Resource Management Technical Report

A REVIEW OF LAND SALINITY TARGETS FOR THE NORTHERN AGRICULTURAL REGION

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nacc managing natural resources in WA's Mid West
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Common Acronyms used in this report

AOCLP	Areas of consistently Low productivity
AHAVF	Average height above valley floor
DAFWA	Department of Agriculture and Food, WA
DoE	Department of Environment
EC	Electrical Conductivity
MA	Management Actions
MATs	Management Action Targets
M&E	Monitoring and Evaluation
NACC	Northern Agricultural Catchments Council
NAP	National Action Plan
NHT	Natural Heritage Trust
NRM	Natural Resource Management
NRMOs	Natural Resource Management Officers
PLM	Program Logic Model
R&D	Research and Development
RCTs	Resource Condition Targets
SIF	Salinity Investment Framework
TIP	NACC's Target Investment Program
WT	Watertables
WA	Western Australia

1. Introduction

This report describes the objectives and process for the review of land salinity targets in the Northern Agricultural Region (NAR). This is the first stage of the review and focuses on targets for land salinity. It will provide a guide for the Technical Advisory Group (TAG) for land comprising representatives from the Department of Agriculture and Food WA (DAFWA) and Northern Agricultural Catchments Council (NACC) for setting other land related targets.

1.1 Background for setting the NAR Targets

The underlying rationale of NHT/ NAP is that resource condition is changed by management actions which are achieved by outputs that require investment. The investments are described through the regional strategy and the investment plan. The effectiveness of the investment can be assessed through monitoring, evaluation and reporting to demonstrate that investment contributes to meeting Resource Condition Targets (RCTs). Regional target setting and accreditation for Natural Resource Management (NRM) are a requirement for the Australian and WA governments to address NRM in a strategic way. The *National Framework for NRM standards and targets* has set down guidelines for NRM bodies to follow when developing their regional NRM plans (NRM Ministerial Council 2002). This Framework also specifies a set of matters for targets (derived from a set of agreed National outcomes) and the process should entail evaluation and review of these targets (see Appendix 2). Where these targets cannot be set, a commitment is required to establish monitoring systems that enable the collation of essential data for setting targets.

In response to these requirements, the Northern Agricultural Regional NRM Strategy (2005) has set out provisional RCTs for the region in relation to a number of natural assets including land, biodiversity, water, coastal and marine management, atmosphere and community. These RCTs are the long-term goals that could be achieved within 10-20 years. In the land section, there are six sub-assets including land salinity. For each RCT a number of Management Action Targets (MATs) have been set to identify medium terms goals. To achieve changes in the resource condition, management actions were also identified. The aim of which is to improve natural resource management in the region, and to ensure that the majority of these actions deliver changes that are clearly observable on-the-ground (NACC, 2005).

1.2 Purpose of Land Salinity Targets Review

In the Northern Agriculture Regional Strategy for NRM, targets explain what we are trying to achieve, guide management action and provide the milestones for assessing progress towards a level at which our assets sustainability is likely to be assured (NACC 2005). To remain robust and clear at guiding this process, the targets need to be reviewed periodically to take into account the latest knowledge about status and trends of our resource condition and to reflect changes in threats, pressures and opportunities for improvement. The review will also allow us to refine our predictions and reassess the effectiveness of actions to address salinity threats. There are several reasons underpinning this review, including:

- Many existing targets were not strategically pitched at the right level (e.g. some of the RCTs were better placed as either aspirational goals or as MATs).
- Many existing targets were set without sufficient knowledge of the existing resource. Largely because of this problem, few of them are quantifiable. Much new knowledge has been gained during the last three years of NACC program delivery which can be reflected in the development of improved targets.
- Many existing targets were time-limited, some have been achieved and some have already expired, and for some plans all targets will expire by June 2008.
- Some targets are no longer relevant in the light of greater knowledge and understanding.
- Climate change is now recognized as a significant factor in our region that was not seriously taken into account when the original land targets were set. This review is perceived as an opportunity to help meet this need, by considering innovative targets that take into account the ecosystem approach and respond to climate change threats.

2. Scope of the Land Salinity Targets Review

Land salinity targets should be used for reporting: This review addresses land salinity RCTs and associated MATs that were set out in the Northern Agricultural Regional Strategy for NRM. By June 2008 NACC will be asked by the Australian and State governments to report on progress made on the sustainable land program. This report will be based on the current targets, and the new targets (i.e. the reviewed ones) will come into effect after June 2008. There will be a final opportunity to refine them after June 2008 so that the latest information can be taken into account.

Land salinity targets should be SMARTer: The current land salinity targets vary substantially in the amount of information they convey. Many are not quantifiable and do not contain end dates, making reporting progress a subjective process. The current land salinity targets also use a range of terms that mean different things in different contexts. As a result, it is difficult to integrate the regional land salinity targets in a meaningful or quantifiable way. These targets therefore were in need of revision to be SMART (Specific, Measurable, Achievable, Relevant and Time-bound). Since, we have improved baseline data, a clearer understanding of regional natural, economic and social systems, and access to local knowledge and experience (e.g. from monitoring effectiveness of actions), land salinity targets therefore warrant a review.

S – Specific	Land salinity targets should represent quantitative milestones toward a point at which land is likely to be viable in the long run.
M – Measurable	We must be able to monitor and report progress toward targets

A – Achievable	NACC are charged with responsibility to ensure that targets are achievable both biologically and pragmatically, making reasonable assumptions about the availability of space, resources and other factors such as climate change.
R – Relevant	The targets should represent progress towards achieving long term viability
T – Time-bound	The targets will incorporate a series of time-bound milestones

Land salinity targets should fit in the Program Logic Framework: Regional NRM groups such as NACC are being challenged to demonstrate the effectiveness and efficiency of their programs, and to be accountable to Australian and State governments (funding bodies) and the taxpayers. One tool that will help us achieve these tasks is to use a program logic model which is an important tool in building our investment strategies, plans and programs.

3. The NAR Regional Assets and Salinity Targets

The Salinity Investment Framework (SIF) was developed by the State Government to guide public investment in salinity management initiatives at State, regional and catchment levels. It identified land, water, biodiversity, infrastructure and social assets at a State level considering their value and threat (DoE 2003; Hu 2006). Geographic priority areas for investment in salinity and water quality have been identified in the NAR using the SIF principles, including value, threat and capacity to make a difference. The identification of the priority areas were based on the SIF report, and additional information from soil-landscape zones defined by the Natural Resource Assessment Group of the DAFWA, Land Monitor Mapping, bore data and reports on biological significance of the Region

Priority area (assets zone) existing salinity.

The soil-landscape zones with highest priority for investment based on managing existing salinity extent and corresponding high proportion of properties affected by salinity are those that occur on the valley floors of the Yilgarn Craton including: Eastern Darling Range Zone (253), Northern Zone of Rejuvenate Drainage (256), Northern Zone of Ancient Drainage (258), Karara Zone (270) and Irwin River Zone (271) (see Figure 1 and 2). These areas are more accurately seen by using the Land Monitor product of Area of Consistently Low Productivity (AOCLP) and correspond with the Yarra Yarra and Eastern Moore and Irwin River Catchments (Bairstow *et al* 2006).

Currently, the amount of land affected by salinity in is about 10% (Alderman and Clarke 2003, Clarke 2001, Bairstow *et al* 2006). While watertables did rise during the 1990's, recent studies (R. Speed pers. com) show falling groundwater levels in monitoring bores in several areas since 2000, linked to drier seasons. This is a reverse of trends noted from 1995 to 1999. Some of the bores around the Yilgarn Craton show that the water table levels have declined to the point that salinity is no longer a short-term risk (Speed pers. com.) The area does, however, have the largest extent of *existing* saline land within the region and the state (Bairstow *et al* 2006). Table 1 below shows the estimate of current salinity and valley hazard for soil-landscape zones on the Yilgarn Craton.

Table 2. Estimate of current salinity and valley hazard for soil-landscape zones in the Yilgarn Craton areas (Land Monitor 2002)

Zone	Code	Area of agricultural land (ha)	Current salinity (ha)	%	Average height above valley floor (ha)	%
Eastern Darling Range Zone	253	77,569	1,692	2.2	13,585	17.5
Northern Zone of Rejuvenate Drainage	256	370,114	55,559	15.0	106,301	28.7
Northern Zone of Ancient Drainage	258	968,335	242,037	25.0	310,978	32.1
Karara Zone	270	80,967	25,253	31.2	39,438	48.7
Irwin River Zone	271	771,646	138,684	18.0	264,423	34.3
Total		**2,268,631**	**463,225**	**20.4**	**734,725**	**32.4**

Priority areas (assets zone) with future salinity risk

As described in Bairstow *et al* (2006) report, there are 31 soil-landscape zones in the south-west region of Western Australia, 19 of which are identified in the Northern Agricultural Region. A number of these zones in the NAR have high to moderate asset value. Five of these zones were identified as the highest priority zone based on *future salinity risk*. These include the Dandaragan Plateau Zone (222) (Figure 1 and 2).Northern Victoria Sandplain Zone (223), Perth Coastal Zone (211), Bassendean Zone (212), and the Pinjarra Zone (213).

The Dandaragan Plateau Zone is an area that has been well researched compared to the rest of the zones and has been considered for the future salinity risk investment plan. Moreover, in the Dandaragan Plateau Zone there are a number of options to manage the salinity threats in the area (Yokwe 2007). The Dandaragan Plateau zone has both shallow and deep ground water systems and the bores in both systems are, on average, rising (R Speed pers. com, A Kern pers. com.) with variable quality Bairstow *et al* (2006). As a result the area is at greatest risk from dryland salinity. Table 2 shows the estimated area of current salinity hazard in the Dandaragan Plateau zone, including remnant vegetation.

Table 1. Estimate of current salinity and valley hazard for soil-landscape zones in the TIP area (Land Monitor 2002)

Zone	Code	Area of agricultural land (ha)	Current salinity (ha)	%	Average height above valley floor (ha)	%
Dandaragan Plateau Zone	222	558,117	11,656	2.1	202,900	36

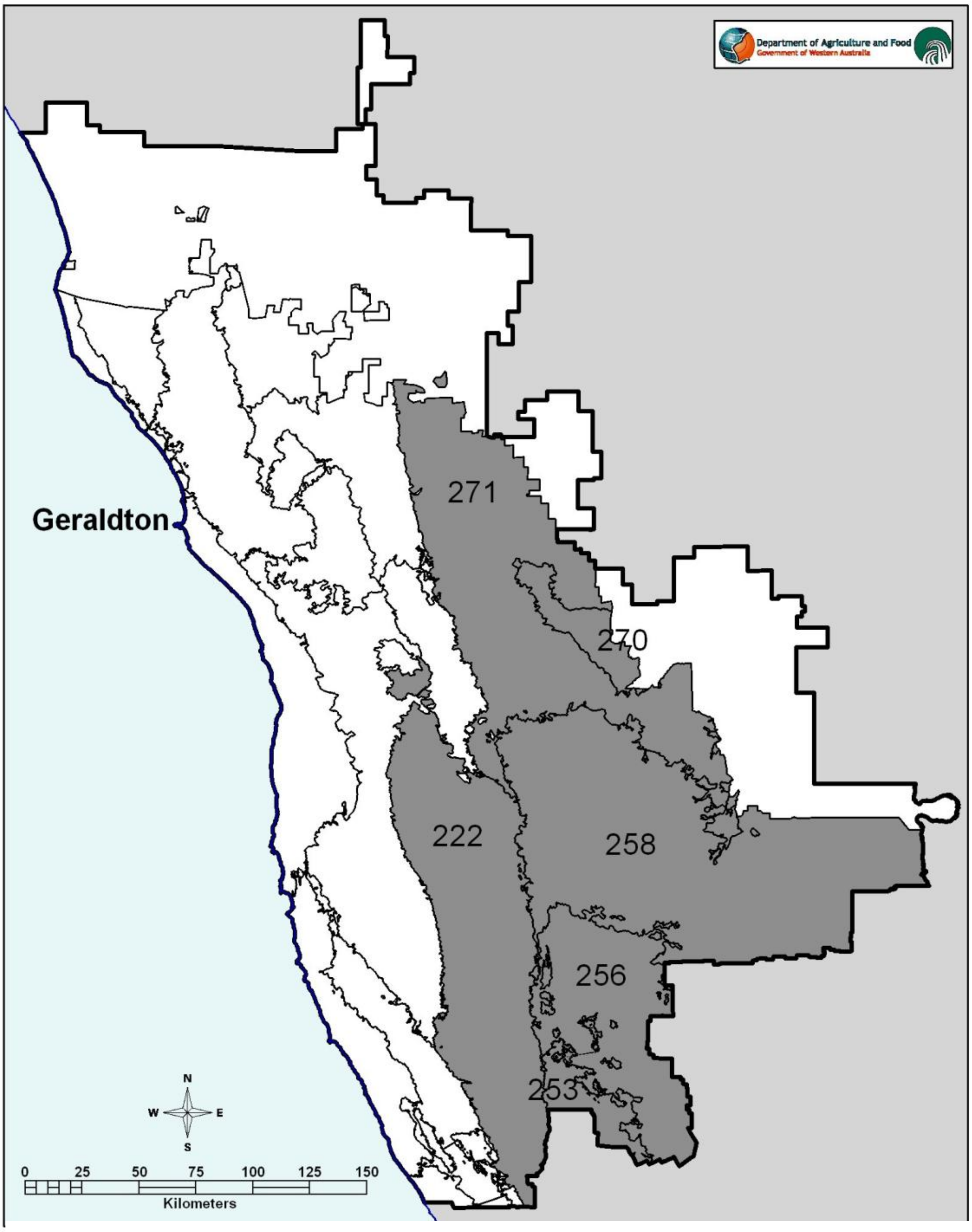


Figure 1: Priority soil-landscape zones for the reviewed land salinity targets in the Northern Agricultural Region.

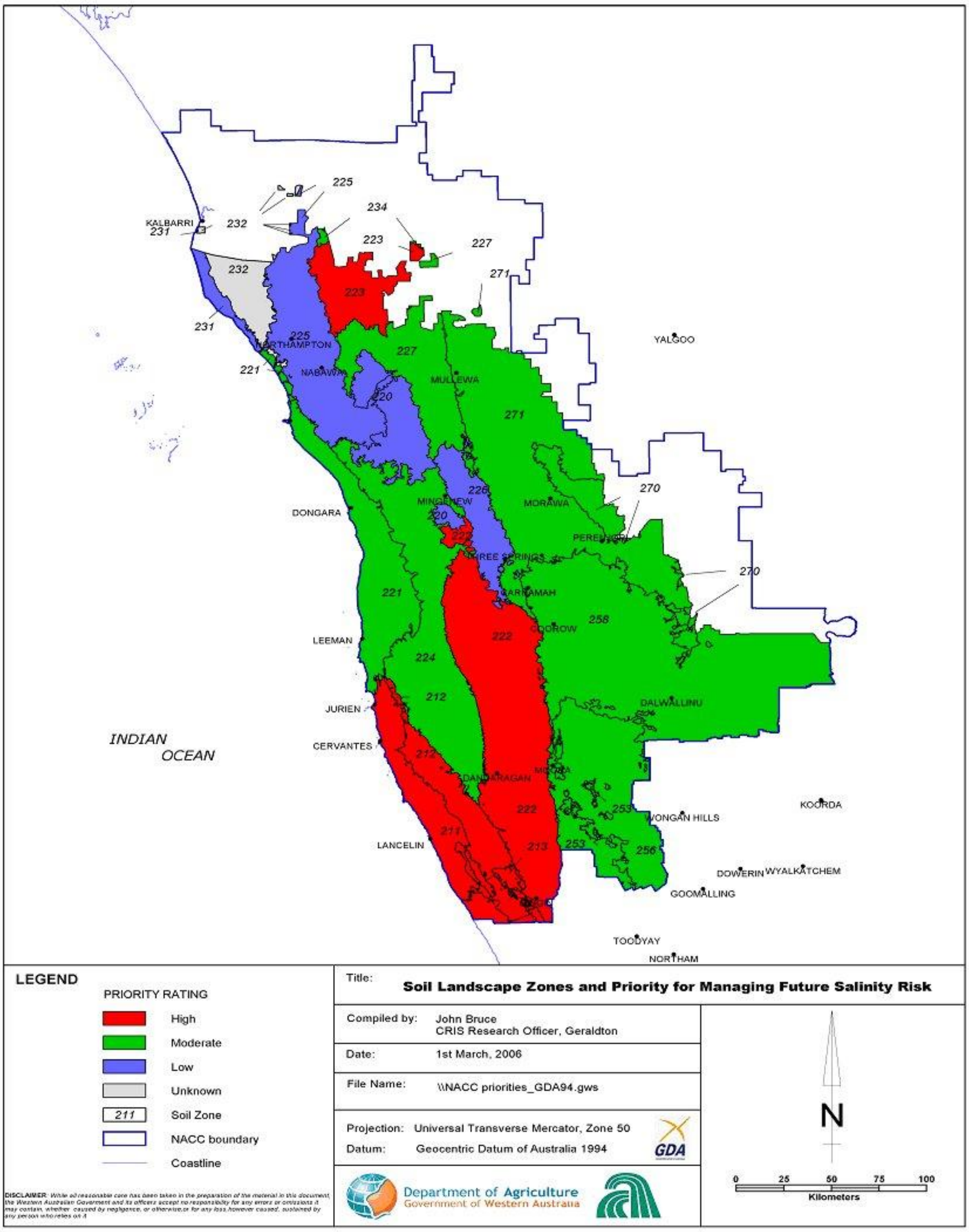


Figure 2: Soil Landscape Zones and priority for managing the existing and future Salinity risk

4. Program Logic Model used to Review RCT's

The land salinity targets review is based on a Program Logic Model (PLM). This method was used to provide a clear guide for choosing what to measure and assess in order to make program improvements in our region. According to the Australian Government NRM Team (2007) program logic is the rationale behind a program – what we understand to be the cause and effect relationships between activities, outputs, intermediate outcomes (MATS), and ultimate outcomes/targets. Represented as a diagram or matrix, the PLM allows us to demonstrate how on-ground activities lead to a change in the natural resource(s) and the consequences of this change; thereby promoting the use of risk management practices to minimise adverse impacts. The National NRM Monitoring and Evaluation (M&E) Framework endorses the use of program logic to improve program design, evaluation and adaptative management activities. Figure 3 identifies core components of the PLM used in this review to accomplish our program outcomes.

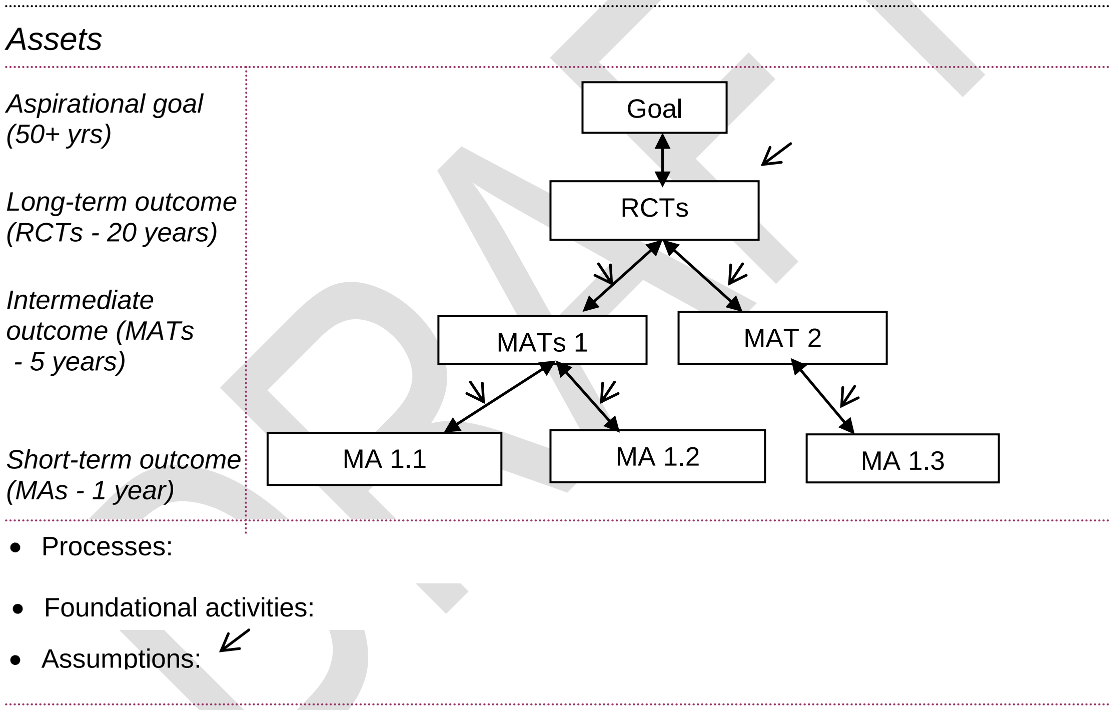


Figure 3: Core components of the program logic model

Aspirational Targets (goals)

Aspirational targets as defined by the Northern Agricultural Regional NRM Strategy are a statement about the desired condition of the asset in relation to salinity in the longer term (50 years +) (NACC 2005). Actions within the plan have been developed with this long-term goal in mind and will progressively move the region towards achieving this goal.

Resource Condition Targets (RCTs)
Resource Condition Targets provide specific, time bound, measurable targets aimed to gauge whether the condition of current assets within the NAR have been improved or maintained (NACC 2005). To comply with the National Framework for NRM Standards and Targets (minimum set of matters for which targets must be set in the region), the land salinity RCTs were reviewed to focus on areas of the existing salinity as well as the areas threatened by shallow or rising watertables.

Steps used in the RCTs review
At this level of targets, the main objective was to set targets and associated performance indicators that can be measured and used to track changes over time with respect to operational objectives. Figure 4 & 5 show draft versions of RCTs targets as they were fitted in the program logic model.

The process of developing the draft targets included a workshop where participants nominated SMART targets and associated indicators. The process involved the following steps:

- Construct a logical diagram to provide clear relationships between different elements or concepts of the program. This was sketched on the white board where the relationships between the concepts were connected with arrows, in a downward-branching hierarchical structure; (see Figure 3);
- Map the casual relationships between the biophysical changes, interrogate the logic and check for gaps;
- Discuss and set the assumptions (Note in Figure 4 & 5, there are some assumptions represented by arrows that we are willing to accept and others we have stated because we feel they require some research);
- Ensure targets are strategically relevant and appropriate. This will allow us to determine if the RCTs are pitched at the right level and whether the overall set of targets gives us a good picture of the progress towards achieving our goals.
- Check that indicators and/or targets are SMART and useful.

Management Action Targets
According to the Northern Agricultural Regional NRM strategy, MATs are the way in which project activities lead to long-term changes in resource condition. These are intermediate outcomes which generally relate to a five year timeframe and are used for measuring progress towards improving asset conditions and for achieving RCTs (NACC 2005).

Ideally, MATs should relate to project activities which lead to long-term change in resource condition. In practical terms, they may take the form of changes in management practices, changes in the knowledge level of land managers or may relate to capacity building, planning, or on-ground works. They may also relate to resource assessment to help determine RCTs and contribute to monitoring and evaluation. In this review we propose to explain how MATs are expected to contribute towards resource condition improvements. Figure 4 & 5 shows the reviewed land salinity management action targets based on program logic model.

Steps undertaken in the review of MATs

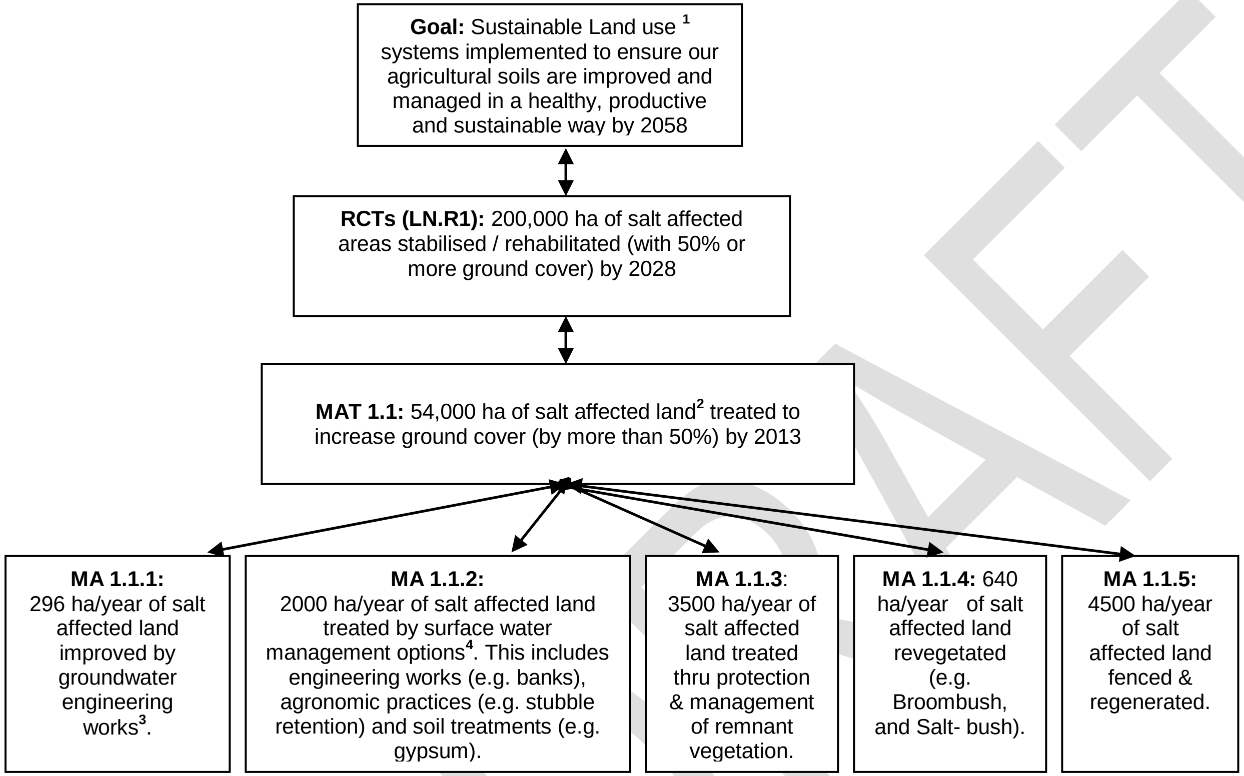
Map the rationale behind a program or project – what are the cause and effect relationships between project activities, outputs, intermediate outcomes and ultimate outcomes;

- Interrogate the logic of the MATs and check for gaps and assumptions;
- Check that the MATs are relevant and appropriate; and
- Check that the reviewed MATs are SMARTer.

Management Actions (MAs)

These are actions which are to be implemented, such as fencing off saline land and creeks, revegetation with trees and perennial pastures, regeneration of native vegetation, etc, to achieve resource condition or salinity targets. The actions agreed to manage salinity in the catchment will be those that most effectively deliver the social, economic and environmental outcomes. Like MATs, MAs relate specifically to those projects that fall under the regional NRM strategy. Nonetheless, we believe it would be beneficial if other projects and program teams that fall outside the regional NRM strategy were to adopt part of or the entire framework used in this program. Figure 4 and 5 show a program logic model of land salinity targets for two asset zones: soil zones around Yilgarn Craton province and Dandaragan Plateau Zone (TIP area).

Figure 4: A program logic model of land salinity targets (in assets zones 271, 258, 270, 253, and 256)



RCT key indicators

- Area of salt affected land

Key Assumptions

- **LN.R1:** Funding and adoption rates of management actions continue at current levels.
- **MAT 1.1:** Funding and adoption rates of management actions continue at current levels.
- **MA 1.1.1:** 6 ha per km of drain is based on the drain having an affect 30m out from each side.
- **MA 1.1.2:** That each km of earthwork will protect 45 ha of land from salinity by reducing the amount of water available for recharge in the catchment.
- **MA 1.1.3:** All the land at risk will be suitable for soil improvements.
- **MA 1.1.4:** Farmers will implement management plans to fence off unproductive land for regeneration.

Definitions: [1]*Sustainable Land use*: Sustainable land use systems refer to activities that are able to be carried out without damaging the long-term health and integrity of natural and cultural environments (SoE Report 2001).

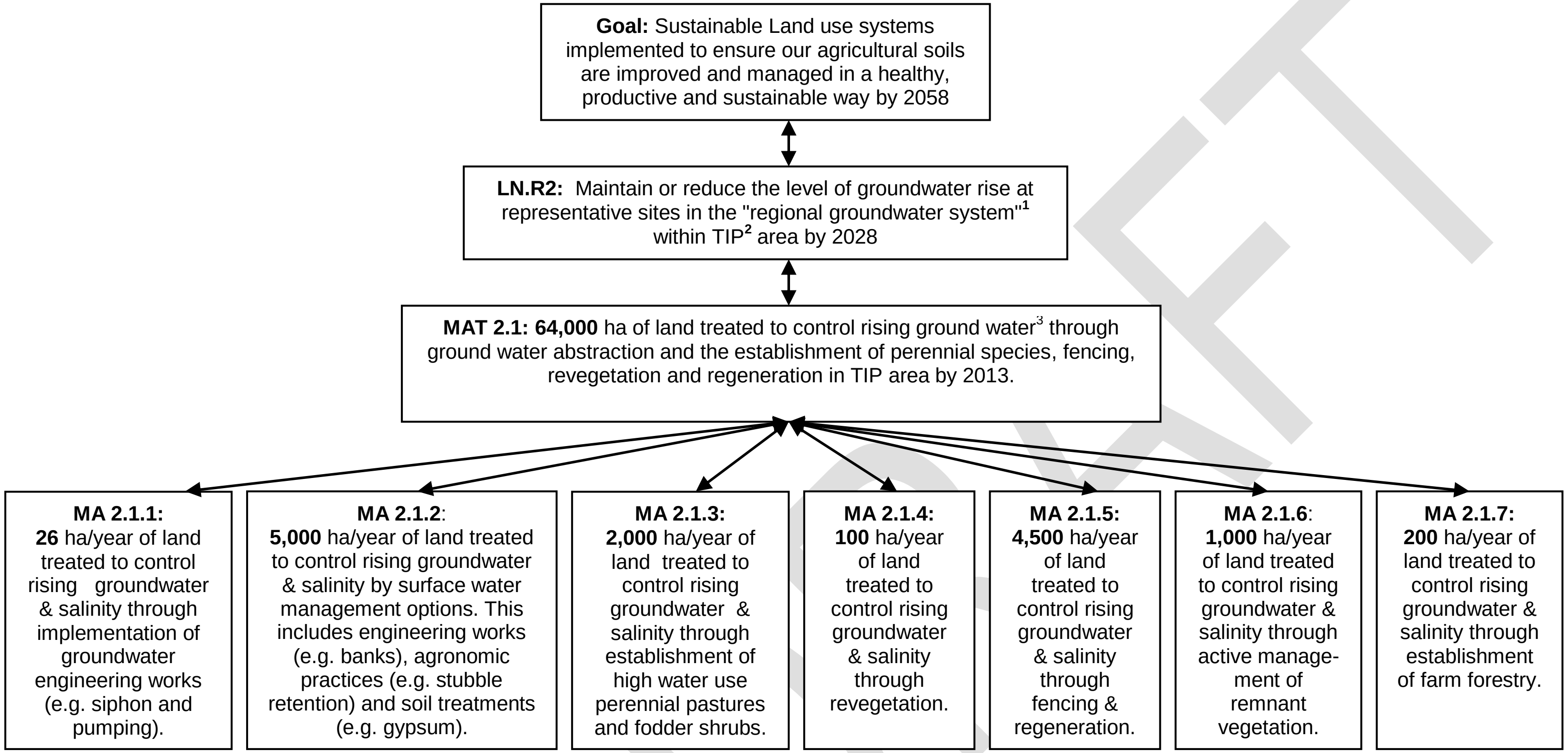
[2]*Salt affected land*: A salt affected land refers to any part of the landscape salinised by shallow or rising watertables, and is further described by the severity of any effects (Australia Government SoE 2006).

[3]*Groundwater engineering works*: Engineering options such as deep drains, siphons or pumping (George, 2004).

[4]Surface water management options: This includes construction of broad based channels, grade banks or shallow drains plus agronomic practices and soil treatment (Coles and Tetlow 2003).

[5]*Management Plan*: is a part of the agreement signed with farmers e.g. the farmer agreed to put up a fence in Autumn and plant saltbush in August and 12-18 months later being able to crash graze each annually (Mike Clarke Person Comm.).

Figure 5: A program logic model of "Regional Groundwater System" targets (for assets) in TIP area



RCT key indicators

- Depth to groundwater[4]

Key Assumptions

- **LN.R2:** Water table change in Parmelia aquifer reflects land use changes.
- **MAT 2.1:** Funding and farmer uptake continues.
- **MA 2.1.1:** Pumping and siphoning is from the surfical aquifer. Groundwater pumping will have an affect on 10 ha of land and a siphon will influence 3 ha of land.
- **MA 2.1.2:** That each km of earthwork will protect 45 ha of land from salinity by reducing the amount of water available for recharge in the catchment.
- **MA 2.1.3:** Adequate seed & seedling supply available to meet demand for pasture establishment.
- **MA 2.1.4:** Landscape-scale revegetated with pastures will minimize recharge.
- **MA 2.1.5:** All the land at risk will be suitable for soil improvements/planting pasture species.
- **MA 2.1.6:** Managing native vegetation is a cost effective method of managing recharge.
- **MA 2.1.7:** Funding continues; farmer uptake continues; Forestry Product Commission schemes continue to operate.
- **4,500,000** KL (4.5 GL) of water allocated for Commercial/Urban use.

Definitions:

[1]Regional groundwater system: Regional groundwater systems occur on a scale of 50 kilometers or more, usually in flat terrain. Limiting recharge is difficult because of the large surface area (Australian Academy of Science 2003).
[2]TIP: Area which identifies high priority natural resources such as rivers, native vegetation and productive agricultural land that are under threat from increasing salinity and declining water quality (NACC 2007).
[3]Rising ground water: Groundwater levels fluctuate naturally with the seasons and in some aquifers fluctuate due to the high recharge rates, low storability of the aquifer and extractions (Beeton *et al* 2006).
[4]Depth to groundwater: defined in meters from the ground surface to water table (recorded in monitoring bores or piezometers) at a specified point in time (NLWRA 2007).

Processes

The process refers to how our program will accomplish desired outcomes. Based on the types of intended outcomes and outputs summarised in Figure 4 and 5, a number of activities and processes are expected to be carried out by the NRM practitioners and land managers. These include, but are not limited to:

- Field days, demonstrations and trials;
- Networking between and within industry and land managers including production and distributions of fact sheets, articles in AgMemo and newspapers
- Education and training programs for the NRMOs and land managers to ensure they are fully aware of the costs and benefits of adopting salinity management strategies.
- Formal extension services linked to Research & Development (R&D). Some of these services could be provided by Natural Resource Management Officers (NRMOs) and project managers to assist in enhancing the link between landholders and industry.
- Delivery of soil carbon and carbon credits baseline data.
- Local Aboriginal community consultation

Foundational activities

These activities involve change in our knowledge base (e.g. research, baseline assessment); development of plans, strategies and programs; and changes in organisation policy (incentives, guidelines, regulation and education.

Assumptions

Assumptions represent the underlying ideas behind specific strategies and activities implemented by the program and how they will lead to the desired outcomes (Powell *et al* 2002). As with target setting, clearly defining and understanding the assumptions associated with the program output and/or activities are fundamental to the program logic modeling process. The assumptions are the mechanism or process through which a specific action will achieve the desired target/milestone. Figure 4 & 5 indicate key assumptions used for monitoring to ensure our salinity targets are both accurate and attainable.

5. Monitoring and Evaluation compatible with the PLM

Purpose of Monitoring & Evaluation

The purposes of monitoring and evaluation are to foster a culture of self-evaluation and learning, and to improve the development of our projects (NACC 2005).

All projects embraced under the RCTs are asked to report to NACC as well as meet their other reporting obligations. The National M&E framework encourages project managers to undertake monitoring and evaluation for their own purposes and for reporting to government. If project managers have their own M&E plans this will ensure that their monitoring and evaluation processes meet their own information needs; they will be able to learn from their successes and failures and deliver valued outcomes more consistently and reliably. The data for project level will be collected by field staff and managers of projects that come under the RCTs.

Approach
There are three approaches that will be used at project level:

- the first will be conducted by project managers;
- the second and the third will be carried out by the monitoring and evaluation manager at the NACC office.

Self-reporting by project managers
At the project level, it is essential that all project teams monitor and evaluate their own performance. As is the NACC current practice, each project will report on a quarterly basis against standard outputs and financials. These reports will be collected and collated quarterly.

Each RCTs strategy/project will be encouraged to develop a basic evaluation plan and submit the resulting evaluation reports to the NACC as part of the annual data collation process. As well as fostering ownership, self-evaluation contributes to clearer project design and locally-driven continuous improvement.

Evaluation plan
Each project will be asked to develop and document a basic evaluation plan based on the methods endorsed by the National M&E framework.

Annual report against evaluation plan
Once a year, each project manager will be asked to submit a two-page report that details results to date against their project logic model.

Aggregation of data by NACC M&E team
One way of making use of multiple project evaluations is through aggregating the project evaluation findings. For this reason, the NACC aims to encourage some standardisation for project evaluations. In the forthcoming year, key evaluation questions will be provided to project managers in addition to the steps identified in the National M&E Framework for developing an evaluation plan. Each year the NACC M&E team will consolidate all project evaluations conducted that year to give a picture of overall achievements.

External evaluations and audits
The credibility of the monitoring and evaluation process will be enhanced by implementing a program of external evaluations and audits that will feed into the project evaluations. The reason for commissioning an external evaluation could include anomalies or unexpected results in the self-evaluations for projects. An annual program of project audits will also be developed. Projects will be selected randomly for auditing.

6. Setting RCT's and assessing the impacts of different Management Actions on changes in the watertable depth.

A range of Management Actions (MA's) have been proposed to control the water table levels of the local ground water systems in the TIP area. In order to measure the effectiveness of the MAs, Resource Condition Targets need to be established. However, there are only 3 bores in the TIP area, covering some 7000 km^2, which are suitable for monitoring watertable levels in surfical aquifers – patently too few to monitor the impact of Management Actions. The regional ground water system, where many more bores may be available for monitoring (***), may also be influenced by proposed Management Actions. Additionally, changes in the water table levels may be used to indirectly monitor the impact of the Management Actions on the local ground water systems.

To assess the impact of MA's, the water use by each proposed action was first obtained from by a range of methods. In the case of pumping and siphoning, known rates of abstraction were used. With surface water management, estimates were obtained using standard design criteria. Water use by plant based MAs (eg revegetation, use of perennial pastures etc) were estimated using AgET, (an evapo-transpiration, water balance model). Estimates from AgET are based values for deep sand which cover 70% of the Region (Stuart-Street, pers. com) and knowledge of the current rotations from whole farm models(C Peek pers. com).

Table 3: Calculation of total recharge reduction to the regional aquifer (Parmelia Formation) in Soil-landscape Zone 222

Management Action	Area Treated (ha/yr)	Water use per ha/year (KL/yr)	Impact on Parmelia Aquifer KL/ha/yr	Weighted average of recharge reduction to Parmelia GL/yr
Siphon & pumping	26	33,580	5212	0.136
Surface water management engineering works, soil amelioration etc.	5,000	100	6.2	0.031
Perennial pastures and fodder shrubs.	2,000	11.0	1.9	0.004
Revegetation.	100	11.0	1.9	0.0002
Fencing & regeneration.	4,500	11.0	1.9	0.009
Active management of remnant vegetation	1,000	3.2	0.24	0.0002
Farm forestry	200	14.2	2.14	0.004
TOTAL	12,826			**0.180**

The water use under proposed MAs and current recharge rates were combined to estimate recharge rates to the regional water table (Table 3). The total water use of 0.180 Gl/yr were summed over 19 years to estimate the

the impact of the MAs on the water table after 19 years (Table 4). The estimates of current recharge and porosity were provided by Department of Water (A Kern, pers. com) and based on experience of aquifers in the Perth Basin. The calculations take into account abstraction from the Parmelia Aquifer for urban, industrial and agricultural uses. The rates of abstraction from the Parmelia are based on the Interim Sub-Regional Allocation Strategy's prepared by Department of Water (A Kern, pers. com

Key assumptions.

i. Climate is similar to the period from 1963 to 1993.
ii. Deep flow from AgET represents recharge to the Surfical and Parmelia aquifers.
iii. Recharge under native vegetation is zero.

Table 4 Changes in water table levels (mm) in the Parmelia Formation under a range of scenarios. For each TIP zone and averaged across the TIP.

Ground Water Area	TIP Zone	WT after 19 years with current system current abstraction.	WT after 19 years with assumed additional abstraction no MAT's implemented	WT after 19 years with proposed MAT's and additional abstraction.
		mm	mm	mm
Arrowsmith	2	2250	1766	1744
Jurien & Gingin	1 & 3	54	-529	-550
	Average TIP	1170	636	614

Key assumptions:

i. Current abstraction is 20% of allocation and does not contribute to current water table changes in the Parmelia.
ii. Water allocated for urban and commercial uses increased by 4,500,000 KL /yr.
iii. Recharge changes to the Parmelia and abstractions from the Parmelia impact the water table uniformly across the Parmelia.

Resource Condition Targets (RCTs) and analysis of water balance.

By using the above analysis we can conservatively set an RCT of an average water table rise of 614 mm above current levels over the next 19 years. This is compared with a rise of 636 mm if the Management Actions are not implemented (Table 4). The local impact of the MAs on the local ground water systems (the intended target of the MAs) may be significant, but this effect is attenuated if assumption iii for Table 4 holds. Effects of the MAs on the Regional ground water may be much larger if there is no effective connectivity within the Parmelia and assumption iii for Table 4 does not hold. Under such circumstances the impact on the water table in the Parmelia will be very site specific and dependant on the location of the MA.

The analysis (Table 3) also shows that siphoning or pumping followed by surface water management has a significant impact on water tables. On average they are between 40 and 10 times more effective than other MA options. However, by far the greatest impact on water tables is abstraction for urban and commercial uses. If projections of increasing water use by 4.5 Gl/yr and assumptions concerning recharge to the Parmelia hold, then the proposed MA may have an adverse impact on the water resource. There is a clear need to accurately determine the water balance for the TIP area and the impact of land use and climate change on the aquifers.

7. Conclusions

The RCTs have been reviewed for the two assets: the assets in the soil zones around Yilgarn Craton (Yarra Yarra, Eastern Moore and Irwin River Catchments) and the Dandagaran Plateau Zone, developed through the program logic model provided by State NRM Office. It is recognized that the area around Yilgarn Craton has existing salinity while the Dandaragan Plateau area is at risk from future salinity and the RCTs were chosen accordingly. The RCT for the Yilgarn Craton are based on the area of salt affected areas stabilised / rehabilitated (with 50% or more ground cover). Whereas, the RCT for the Dandaragan Plateau Zone is based on rising water tables in the deep aquifers. Each RCT relies heavily on a number of key assumptions many of which have yet to be verified, in particular those assumptions surrounding the quantification of recharge to the Parmelia Aquifer and the impact on water table rise.

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APPENDIX 1: DEFINITION OF CONCEPTS AND TERMINOLOGIES

Depth to groundwater below surface

Depth to groundwater is defined in metres from the ground surface to water table (recorded in monitoring bores or piezometers) at a specified point in time (NLWRA 2007). Depth to a groundwater resource is an important factor in determining the feasibility of developing the resource and is therefore a surrogate indicator for availability of the resource for human use. It is also a direct indicator for the pressure of rising or falling groundwater on the land (Beeton *et al.* 2006).

Rising groundwater level

Groundwater levels fluctuate naturally with the seasons and in some aquifers fluctuate due to the high recharge rates, low storability of the aquifer and extractions. Many of the good quality groundwater aquifers in Australia are highly developed, with some having falling levels due to over-extraction. In other areas with falling levels, drought conditions over the last few years are the cause. Groundwater levels do not respond immediately to recharge, and so the effects of drought or over-extraction may occur years after the stress on the system (Beeton *et al.* 2006). Dryland salinity and waterlogging problems can occur where water levels have risen to near the ground surface due to clearance of native vegetation. This can reduce the availability of groundwater for both natural and human uses, as well as increasing surface salt load with catastrophic impacts on land and biodiversity (Yokwe 2007).

Regional groundwater systems

Regional groundwater systems occur on a scale of 50 kilometres or more, usually in flat terrain. Limiting recharge is difficult because of the large surface area and also because regional groundwater systems often occur in semi-arid areas where tree-planting may not be economically viable. Moreover, efforts to lower watertables in intermediate and regional-scale groundwater systems is made more difficult by their generally low discharge capacities: in other words, since the terrain is often quite flat, the flow of groundwater to low points in the catchment and subsequent drainage out of the system can be very slow. So even if recharge is prevented, the watertable may take decades – and even hundreds of years – to return to previous levels (Australian Academy of Science 2003).

Salt affected Land

Salt affected land refers to any part of the landscape salinised by shallow or rising watertables, and is further described by the severity of any effects. This occurs where soils and vegetation are degraded by the discharge and evaporative concentration of saline groundwater. It commences when the watertable either reaches the root zone or where it can be evaporatively concentrated (commonly within two metres of ground surface) (Australia Government SoE 2006).

Sustainable land use systems

Sustainable land use systems refer to activities that are able to be carried out without damaging the long-term health and integrity of natural and cultural environments (SoE report 2001). In an agricultural context, Rural Industries Research and Development Corporation (RIRDC1997) describes sustainable land use systems as practices/systems that maintain or improve the following:

- the economic viability of agricultural production;
- the social viability and well-being of rural communities;
- the ecological sustainable use of Australia's biodiversity;
- the natural resource base; and
- ecosystems that are influenced by agricultural activities.

Surface and groundwater water management options

Excess water on and below the land surface can be managed using engineering options such as grade banks and waterways, shallow or deep drains and, in some situations, groundwater pumping or relief wells. These structures are designed to control run-off, to lower groundwater tables and reduce the effects of water erosion, waterlogging, flooding, groundwater recharge, groundwater discharge, shallow watertables and salinity. Effective water management options can therefore reduce productivity losses caused by excess water. Systems to manage excess water include (Coles and Tetlow 2003):

- *surface water management options*, through the construction of broad based channels, grade banks or shallow drains;
- *Groundwater management options*, through deep drains, relief wells, siphons or pumping.

Management plan

Based on the salinity rehabilitation and extension project (by Mike Clarke and team of the DAFWA), the management plan is a part of the agreement signed with farmers e.g. the farmer agreed to put up a fence in Autumn and plant saltbush in August and 18 months later being able to crash graze each annually.

TIP area

The TIP identifies high priority natural resources such as rivers, native vegetation and agricultural land that are under threat from increasing salinity and declining water quality. The program is designed to assist land managers to adopt practices that will address these threats (NACC 2007).

APPENDIX 2: NATIONAL OUTCOMES AND MINIMUM SET OF REGIONAL TARGETS

National outcomes	Matters for which Regional Targets must be set
The national outcomes are aspirational statements about desired national natural resource outcome	**Resource condition matters for Targets**
1. The impact of salinity on land and water resources is minimized, avoided or reduced. 2. Biodiversity and the extent, diversity and condition of native ecosystems are maintained or rehabilitated. 3. Populations of significant species and ecological communities are maintained or rehabilitated. 4. Ecosystem services and functions are maintained or rehabilitated 5. Surface and groundwater quality is maintained or enhanced. 6. The impact of threatening processes on locations and systems which are critical for conservation of biodiversity, agricultural production, towns, infrastructure and cultural and social values, is avoided or minimized.	1. Land salinity 2. Soil condition 3. Native vegetation communities integrity 4. Inland aquatic ecosystems integrity (rivers and other wetlands). 5. Estuarine, coastal and marine habitats integrity 6. Nutrients in aquatic environments 7. Turbidity/suspended particulate matter in aquatic environments 8. Surface water salinity in freshwater aquatic environments 9. Significant native species and ecological communities 10. Ecologically significant invasive species
7. Surface water and groundwater is securely allocated for sustainable production purposed and to support human uses and the environment, within the sustainable capacity of water resource. 8. Sustainable production systems are developed and management practices are in place, which maintain or rehabilitate biodiversity and ecosystems services, maintain or enhance resource quality, maintain productive capacity and prevent and manage degradation.	**Management Action Matters for Targets** 1. Critical assets identified and protected. 2. Water allocation plans developed and implemented. 3. Improved land and water management practices adopted.

Note: This table should be read in conjunction with the National NRM Monitoring and Evaluation Framework (Source: Natural Resource Management Ministerial Council 2002).

Appendix 3a (Ref to Figure 4): A program logic model of land salinity targets for existing saline land (in assets zones 271, 258, 270, 253, and 256)

Ref#	MA	Protected Ha/year	Explained how you arrive to this figure	Water use ha^{-1} yr^{-1}	Data for monitoring	Assumptions	SMART Test S	M	A	R	T
	RCT (LN.R1)	200,000 ha of salt affected areas are stabilized / rehabilitated (with 50% or more ground cover) by 2026									
	MAT 1.1	54,000 ha of salt affected land are treated to increase ground cover (by more than 50%) by 2012									
MA 1.1.1	ha/year of salt affected land improved by groundwater engineering works This includes: 120 ha of drains; 6 ha of siphon and 20 ha of drainage pumping.	**296**	Since each km of drain can influence 6ha of land if a significant drawdown is achieved 30m either side of the drain, then 20km of drains constructed per year should influence 120ha land. A further 2 pumps and 2 siphons will influence a further 26ha of land.	11 m^3 per year per km of drain can be generated. If each km affects 6 ha then water used is 1.8 $m^3ha^{-1}yr^{-1}$. Pumping and siphons can yield a further 32 300m^3. = 32 302 $m^3ha^{-1}yr^{-1}$.	Kilometers of drains and numbers of siphons and pumps constructed in the Yilgarn area.	It is assumed that drainage will have any affect at all on the water table. 6 ha per km of drain is based on the drain having an affect 30m out from each side.	Y	Y	Y	Y	Y
MA 1.1.2	ha/year of surface water management options be implemented. This includes engineering works (e.g. banks), agronomic practices (e.g. stubble retention) and soil treatments (e.g. gypsum).	**2,000**	Since 1 km of grade bank can beneficially influence up to 45 ha of land it will require 111km of earthworks to protect 5000 ha of land per yr. Given that trained surveyor can survey up to 5 km per day it is not unrealistic to implement this amount per year to protect land.	70 m^3 of runoff per hectare per year can be captured using surface water management works in the Yilgarn area.	Kilometres of earthworks that are installed in the Yilgarn area to protect saline land per year.	That each km of earthwork will protect 45 ha of land from salinity by reducing the amount of water available for recharge in the catchment. 2% of rainfall is captured by earthworks.	Y	Y	Y	Y	Y
MA 1.1.3	ha/year of salt affected land treated thru protection and management of remnant vegetation.	**3,500**	Using the Map Unit Database, I used the estimate of the area of arable land affected by or at high risk from, secondary salinity (areas greater than 10% and excluding drainage floors and salt lakes)	would use all incident rainfall	Data from saltland rehabilitation and extension projects	I am assuming that all the land at risk will be suitable for soil improvements.	Y	Y	Y	Y	Y
MA 1.1.4	ha/year of salt affected land revegetated (e.g. Broombush, and Salt-bush).	**640**	This is the figure includes Woodland Watchand Land for Wildlife figures for 2000-2005 of 1,500ha/yr as well as what is currently being achieved by the Salinity Rehabilitation and Extension Project	would use all incident rainfall	figures from Land for Wildlife, Woodland watch, Envirofund and other NLP projects	funding continues	Y	Y	Y	Y	Y

***Y=Yes**

Appendix 3b (Ref to Figure 5): A program logic model of "Regional groundwater system" targets (for assets) in TIP area

Ref#	RCT (LN.R2)	LN.R2: Maintain or reduce the level of groundwater rise at representative sites in the "regional groundwater system" within TIP area by 2026									
	MAT 2.1	MAT 2.1: 64000 ha of land treated to control rising ground water through ground water abstraction and the establishment of perennial species fencing, revegetation and regeneration in TIP area by 2012.									
	MA	**Protected Ha/year**	**Explained how you arrive to this figure**	**Water use ha^{-1} yr^{-1}**	**Data for monitoring**	**Assumptions**	**SMART Test** S	M	A	R	T
MA 2.1.1	ha/year of land treated to control rising groundwater & salinity through implementation of groundwater engineering works (e.g. siphon and pumping).	**26**	Drains are not recommended for this landscape. A groundwater pump can influence 10ha of land and produce 100m3 day of water. A typical siphon with a 50mm pipe needs to yield 108m3 day to work and can influence approx. 3 ha land. It is estimated that there are 4 separate situations where these treatments can be applied per year (i.e. 2+ 2).	33,580 Kl /ha/ year can be yielded from this amount of groundwater pumping. The weighted avargae recharge the Parmelia is 5212 KL.	Number of siphons and groundwater pumps constructed in the TIP area.	Pumping and siphoning is from the surfical aquifer. 30 % would recharge the Parmellia aquifer north of Badgingarra and 0.006% south. It is assumed that groundwater pumping will have an affect on 10 ha of land and a siphon will influence 3 ha of land.	Y	Y	Y	Y	Y
MA 2.1.2	ha/year of land treated to control rising groundwater & salinity by surface water management options. This includes engineering works (e.g. banks), agronomic practices (e.g. stubble retention) and soil treatments (e.g. gypsum).	**5,000**	Engineering works: Since 1 km of grade bank can beneficially influence up to 45 ha of land it will require 111km of earthworks to protect 5000 ha of land per yr. If 10% of the landscape is salt affectd we can assume that 500ha of this protected area will be salt affected land. It is assumed that the 100 KL is diverted to an open drainage line or is used such that it does not contribute to recharge. Given that trained surveyor can survey up to 5 km per day it is not unrealistic to implement this amount per year to protect land. Agronomic practices/Soil treatment: Using the map database land with greater than 10% of moderate to high risk of waterlogging within the TIP area.	100 KL/ha/yr of runoff can be captured using surface water management works in the TIP area. Of this 100KL it is estimated using AgET that 40% is deep flow (40 kl). Of the 40 KL, the weighted average recharge of 15 % recharges the Leederville Parmellia aqufier (based on ratio between AgET model results and DoW recharged rates). It is assumed that the agronomic practices and soil treatments assist in controlling 100 KL of runoff.	Kilometres of earthworks that are installed in the TIP area to prevent waterlogging	Engineering works: That each km of earthwork will protect 45 ha of land from salinity by reducing the amount of water available for recharge in the catchment. In the 500 mm TIP area, 2% of rainfall again becomes runoff. So 10 mm or 10 L runs per square metre of catchment. Over one hectare this is equivalent to 100 000L or 100m3. Of the 100 KL that run off, assumes 40 % normally recharges if ponde on 10% of the land. Of this 40% 30% recharges the aquifer. Agronomic practices/soil improvment: All the land at risk from salinity will be suitable for soil	Y	Y	Y	Y	Y

			Agronomic practices are undertaken on the 5000 ha as a complete package.			improvement.					
MA 2.1.3	ha/year of land treated to control rising groundwater & salinity through establishment of high water use perennial pastures and fodder shrubs.	**2,000**	A mix of sub tropical perennials, tagasaste, Rhagodia & salt bush depending on the soil type. 50 farmers doing 40 hectares each per year.	11.0 Kl more water used than existing crop rotations. Based on AgET estimates on deep sand for lucerne (proxy for other perennials), tagasaste and atriplex.	Seed sales for perennial grasses and contractor plantings of shrubs	Adequate seed & seedling supply available; Waterlogging/saline sites will not be appearing in regional groundwater system areas yet.	Y	Y	Y	Y	Y
MA 2.1.4	ha/year of land treated to control rising groundwater & salinity through revegetation.	**100**	EOIs for TIP reveg incentive, without any guarantee of funding has already seen a potential for nearly 100ha of strategic reveg applied for; reveg will occur under other funding arrangements such as Envirofund.	11.0 KL more water used than existing land use. Assumes, non productive land has similar water use to current rotation. Estimates for revegation are based on AgET estimates on deep sand using proxy's for native perennial communities (lucerne , tagasaste and atriplex).	ha of strategic reveg planted	Funding continues; farmer uptake continues; landscape-scale reveg with pastures will minimise recharge; seed is available to meet demand for pasture establishment	Y	Y	Y	Y	Y
MA 2.1.5	ha/year of land treated to control rising groundwater & salinity through fencing & regeneration.	**4,500**	EOIs for TIP reveg incentive, without any guarantee of funding has already seen a potential for nearly 100ha of strategic reveg applied for; reveg will occur under other funding arrangements such as Envirofund.	11.0 Kl more water used than existing land use. Assumes, non productive land has similar water use to current rotation. Estimates for regeneration are based on AgET estimates on deep sand using proxy's for native perennial communities (lucerne , tagasaste and atriplex).	ha of regenerated plants	Funding continues; farmer uptake continues; landscape-scale reveg with pastures will minimise recharge; seed is available to meet demand for pasture establishment	Y	Y	Y	Y	Y
MA 2.1.6	ha/year of land treated to control rising groundwater & salinity through	**1,000**	Current TIP signed agreements for remnant veg management total approximately 1,500 ha; remnant vegetation will be managed under	3.2 Kl more water will be added to the water table with the degradation of each 1000. Assumes, that native	ha of native vegetation actively managed	Funding continues; farmer uptake continues; managing native vegetation is a cost effective method of managing	Y	Y	Y	Y	Y

	active management of remnant vegetation.		other funding arrangements such as Envirofund.	vegetationis degrading at 1000 ha/yr such that the degraded vegetation has similar water use to introduced perenials and recharge from existing native vegetation is zero. Recharge rates are based on AgET estimates on deep sand using proxy's for degraded native perennial communities (lucerne , tagasaste and atriplex).		recharge					
MA 2.1.7	ha/year of land treated to control rising groundwater & salinity through establishment of farm forestry.	**200**	EOIs for TIP farm forestry incentive are currently approximately 200 ha.	14.2 Kl more water used than existing crop rotations. Based on AgET estimates on deep sand using eucalyptus as a proxy. Reharge is considered to be zero.	ha of farm forestry established	Funding continues; farmer uptake continues.	Y	Y	Y	Y	Y
TOTAL HA/YEAR		**12,826**									
	Assumption : x GL of water allocated for Commercial / urban uses										
	KL of water allocated for Commercial / urban uses	**4.5**	97 Gl available for abstraction (DoW Allocation strategy documents, Arrowsmith, Jurien and Gingin ground water areas). Only a small portion of the allocated water (57 Gl) is used (estimated at 11 Gl assuming 20% of current allocation) because many large horticulture developments have stage-development programs and are currently in the first years of development. It is assumed that the the remaining unused and unallocated water abstraction is increased uniformly to a maximum of 86 GL over 19 years (ie 86/19).	4,500,000 KL of water abstracted for horticulture, mining and urbane uses	DoW water licensing records	Abstraction from Parmelia Aquifer is uniform.					
TOTAL GL OF H_2O/ha/yr		**4.5 GL**									

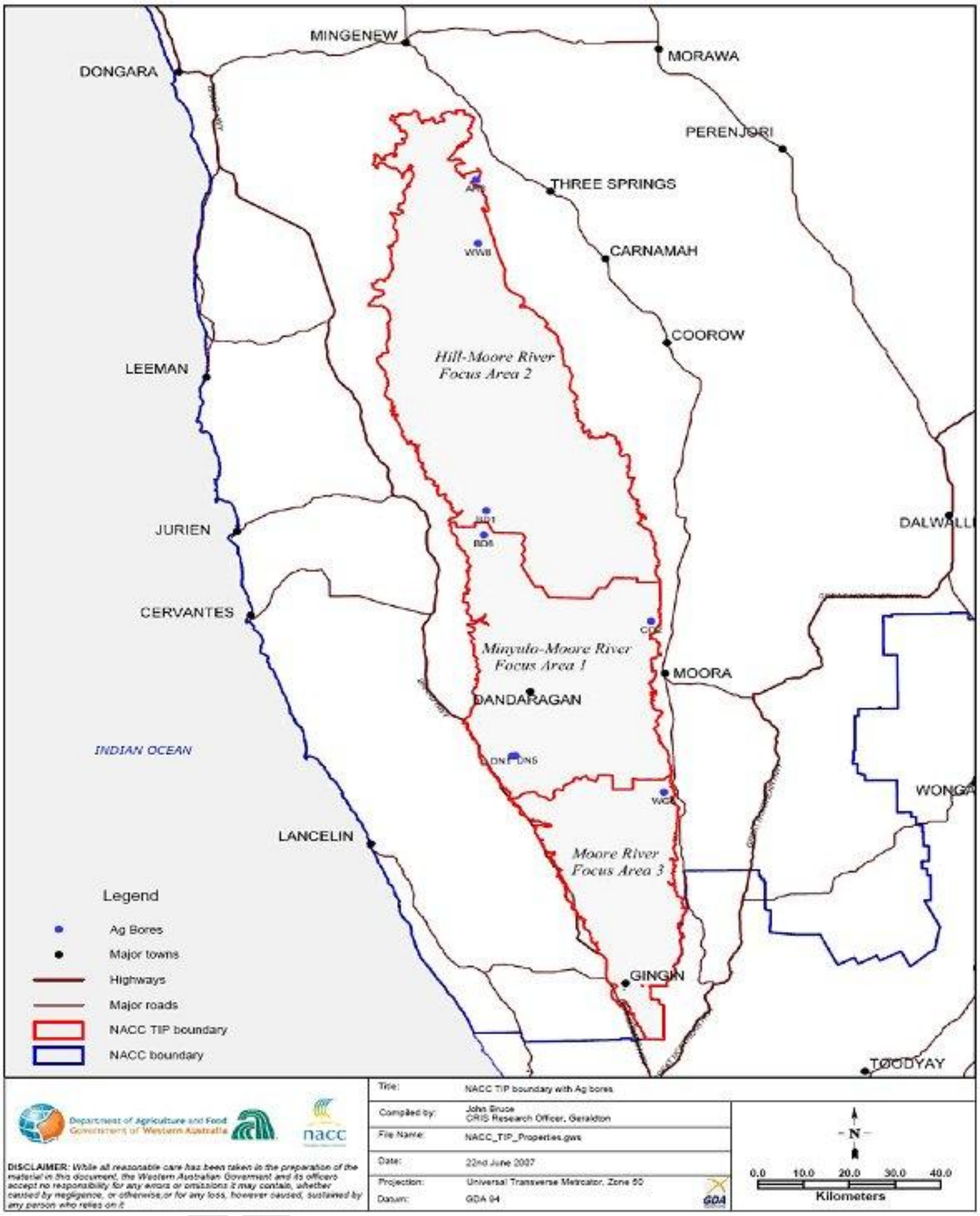
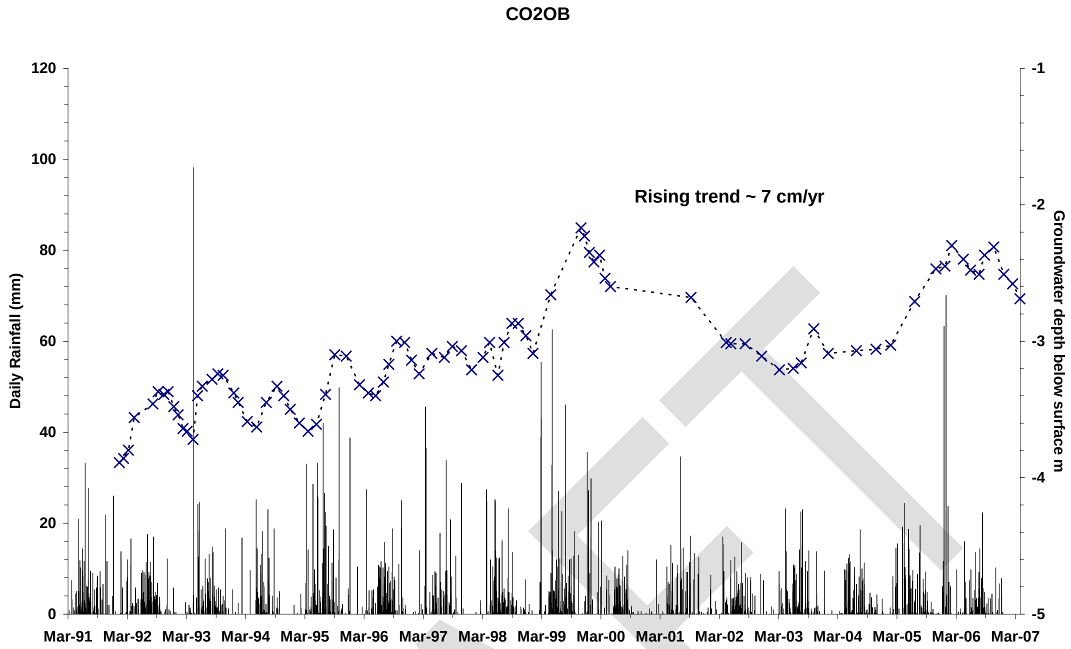
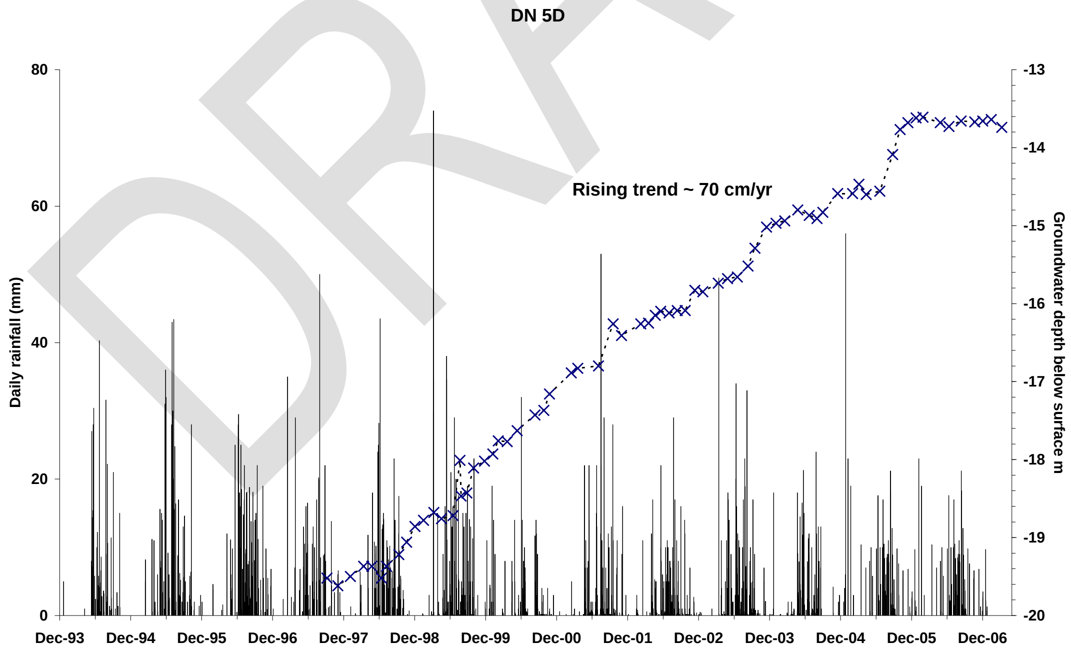
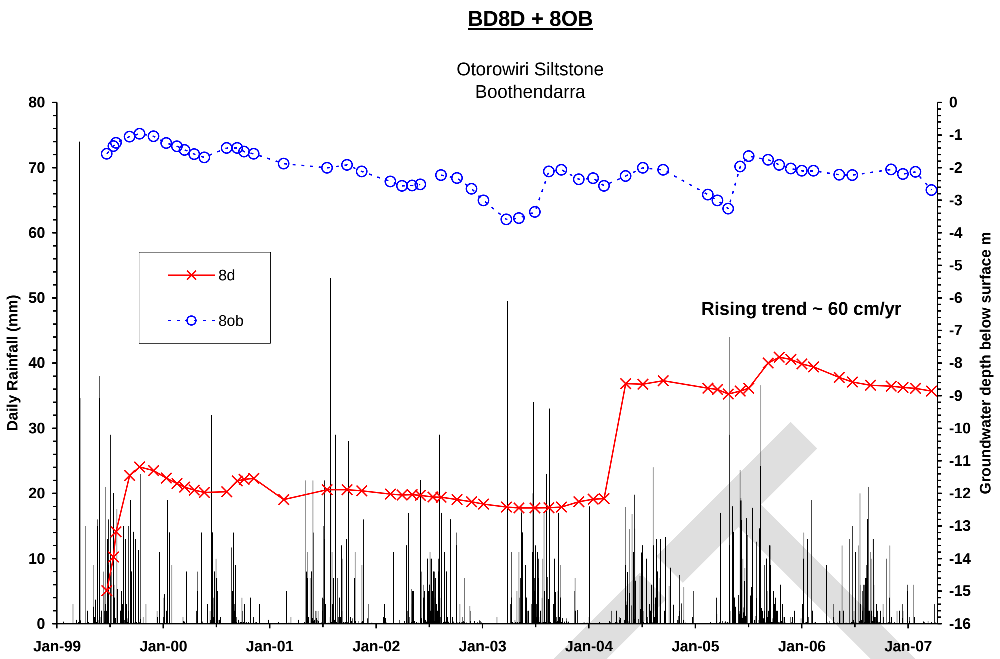


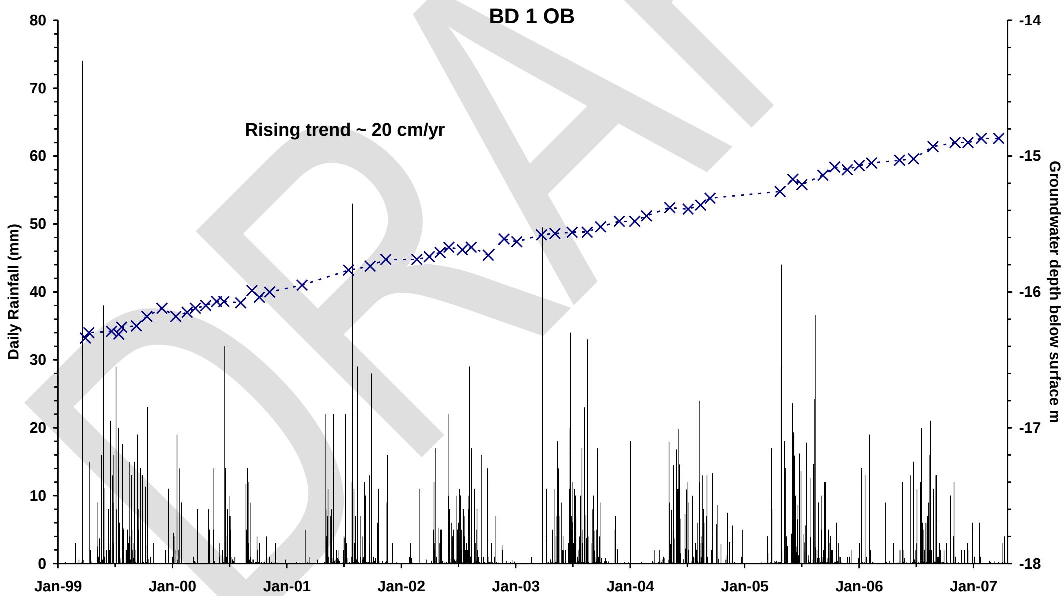
Figure 1. Priority areas for Targeted Investment Program in the Northern Agricultural Region

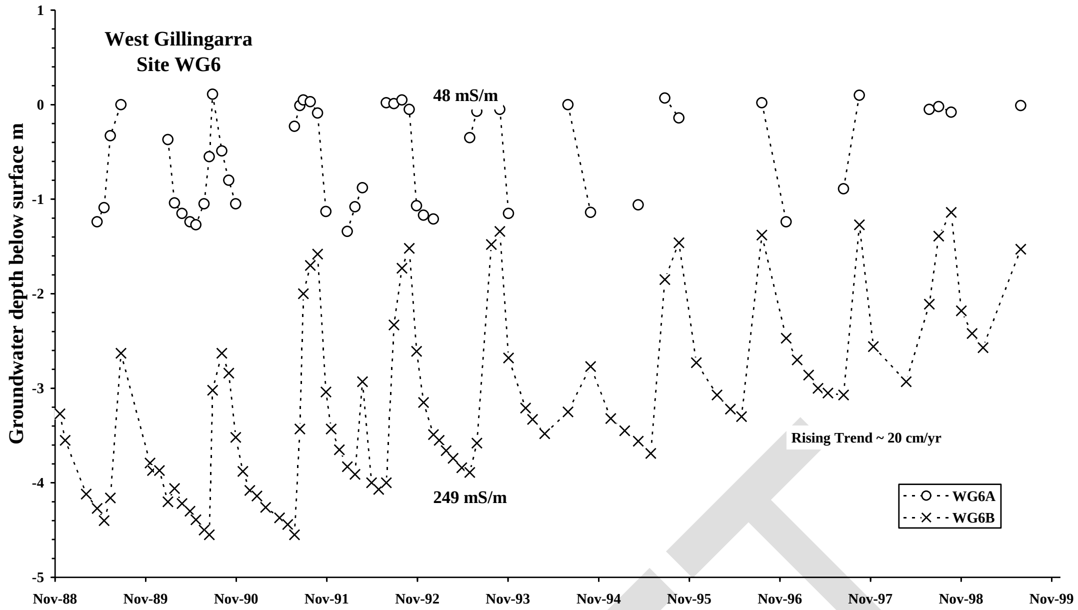
Appendix 2: Representative monitoring sites (bores) in the Dandaragan Plateau Zone (TIP area)

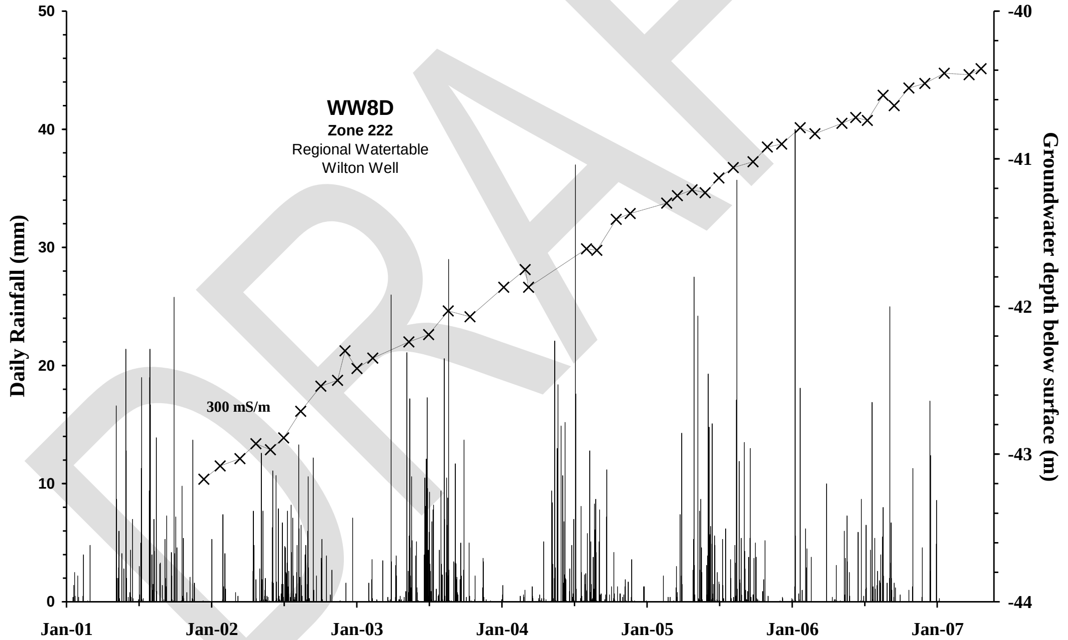





BD8D + 8OB
Otorowiri Siltstone
Boothendarra
Daily Rainfall (mm)
Groundwater depth below surface m
8d
8ob
Rising trend ~ 60 cm/yr
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07


BD 1 OB
Rising trend ~ 20 cm/yr
Daily Rainfall (mm)
Groundwater depth below surface m
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07


West Gillingarra
Site WG6
Groundwater depth below surface m
48 mS/m
249 mS/m
Rising Trend ~ 20 cm/yr
WG6A
WG6B
Nov-88
Nov-89
Nov-90
Nov-91
Nov-92
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99


WW8D
Zone 222
Regional Watertable
Wilton Well
300 mS/m
Daily Rainfall (mm)
Groundwater depth below surface (m)
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07