to the plantation industry.
- The development of the operational policy will require engagement with the plantation industry to ensure the policy is robust, acceptable and in line with legislation.
- Fieldwork will be required in priority areas to determine plantation water use in the region. This will set the basis for regulation and determination of 'significant impact'.
- The position statement on self-supply irrigation will provide guidance to self-supply irrigators who wish to form as an irrigation service provider (ISP).
- The formation of water user groups will facilitate a more structured approach to engagement between water users and the department.
- Need to continue the dialogue with water users in developing innovative collaborative partnerships where emerging water resource issues can be addressed jointly in a positive and practical manner.

Milestone 7 products

Milestone number	Milestone detail	Product status	Products
7	7.1 – Completion of interception and accounting policy (plantations)	Completed	• Map Plantations, • Strategic Policy – managing water interception by plantation forestry in Western Australia, Dec 2009

Milestone number	Milestone detail	Product status	Products
	7.2 – Completion of self management process	Completed	• Interjurisdictional analysis of community based governance arrragements for water resource management in Western Australia, Oct 2008 • Position statement – Self supply irrigators forming as an irrigation service provider • Model for community self management • Water user group guidelines

4 Statement against project objectives (Schedule A7)

OBJECTIVE A

To improve monitoring, reporting and accounting of water use through expansion of monitoring networks, accounting of water allocated to the environment and expansion of metering of groundwater users

(See Milestone 1 & 8)

This objective has been achieved in a number ways.

Monitoring bores have been installed throughout the South West groundwater areas into both deep and shallow aquifers. In some shallow bores water level loggers have been installed to record high-resolution time series data, which will be used to calibrate local-scale models. Deep monitoring bores have been drilled into the Yarragadee aquifer in the Bunbury groundwater area to monitor the saltwater–freshwater interface and the Busselton–Capel area to provide a more comprehensive monitoring network. Knowledge of the aquifers attained through this process will allow improved conceptual modelling and better calibration of the SWAMS model. The bores will also provide valuable, long-term monitoring data for assessing aquifer performance and sustainability in response to future abstraction and climate changes.

We have improved accounting of environmental water by:

- hydrogeological analysis that has accurately defined the boundaries of aquifers supporting groundwater-dependent ecosystems and that has defined the partitioning of the saturated and unsaturated zone water
- eco-hydrogeological and ecophysiological analysis that has enabled a more accurate estimate of evapotranspiration to be made, which improves water balance calculations.

These investigations allow a greatly improved groundwater model to be developed, particularly in computing recharge and representing shallow aquifers. The model is the main water balance ‘calculator’ used to determine and account for environmental water.

A major review and amendment of high risk licences undertaken as part of this project has resulted in an increase in the number of licences over 50 000 kL requiring a meter. This will enable a more accurate determination of the actual volumes of water used in fully allocated or near fully allocated aquifers in the future.

Monitoring undertaken as part of meeting this project objective, and ongoing monitoring, will be reported in the annual *South West groundwater plan evaluation statement.*

OBJECTIVE B

To improve public access to information with the establishment of a community monitoring review group and the development of an internet based user system

(See Milestone 1)

The Whicher Water Resource Management Committee has assisted the department in the development of the *South West groundwater plan*. The community has formed three water user groups to work with the department to look at operational issues including the state of local water resources. These groups are:

- Capel water user group
- Scott coastal plain water user group
- Capes water user group.

The department has also formed a broader communication and involvement framework for stakeholders in the region.

Monitoring data and the current status of work in the South West groundwater areas will be in the annual evaluation statement that will be available to the community on the department website.

The gathering, data cleansing and data processing from all the projects is now available through the department's databases upon request. Broader access to this information will be possible as the department continues its information architecture project.

The State Reference Network – WIN data cleansing sub-project has provided the basis for ongoing digital documentation for changes regarding the maintenance and groundwater data collection for each bore. This information is then readily available for updating the Bureau of Meteorology database and consequently will be available to the public.

OBJECTIVE C

To improve specification of environmental outcomes and provision of water to meet these outcomes, by the development of tools to help standardise quantitative determination of water requirements, economic evaluation of water allocation options, and multi-criteria analysis of stakeholder/community preferences regarding water allocation options

(See Milestones 5 and 7)

The specification of environmental outcomes is an implicit objective of Milestone 5. Tools, and importantly methodologies, to standardise the determination of ecological water requirements have been and are being developed. We are already applying the techniques and processes developed in the Water for the Future South West groundwater areas project. These have greatly assisted the progress of the National Water Commission funded 'GDE vulnerability in the Midwest' project.

As a result of this project, water users in the South West groundwater areas and representatives from the department were able to discuss mechanisms for water allocation and management options. A discussion paper and process was developed for self management for self-supply irrigators. Given the complexity of this issue, an alternative mechanism for community involvement in allocation options was developed through the formalisation of water user groups.

OBJECTIVE D

To develop local area hydrogeological models to refine, and increase certainty in, the regional groundwater model. This will help to define the risk and impacts to environmental assets

(See Milestones 2, 3 & 4)

Local area hydrogeological models were developed and improved through this project to provide more accurate prediction of water levels in the South West groundwater areas. Information was obtained by core drilling for stratigraphy, installing monitoring bores, logging of water levels, environmental tracer sampling, analysis of recharge zones of the Yarragadee and Leederville aquifers, and water quality analysis. This was used to develop a hydrogeological model, which will significantly improve the department's ability to allocate and manage groundwater in the South West groundwater areas.

OBJECTIVE E

To develop a comprehensive assessment of ecological water requirements for critical environmental assets

(See Milestone 5)

Progress towards this objective has been very good, as shown by:

- the shallow groundwater systems investigations on the Swan Coastal Plain being completed and the Scott Coastal Plain
- ecohydrogeological investigations at high conservation value groundwater-dependent ecosystems.
- the development of an ecological water requirement framework for groundwater-dependent ecosystems
- the extension of technical knowledge into climate sensitive management triggers.

OBJECTIVE F

To develop water management plan for the groundwater resources of the SWGAs. This includes development of a comprehensive hydrogeological and environmental monitoring program, adaptive management and reporting/accounting frameworks for monitoring and allocation of water. These programs and frameworks will be used to inform the development of the statutory management plans for completion in 2010

(See Milestone 5)

The *South West groundwater areas allocation plan* was finalised in May 2009 and controls individual licences (entitlements) issued under the *Rights in Water and Irrigation Act 1914*. The allocation plan is supported by:

- a dedicated monitoring network and monitoring for environmental water and resource condition assessment
- a dedicated monitoring program for measuring progress towards the allocation plan's objectives.

Water For The Future funded investigations are enabling us to set more informed environmental management triggers (critical in the South West groundwater areas where allocation limits have been reached or are close to being reached). The quality of these triggers, which are being developed in Milestone 5, will be an essential part of our adaptive management framework.

A web based 'management triggers and responses' framework has been developed for the 2009 allocation plan, which will be vastly improved by having the refined management triggers for the 2010 version.

The first web based annual evaluation statement of the performance of management against the plan's objectives will be completed in mid 2010.

5 Findings and management implications

The Water for the Future South West Groundwater Areas management plan project has significantly improved the quality of information that will underpin the next water allocation plan. The detailed investigation and assessment of the South West groundwater areas has led to a higher level of understanding of how the total system works and how it responds to abstraction and stresses.

When the project began there were significant gaps in our knowledge and understanding of how the groundwater system functioned, how it responded to abstraction and recharge and how ground and surface water systems interacted. This had led both the community and the state's peak environmental protection agency to raise questions about how the South West groundwater areas were being managed.

Specifically, the Environmental Protection Authority had expressed concerns about the amount of water that could be safely abstracted from the Yarragadee aquifer, particularly in relation to climate change. The community was concerned that the department had set its allocation limits using information collected by the Water Corporation in support of its proposal 45 GL abstraction proposal. Fundamentally the community questioned the independence of the information and its accuracy.

Through this project and matching departmental funds we have drilled a total of 152 bore holes and installed 168 data loggers. These were distributed as shown below:

- 61 bores in the Superficial aquifer, with 59 of these funded through Water for the Future
- 72 bores in the Leederville aquifer, with 52 of these funded through Water for the Future
- 19 bores in the Yarragadee aquifer, with 14 of these funded through Water for the Future
- 2 bores in the Lesueur aquifer, with both these funded through Water for the Future
- 168 data loggers, with 141 of these funded through Water for the Future.

The three most significant findings and management implications from this project are:

- that better data and use of data has led to:
  - an increased robustness in both our regional and local models
  - an increase in our understanding of ground and surface water interactions
  - the ability to set future allocation limits (or consumptive pools) with greater precision
- an increased understanding of recharge of the system, which is indicating that there is more recharge to the system than our previous work had indicated

- we have provided the community and decision making agencies with confidence in the independence of our data and the validity of our allocation planning decisions

The results of the Water for the Future project will ultimately lead, through the allocation planning process, to more sustainable water use and improved environmental outcomes.

Refer to Section 2 above for Figure 2 showing how Water for The future project activities relate to the Department of Water allocation process for the delivery of the next South West allocation plan.

Appendices

Appendix A – List of products completed through the project

Milestone No.	Milestones details	Products
1	SGS Investigation assessment	1 Swan Coast plain, statigraphic drilling program between Bunbury and Dunsborough – HR 289, Nov 2009–SGS Drilling Activity 2 Southwest groundwater areas, Shallow groundwater systems drilling activity, HR 293, Nov 2009 3 Bore completion report – Scott coastal plain, HR 296, Nov 2009
2	SGS Groundwater interaction (hydrology)	1 Analysis of Lower Blackwood River and tributaries flow, Groundwater and climate relationships and recommendation for management triggers, Sept 2008 2 HECRAS and river analysis package, May 2010
3	Groundwater Assessment	1 Bore completion report for southwest regional reconnaissance investigation– HR 287, Oct 2009 2 Development of a conceptual model for the Confined Aquifer, using PETREL, Nov 2009Petrel model 3 Swan Coastal plain groundwater modelling, June 2010 4 SWAMS model upgrade and use – data collection, methods and analytical results (HR 305), May 2010
4	SW Groundwater	1 Bore Completion report for the south west groundwater areas– HR287, Oct 2009 (part of)
5	Environmental water requirements	1 2007 Monitoring of groundwater dependenat vegetation – Southern blackwood plateau and eastern Scott coastal plain, May 2008 2 2007, Vegetation monitoring – Swan coastal plain(Bunbury, Busselton – Capel Groundwater areas) 3 Groundwater level trend analysis for the Southwest groundwater areas, Aug 2008 4 2008, Monitoring of groundwater dependent vegetation Southern Blackwood plateau & Scott coastal plain, Dec 2008 5 Ecohydrological status and vulnerability of GDE in the southwest , May 2010 6 2009, monitoring of groundwater dependent vegetation –southern Blackwood plateau and Scott coastal plain, May 2010 7 Vegetation monitoring Swan coatal plain (Bunbury – Busselton-Capel groundwater areas) 8 Acid sulphate soils survey od selected wetlands on the Blackwood plateau and Soctt

		coastal plain, Nov 2009 9 Migration pattern of fishes of the blackwood river and relationships to groundwater, nov 2009 intrusion, Nov 2009
6	Social/Cultural Water requirements	1 The social values of Southwest water resources
7	Economics and Demand	1 Map – Location of Plantations 2 Strategic policy – Managing water interception by plantation forestry in western Australia, Dec 2009 3 Interjurisdictional analysis of community based governance arrangements for water resource management in Western Australia, Oct 2008 4 Position statement – Self supply irrigators forming as an irrigation service provider, April 2010 5 Model of community self management of water options development revision one, Feb 2009 6 Guidelines for water user groups, Sept 2009
8	Licence assessment – Monitoring and compliance	1 Scott River Licence review, Nov 2009 2 Scott Coastal Plain – recommended Monitoring and Reporting programs, May 2010

Appendix B — List of products submitted as evidence for completion of May10 milestones

Milestones No.	Milestones details	Product delivered
1.4	Completion of groundwater and sediment sampling and analyses (Phase 2)	1 Bore completion report – Scott coastal plain, HR 296, Nov 2009
2.3	Completion of stage 3 – HECRAS and RAP Modelling of Blackwood and tributaries	1 HECRAS and river analysis package, May 2010
3.3	Completion of the Swan Coastal Plain local Scale assessment and modelling	1 Swan Coastal plain groundwater modelling, June 2010
3.4 a **3.4 b**	Completion of Stage 1 – SWAMS model Completion of Stage 2 – SWAMS Model	1 SWAMS model upgrade and use – data collection, methods and analytical results (HR 305), May 2010
5.1c	Environmental water requirements – completion of Stage 3	1 Ecohydrological status and vulnerability of GDE in the southwest, May 2010 2 , 2009, monitoring of groundwater dependent vegetation –southern Blackwood plateau and Scott coastal plain, May 2010 3 Vegetation assessment Swan Coastal Plain,(Bunbury, Busselton-capel groundwater areas), May 2010
7.2*	Economics and Demand – Completion of self management process	1 Position statement – Self supply irrigators forming as an irrigation service provider, April 2010
8.2* **8.3***	Monitoring/ management framework systems support and development: • Completion of Stage 2 • Completion of Stage 3	1 Scott Coastal Plain – recommended Monitoring and Reporting programs, May 2010

* These milestones have been delayed from November 2009.