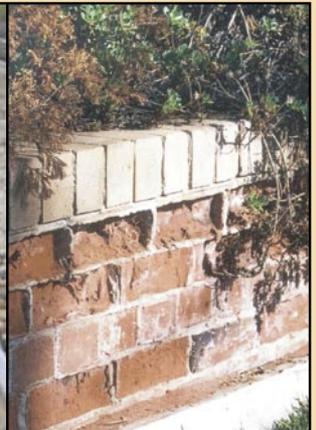




Department of Agriculture and Food
Department of Environment and Conservation
Department of Water



Salinity Investment Framework

Phase II

Salinity and Land Use Impacts Series

REPORT NO. 34
DECEMBER 2006

SALINITY INVESTMENT FRAMEWORK PHASE II

by

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SALINITY AND LAND USE IMPACTS SERIES

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Range of assets

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Foreword

This report was prepared with the State Salinity Investment Framework Steering Committee on behalf of the Natural Resource Management Council of Western Australia. This is the second report documenting the work in developing a framework for the investment of public funds in salinity management. The report is not Government policy but aims to promote debate on how we manage the State's natural resources, especially those at risk from salinity.

The first report (Department of Environment 2003), described processes for selecting a list of assets of highest value to the State, and which face the highest level threats from salinity pressures. These so-called 'Tier 1' assets were developed for four domains: agricultural land, rural infrastructure, biodiversity and water resources. The social assets essential for addressing salinity threats were also identified.

This study is based on a range of assumptions about the treatments that could be used in different situations, and about their costs and benefits. The analysis was done on a 'desktop' basis, with varying methodologies for the agricultural land, rural infrastructure, biodiversity and water resource assets. It was an ambitious analysis with feasibility assessments generated by experts from several government agencies and consultancies. The findings presented are preliminary, but will be useful in helping to set priorities for further investigations. The information on the suggested interventions will be used to provide a preliminary assessment of what might be needed to address the salinity threat to the assets.

The report has two broad dimensions: the Salinity Investment Framework methodology, and the results of its application at the state level. The report demonstrates the value of the overall framework approach, and the need for a systematic and outcome-focused procedure for selecting salinity investments. It highlights that the feasibility of achieving salinity management goals varies widely between individual assets in each of the domains, and between the domains themselves. The total cost of direct intervention estimated across all 48 assets in this investigation is large — \$950 million over 30 years. Since public expenditure of this magnitude seems unlikely to occur in Western Australia, it is important that there is further investment in industry development to address the salinity threats while at the same time yielding economic returns. Only by that strategy will we be able to extend the range of assets adequately protected beyond a short list of the most significant.

This report provides fundamental concepts, methods and important information for governments and regional natural resource management bodies to decide how limited public funds can best be used to manage salinity. Some of the information is challenging, but nevertheless needs to be understood and recognised as we together develop achievable strategies and actions over the coming years. Finally, it is emphasised that priorities for action and the decision methods used to generate them must constantly be adjusted in the light of new knowledge and techniques. The information and ideas presented here are a milestone in a journey, not the endpoint.

John Ruprecht
on behalf of NRM Senior Officers Group
December 2006

Contents

Summary	1
1 Introduction	6
1.1 Principles in salinity investment planning	6
1.2 Salinity Investment Framework Phase I	7
1.2.1 Summary of the work completed in Phase I of SIF	7
1.3 Salinity Investment Framework Phase II	8
1.3.1 Specific tasks for Phase II	9
1.3.2 Project management in Phase II	9
1.4 This report	10
2 Assessing the feasibility of asset protection — the approach	11
2.1 Tier 1 assets for feasibility assessment	11
2.2 Selecting goals for feasibility assessment	12
2.3 Identifying the biophysical threats	12
2.4 Assessing the technical requirements and costs of achieving the goal	15
3 Results	16
3.1 Biodiversity assets	16
3.1.1 Introduction	16
3.1.2 Achieving the goal — recharge or discharge management	17
3.1.3 The technical feasibility and economic cost of conserving biodiversity in the assets	17
3.1.4 Categorising the assets	20
3.1.5 Benefits of intervention for neighbouring agricultural land	22
3.1.6 Interpreting the results	22
3.1.7 A second assessment	24
3.1.8 Provisional analysis, conclusions and recommendations	25
3.2 Water resource assets	26
3.2.1 Introduction	26
3.2.2 Collie Water Resource Recovery Catchment	26
3.2.3 Denmark Water Resource Recovery Catchment	28
3.3 Rural town assets	29
3.3.1 Introduction	29
3.3.2 The nature of townsite salinity	30
3.3.3 Options in managing townsite salinity	31

3.3.4	The costs and benefits of managing salinity in 16 towns.....	31
3.3.5	Categorising the towns.....	33
3.3.6	Recommendations for all towns	35
3.4	Roads and railways.....	35
3.4.1	Roads.....	35
3.4.2	Railways.....	36
3.4.3	Summary — the costs of direct intervention to protect biodiversity, water and infrastructure assets	36
3.5	Salinity management on agricultural land	38
3.5.1	The value of private investment in salinity control	38
3.5.2	The role of industry development	39
3.6	Applying the SIF in the Avon region.....	46
4	Conclusions	47
4.1	Strategies for investing in salinity management	47
4.1.1	Direct investment in protection of particular assets	47
4.1.2	Industry development	47
4.2	The Salinity Investment Framework.....	48
4.2.1	The value of the SIF analysis	48
4.2.2	Limitations of the analysis	49
4.3	Future work.....	49
5	Recommendations.....	51
	References	52

Appendices

1	- Key assumptions in the methodology.....	55
2	- Calculating private benefits of protecting biodiversity and water resources.....	57
3	- Assessment of the value of industry development in addressing salinity threats.....	67
4	- Biodiversity asset priorities — Threatened species and communities	72
5	- Assessment across assets.....	77

Figures

1.	Forms of investment in salinity management.....	38
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Tables

1. Tier 1 asset items	12
2. Assessing biophysical threats to biodiversity and water assets	14
3. Protecting existing biodiversity.....	19
4. Comparing all biodiversity assets for technical success and treatment cost per hectare.....	20
5. Comparison of all biodiversity landscape assets for technical success and total treatment costs over a 30-year period	21
6. Comparing costs of second study with first study	25
7. Costs and benefits of recovery in the Collie Water Resource Recovery Catchment.....	27
8. Costs and benefits of recovery in the Denmark Water Resource Recovery Catchment	29
9. Summarised status for each town.....	33
10. Comparing towns for time until impact and BCR	34
11. Direct investment for high priority assets	37
12. Summary of base scenario for protection of 30 biodiversity assets	44
13. Summary of potential savings with new industries.....	45
A2.1 Impact of treatments on preventing salinisation on non-treated agricultural land	59
A2.2 Gross benefits from correcting dryland salinity	60
A2.3 Estimates of costs of salinity	61
A2.4 Three methods of valuing salinity impacts compared (\$/ha).....	62
A2.5 Costs of salinity depending on time of first impact.....	63
A2.6 Economic benefits to agriculture from investments in protecting biodiversity	64
A2.7 Area of land affected by saline seepage.....	65
A2.8 Options for recovery in the Denmark Water Resource Recovery Catchment.....	66
A3.1 Effect of reduced net cost of lucerne subsidy	68
A3.2 Saving with reduced years of pumping.....	69
A3.3 Cost summaries for base solution and assets subjected to high flow rates.....	70
A3.4 New industry benefits over a range of cost-share ratios (\$m)	71
A3.5 Per kL costs for selected assets	71
A5.1 Performance of decision tools in relation to principles for effective NRM	80
A5.2 Examples of principles/criteria for expert assessment and application.....	82
A5.3 Alternative projects ranked by selecting one funding scenario among four alternatives to meet the available funds (in this case \$4.8 million).	83
A5.4 Alternative projects ranked within asset categories, priority projects selected to meet the available funds (in this case \$4.8 million).....	84
A5.5 Types of criteria to assess asset values	85

Summary

Given the extent and consequences of salinity, and the resultant costs of its management, it is crucial to have a rigorous framework for prioritising salinity investments by governments. The *Salinity Investment Framework* (SIF) is designed to meet that need.

This report provides information about SIF and its application to key assets of state-wide significance that are threatened by salinity and demonstrates the applicability and importance of the SIF, and highlights some crucial implications for future salinity investment and policy development.

The results presented indicate that, if underlying trends in the development of salinity established in the last few decades (1975–2000) are maintained, the cost of protecting the 48 natural resource assets identified in Salinity Investment Framework Phase 1 as ‘high value and at high risk’ from salinity is \$950 million over 30 years. An additional cost of \$2.1 billion over 30 years was estimated for maintenance of at-risk road and rail.

The current cost of salinity to agricultural land is difficult to assess, but the current estimates are that the cost is approximately \$35 million per year, which could rise to between \$170 and \$260 million per year if the Land Monitor predictions eventuate.

The key lessons from the SIF are:

- Cost-effective salinity investments require systematic analyses, including consideration of the values of the assets under threat, the treatment options, their effectiveness, and their costs.
- Without a SIF-style analysis, there is high risk that low priority tasks will be undertaken.
- The current resources are only sufficient to protect a relatively small number of the top-priority assets.
- For the majority of threatened assets that cannot be protected by public funding for on-ground works, the key strategy is to ensure that profitable systems of salinity management are available so that commercial decisions at the farm scale can generate benefits at the catchment scale. ‘Industry development’ is the process of developing ways to treat salinity that are more cost-effective and can be adopted in the course of a typical farm business.

The Salinity Investment Framework

The development of the Salinity Investment Framework (SIF) was commissioned by the State Salinity Council in 2000 to guide public investment in salinity management initiatives at state, regional and catchment levels. The aims of the SIF are (a) to improve the cost-effectiveness of public investment in salinity management by directing funds to projects with the best potential to protect assets of high public value and (b) to consider strategies for supporting salinity management where direct investment in on-ground works cannot be justified.

Phase I of the SIF project was conducted from March 2002 with the results being published in an Interim Report in October 2003. Phase I developed an asset identification and prioritisation process and then used this to identify salinity-threatened assets of high importance at a state level within the following classes — biodiversity, water resources, agricultural land, rural infrastructure and social.

A key recommendation from Phase I was that a Phase II of the SIF project was necessary to identify *investment* priorities through further analysis of the *asset* priorities identified in Phase I. This recommendation was endorsed, Phase II followed directly from Phase I and the results are contained in this report.

Purpose of SIF Phase II

When the SIF Phase I Interim Report was published, the proposed products of Phase II were:

- a method for identifying assets of high-importance at regional scale
- a method for collecting feasibility information on high-importance assets at state and regional scales
- a process for deciding priority and importance between asset classes
- a process for determining the appropriate level of investment in industry development at state scale
- a process for making a final investment decision at regional scale
- a list of investment priorities for the state
- a list of investment priorities for the Avon Region.

To accomplish this, the work completed in Phase II focused on:

- developing a method to assess the feasibility of protecting assets through on-ground works and then analysing all assets of high-importance using this method
- developing a method for deciding where investment in industry development would be best applied
- asset prioritisation work in the Avon Region done in parallel with the development of a Regional Strategy for accreditation.

Phase II summary of results

It is emphasised that the cost estimates given below are based on a range of assumptions, and they cannot be adequately interpreted without reading the relevant report sections on each asset type where the limitations of the work are described.

Biodiversity and waterscape assets

The cost to meet the goals for all 30 biodiversity assets is calculated at \$854 million (present value over 30 years at 5% discount rate), with the range for individual assets being \$3 to \$121 million. The cost is not necessarily related to the size (area) of the asset, but reflects the level and nature of intervention required. Three of these assets were also defined as Tier 1 waterscapes¹.

Water resources

A range of options was assessed and costed for the two water resource assets (Collie and Denmark rivers). For the Collie River, the cost of the four options which gave the lowest salinity in the reservoir ranged from \$38 to \$68 million with Benefit Cost Ratios from 0.8 to 1.7.

¹ Lake Warden, Toolibin Lake and the Fitzgerald River were also defined as Tier 1 waterscapes

Rural towns

The salinity control cost for the 16 rural towns varied between \$0.49 and \$7.61 million (present value over 30 years at 5% discount rate) and the net benefits in terms of damage avoided by undertaking control measures varied from \$0.12 to \$7.45 million. Control costs within the towns indicate the potential impost on local government in implementing management measures and range from \$600 to \$4500 per head of population.

Road and rail infrastructure

Based on large-scale data, about 252 km of highways and main roads and 3850 km of local and unclassified roads are currently estimated to be affected by salinity. The total combined current annual cost is around \$21 million. However, 1194 km of highways and main roads and 22 960 km of local and unclassified roads have a high hazard (likely to be an overestimate). Allowing for the gradual increase in repair and maintenance of roads as salinity spreads, and assuming all affected roads are repaired, the present value of forecast road repair costs is \$1938 million, of which \$271 million is for highway and main road repairs. The present value of rail repair and maintenance is \$176 million.

Agricultural land

Current estimates are that the area on private land affected by salinity is likely to expand from the current 0.82 million hectares (ha) to an estimated 2.9–4.4 million hectares (McFarlane et al. 2004). However, if farmers act now to address their currently affected areas, it was assessed that it would be possible to recover 0.415 million ha of saline land, to prevent or delay salinisation of a further 0.445 million ha, and to actively manage 0.750 million ha of currently saline land using salt-tolerant species.

Consistent with the principles of the SIF, Government support for managing salinity on agricultural land should be delivered through two methods: (a) direct financial support for land-use change or engineering works where this contributes to protecting the highest priority Tier 1 assets, and (b) industry development, including research and development and infrastructure, to provide profitable new salinity management options for farmers themselves to implement.

Implications for investment

Assumptions and estimates used in these analyses are open to debate, and indeed such debate and re-analysis is a prerequisite to moving from this scale of analysis to implementation.

The results of this study emphasise the enormous cost that would be involved in fully protecting public assets from salinity, even if investment were limited to the highest-priority assets. The estimated cost of protecting the 48 Tier 1 (public) natural resource assets is \$890 million. An additional \$2.1 billion may be required to maintain roads and rail at risk. It should be emphasised that these costs will not all be realised until the full extent of salinity occurs.

The analysis from the SIF highlights the importance of undertaking systematic analyses, including consideration of the values of the assets under threat, the treatment options, their effectiveness, and their costs. Without a SIF-style analysis, there is a high probability that funds will be invested with low cost-effectiveness.

The targeting of funds to top-priority assets inevitably means that many assets will not receive direct funding support. This may include lower-priority public assets, and agricultural land that is not associated

with the top-priority assets. The strategy recommended for these cases is ‘industry development’, meaning the development of new technologies and land uses that allow private industry investment to produce salinity benefits in the course of undertaking profitable farming systems.

Even where an asset is considered to have a high public benefit and to require funding for on-ground works, local-scaled investigations will be needed to determine what investment mechanism would deliver the best salinity management outcome.

In summary, at the state level, the framework leads to support for changes on agricultural land in two ways. Firstly, through direct investment in changing management of specific farm land to protect specific priority assets, where such investment is cost-effective and, secondly, through industry development to create new technologies and land uses that allow farmers to farm more profitability and sustainably.

At the regional level, the framework may also support investment in innovative schemes and programs that address regional priorities, such as support for farming systems groups or for pilot schemes to investigate new farming practices.

Future work

It is intended that following publication of the Phase II Report, Regional NRM Groups and other key stakeholders who may wish to use the methods developed during SIF Phases I and II will be consulted to assess what form of ‘kit’ or information packages will enable them to use the data and analyses for their own investment prioritisation purposes.

Recommendations from Phase II

- Communicate the SIF Phase II analyses and methodology to key stakeholders and potential users, particularly NRM agencies and Regional NRM Groups.
- Further develop the SIF methodology and approach for salinity projects and for broader natural resource management application.
- Use the approach and methodologies for setting priorities for action and investment in managing salinity and natural resources at local, catchment and regional scales. Within reason, make the application of a rigorous but simple process a condition of funding.
- Analyse industry development opportunities.
- Based on the analyses contained in the report, encourage agencies, through the Senior Officer Group of state agencies involved in NRM (SOG) and Director General NRM meeting process, to jointly re-evaluate Government strategic direction and investment in the salinity area. Key considerations are:
 - Government to directly invest in implementing a number of targeted projects that protect high value, high threat assets (Tier 1).
 - Re-evaluate investment in salinity. The scale of direct investment required to achieve either recovery or containment for the high value, high threat assets is \$3.3 billion. There is a fundamental issue in salinity management of either protecting these assets with a substantial increase in funding or accepting that, with current resource allocations, adaptation will be required.

- Industry development is a vital component of the response to salinity that needs to be expanded to include technologies aimed at discharge management (e.g. beneficial use of abstracted saline groundwater and engineering approach) as well as technologies aimed at recharge management (perennial-based farming systems).
- In view of the potential of industry development to generate cost-effective options for salinity and the high cost of direct intervention, there needs to be targeted investment in industry development.
- Given the evidence of a drying climate across south-western Western Australia, the assumptions about the rate and ultimate extent of salinisation and related costings undertaken in this study need to be part of any re-evaluation.
- Invest in an ongoing watch and review of the feasibility assessment of high-value, high-threat (Tier 1) assets as new technologies are developed and as improved information about the assets becomes available.

1 Introduction

Governments have invested in the protection of plants, animals, wetlands, lakes, rivers, roads, rural towns and agricultural land from the threat of dryland salinity.

The SIF is about setting priorities for salinity investment according to need, the level of threat to our most important natural assets, saving our most important natural assets, and getting value for money. The aim of the framework is to improve the cost-effectiveness and impact of public investments in salinity management in Western Australia. The problem is, in effect, similar to the sorts of problems we all face in managing our household budgets: some desirable expenditures we treat as top priority for immediate investment, some are deferred, and some will never be affordable. In some cases we need to invest now to better meet our future needs.

The SIF process classifies natural and man-made assets into four main classes or domains: biodiversity, water resources, agricultural land, and rural infrastructure (towns and roads). Priorities are then assigned to each asset based on three main criteria: its value, the threat to it, and the feasibility of options available to protect it (including consideration of costs and treatment effectiveness).

The SIF is aimed at agency and regional groups working within the natural resource management context. State and Commonwealth agencies have been involved in accrediting regional NRM strategies which require regional groups to demonstrate a valid process for setting investment priorities. In these strategies the full array of threats to natural resources is considered. While the SIF methodology is suitable for setting priorities for salinity management, the general approach can be adapted to other resource management issues.

The principal aim of the SIF process is to create a robust methodology for prioritised, targeted investment integrated across asset classes to protect highly-valued assets threatened by dryland salinity using a decision-making process for assigning public funds which is open, transparent, accountable, transferable and, in particular, cost-effective.

This report documents a method for evaluating the feasibility of achieving defined goals for a set of high-value, highly-threatened assets — defined in the *Salinity Investment Framework Interim Report — Phase I*, published by the Department of Environment in October 2003 — using currently available salinity management techniques, and considers strategies for supporting salinity management where direct investment in on-ground works cannot be justified.

1.1 Principles in salinity investment planning

Eight principles, which were developed by the State Salinity Council after significant public and community consultation and participation, underpin the priority setting in the application of the SIF:

1. The top priority public investments are those which generate the greatest public benefits per dollar of public investment.
2. Direct financial assistance to landholders to undertake salinity action should be strategic and should not exceed the public benefits that result.

3. Where the priority is high and the net public benefits are sufficient, Government should be prepared to take strong action to ensure protection of the asset.
4. Where the public priority is low but there are extensive private assets at risk, public investment should be aimed at industry development.
5. Inevitably, a targeted investment strategy in salinity management will result in unequal distribution of investment across the State.
6. Government must fulfil its statutory obligations for land, natural resources and functions (such as research) when it sets its priorities for investment in salinity action.
7. The process required for priority setting will involve continuous learning and need constant feedback.
8. Setting priorities must proceed even when there is only limited or imperfect information about prevailing environmental, social and economic circumstances.

1.2 Salinity Investment Framework Phase I

The development of the Salinity Investment Framework (SIF) was initiated by the State Salinity Council in 2000 and strongly endorsed by the Salinity Taskforce in 2001 (Frost et al. 2001).

In March 2002, a Notice of Intent was signed by the Hon. Judy Edwards (Minister for the Environment and Heritage), Mr Alex Campbell (Chairman of the State Salinity Council), Mrs Barbara Morrell (Chair of the Avon Catchment Council) and Mr Robert Atkins (Acting Director for Regional Operations of the then Department of Environment). The Notice of Intent outlined the outcomes expected from application of the Salinity Investment Framework to the State (South West Agricultural Zone) and the Avon Natural Resource Management Region (also referred to as the Avon Basin).

To create a Salinity Investment Framework at state and regional scale \$366 000, from the Alinta Gas Fund, (later to be part of the National Action Plan for Salinity and Water Quality) was allocated by the Western Australian Government to undertake a project to develop:

- a priority listing of projects for the Avon NRM region
- a documented SIF process that works
- an evaluation of the process as applied during the trial
- a set of guidelines on how to implement the process
- criteria used in the analysis to make a decision
- details of information sets needed to make decisions
- skills required by the people involved
- the approximate cost of implementing the process.

1.2.1 Summary of the work completed in Phase I of SIF

The SIF process was used to identify important natural assets which fall into four main classes: biodiversity, water resources, agricultural land, and rural infrastructure such as towns and roads. Priorities were then assigned based on three main criteria — the value of the natural asset, the threat to it, and the feasibility of options available to protect it. Work on the Salinity Investment Framework commenced in 2001 and resulted in the following achievements:

- a) creation of a Steering Committee to manage the process. It has involved people from community groups and agencies including the Avon Catchment Council; the Conservation Council; the Departments of Agriculture, Conservation and Land Management, and Environment; and the University of Western Australia. Natural Resource Management Council member Rachel Siewert chaired the team². This strong multi-agency and community-based team appreciates the challenging nature of the task and is committed to producing tools to help achieve accreditation of the regional plans required under the National Action Plan for Salinity and Water Quality. The then Department of Environment coordinated the SIF project.
- b) development of an over-arching process for identifying high-importance assets based on value and threat information and its application across the state's South West Agricultural Zone
- c) development of individual processes for identifying salinity-threatened high-importance assets in the following classes: biodiversity, water resources, agricultural land, rural infrastructure and social. For each asset class, broad groups of high-importance, or 'icon' assets, were identified at State (South West Agricultural Zone) level.
- d) commitment by the Avon Catchment Council to use similar processes for identifying strategic directions for investment through the NRM Strategy being prepared for the Avon NRM
- e) release by the Minister for Environment in October 2003 of the report *Salinity Investment Framework Interim Report — Phase I* (Department of Environment 2003) in which assets were allocated to three tiers, with 'Tier 1' assets being the most valuable and at the highest risk from salinity.

1.3 Salinity Investment Framework Phase II

Phase II identifies our ability to achieve the management goal for each asset — recover from salinity, contain salinity or adapt to salinity. To do this there was a simple desktop appraisal of the technical feasibility — in terms of engineering or vegetative intervention options — for the high-value and high-threat (Tier 1) assets. The intervention options have been costed and the Tier 1 assets prioritised according to the potential success of intervention options (high, medium, low) and cost (high, medium, low).

The other matter addressed in Phase II was 'industry development'. While the SIF project addresses how to save public assets with public money, the 'industry development' work assesses how to protect private agricultural land with indirect support. This support will include defining industry development, encouraging the adoption of new land-use practices, and identifying untapped opportunities, spin-offs and policies to support innovation. (Section 3.5 covers this topic in greater detail.) It is emphasised that successful industry development, where sustainable and environmentally-benign, is also essential to protect public assets.

Also as part of Phase II, the SIF State Steering Committee worked with the Avon Catchment Council to apply the SIF at a regional scale. The aim was to support the Avon Catchment Council with their strategic direction for investment through the NRM Strategy. The process developed by the Avon Catchment Council is detailed in Section 3.6 of this report.

² Ms Siewert resigned this position after her election as a Senator for Western Australia in the 2004 Federal election.

1.3.1 Specific tasks for Phase II

When the SIF Phase I Interim Report was published, the proposed products from Phase II were:

- a method for identifying assets of high-importance at regional scale
- a method for collecting feasibility information on high-importance assets at state and regional scales
- a process for deciding priority and importance between asset classes
- a process for determining the appropriate level of investment in industry development at state scale
- a process for making a final investment decision at regional scale
- a list of investment priorities for the state
- a list of investment priorities for the Avon Region.

To accomplish this, the work completed in Phase II focused on:

- developing a method to assess the feasibility of the ‘treatment’ of assets and then applying the method to Tier 1 assets defined in Phase I
- analysis of the role for investment in industry development
- asset prioritisation work in the Avon Region done in parallel with the development of a Regional Strategy for accreditation.

1.3.2 Project management in Phase II

The Steering Committee from the State Natural Resource Management Council that initiated the SIF process and prepared the *Salinity Investment Framework Interim Report — Phase I* also commissioned Phase II. The SIF Steering Committee included two representatives from the Council, Rachel Siewert (Chair) and Neil Young. Barbara Morrell (Chair of the Avon Catchment Council) represented the Regional Groups. Professor David Pannell provided expertise as a resource economist and because of his extensive work on prioritising investment for salinity management (Pannell 2001). The three agencies involved were represented by John Ruprecht (then Manager, Salinity and Land Use Impacts Branch, Department of Environment), Dr Bob Nulsen (Manager, Natural Resources, Department of Agriculture) and Ken Wallace (Manager, Natural Resources Branch, Department of Conservation and Land Management). Dr Michael Burton and Jonelle Black of the University of Western Australia were advisers to the Committee. The Executive Officer during Phase II was Louise Stelfox and Project Manager was Tim Sparks, both now of the Department of Water.

The Project Team, established to coordinate the tasks in Phase II (presented in Section 1.2) and coordinated by Louise Stelfox consisted of:

- Drs Bob Nulsen and Richard George (Department of Agriculture), supported by Ross Kingwell, Janette Hill-Tonkin, Russell Speed and John Simons
- Ken Wallace and Rod Short (Department of Conservation and Land Management)
- John Ruprecht and Tim Sparks supported by Nick Cox and Peter Muirden
- Professor David Pannell (University of Western Australia).

Activities undertaken included appointing URS Australia Pty Ltd as consultants to the Project Team to undertake the feasibility assessment (see URS 2004a) and investigations on agricultural land and rural infrastructure by the Department of Agriculture (George et al. 2005). Biodiversity work by the Department of Conservation and Land Management that began before SIF, and then continued in parallel (Wallace et al. 2003), has also contributed to the development of methodologies. The assessments of feasibility for water resource assets relied on the published salinity situation statements for the Collie and Denmark rivers (Mauger et al. 2001; Bari et al. 2004).

1.4 This report

Section 1 introduces the SIF project and explains the transition from Phase I to Phase II.

Section 2 presents the conceptual approach used in assessing the feasibility of protecting the assets.

Section 3 presents the findings from the analysis of the assets and a discussion about the opportunities for industry development as a complement to direct intervention (i.e. funding on-ground works).

Section 4 documents conclusions and recommendations for further work.

Section 5 documents references.

Appendices provide supporting detail about the analyses of feasibility in the different asset classes.

2 Assessing the feasibility of asset protection — the approach

‘Feasibility’, which is the focus of this SIF Phase II Report, is defined as *the extent to which an asset can be protected from salinity*, and requires:

- confirmation of the goal or goals for the asset(s) in question
- assessment of the biophysical threats to the asset(s)
- assessment of the technical capacity to manage the assets in light of the biophysical threats, including an assessment of costs to manage
- assessment of the socio-political will/capacity to apply adequate resources to achieve the goal for the asset(s).

In Phase I of the project, assets were categorised into three levels of value-salinity threat, with Tier 1 assets having the highest values and salinity threat.

In Phase II, the feasibility of protecting the Tier 1 assets defined in Phase 1 were assessed using the first three criteria. The fourth criterion was considered to be more appropriate for the next stage of assessment.

2.1 Tier 1 assets for feasibility assessment

These assets were defined and listed in the *SIF Interim Report – Phase I* (Department of Environment 2003). The location of their descriptions is shown in Table 1.

There were some revisions to this list in deciding a final number for initial feasibility analysis:

- The biodiversity listing was reduced to 30, through the amalgamation of Target Landscape (TL) 80 with Lake Bryde, and TL82 with Dunn Rock–Lake King. In both situations the assets overlapped significantly.
- One of the waterscape assets — Swan–Avon — was deleted from the list, and given that the other three waterscape assets (Lake Warden, Toolibin Lake and the Fitzgerald River) were included as biodiversity assets, they were considered in that analysis (URS 2004a).
- The rural towns listing was altered to delete Mullewa, and include Tambellup, Boddington and Perenjori to ensure a better spread of towns across the agricultural areas.
- Road and rail infrastructure were included in the analysis, with the lengths of these assets in different classes currently affected and ‘at risk’ estimated using salinity-prediction data (see George et al. 2005).

Table 1. Tier 1 asset items

Domain	Number and type of asset items included in Tier 1	Source in SIF Interim Report – Phase 1*
Biodiversity	32 representative landscapes (including current and potential natural diversity catchments ^a . Note also that threatened species and communities, where threatened by salinity, are also Tier 1 assets (see biodiversity section below for details).	Figure 2.2, p. 75
Water resources	3 waterscapes (also identified as biodiversity assets) 2 water supplies: Denmark and Collie Water Resource Recovery Catchments	Addendum 1
Infrastructure	Rural town infrastructure: estimated as the 16 highest-ranking towns on population size and time to impact. Linear infrastructure: roads and rail in the agricultural areas	Table 4.4 p. 114 See George et al. (2005)
Agriculture	Agricultural land associated with the assets above. A proportion of that land would be treated with plant-based systems or engineering works	See comments in the text above. See George et al. (2005)

*Department of Environment (2003)

^a This number was reduced to 30 after initial analysis

2.2 Selecting goals for feasibility assessment

Feasibility can only be assessed in terms of a goal or goals for specific asset(s). The relevant goals are specified below with the summary for each asset type.

- *Biodiversity*: The goal adopted for the catchment scale was ‘containment’; that is, to protect the existing suite of biodiversity in its existing condition within each asset.
- *Water resources*: The goal adopted was ‘recovery’, with specific targets in place for water quality improvement to potable standards.
- *Rural town infrastructure*: The goal adopted was ‘recovery’ where town infrastructure is already being affected by rising saline groundwater, and ‘containment’ where rising groundwater has not yet affected roads and buildings.
- *Linear infrastructure*: The goal adopted was ‘recovery’ where roads and railways are already being affected by rising saline groundwater, and ‘containment’ where rising groundwater has not yet affected this class of infrastructure.
- *Agricultural land*: Where land management was changed to protect a high-priority asset, the goal corresponded to the goal of that asset. In the analysis undertaken at land-zone scale, the goal was ‘recovery’, ‘containment’, or ‘adaptation’ depending on expert assessment.

2.3 Identifying the biophysical threats

Once the goal has been selected, the next step in the feasibility analysis is to assess the biophysical threats to an asset or group of assets that would prevent the relevant goal(s) being achieved. Under SIF Phase I, the only biophysical threat considered was salinity.

However, from the outset, it has been recognised that the Salinity Investment Framework is limited by only dealing with one biophysical threat, salinity, to the assets being managed. To effectively assess the

feasibility of managing an asset threatened by salinity, it is essential to at least review the other existing and potential biophysical threats. This is because one or more threats may have a significant effect on management outcomes.

For example, while it may be feasible to protect a wetland biodiversity asset from salinity, it may be much more difficult to prevent an invasive weed destroying its key biodiversity elements. In this case, it would make little sense to work on controlling salinity without also being confident that the invasive weed could be managed. Or, for example, a potable water asset may be threatened by both salinity and potential pollution from a developing land use. Once again, one would need to be confident that both threats could be managed adequately before embarking on an expensive program of salinity works.

Table 2, based on threat analysis techniques described in Wallace et al. (2003), was developed during this project as a means of accounting for other biophysical threats in relation to biodiversity and water assets. The table provides a framework for an expert, desktop analysis of the probability that threats will prevent goal achievement in relation to a specific asset over a specified time period.

While this component of the feasibility analysis has not been undertaken the table has been included as an example of how identification of biophysical threats could be done.

Table 2. Assessing biophysical threats to biodiversity and water assets

Threat category	Management issue (examples)	Column A ^a	Column B ^b	Column C ^c
Altered biogeochemical processes	Hydrological processes, particularly salinity. Nutrient cycles, including eutrophication Carbon cycle and climate change	1.0		
Impacts of introduced plants and animals	Environmental weeds Feral predators Preventing new introduction of damaging species Grazing by stock Competition for food and shelter (other than as above, and includes habitat damage by pigs)			
Impacts of problem native species	Parrots Defoliation by scarab beetles, lerps, etc.			
Impacts of disease	Dieback (<i>Phytophthora spp</i>) <i>Armillaria</i>			
Detrimental regimes of physical disturbance events	Fire Cyclones Flood Drought Erosion (wind and water, includes sedimentation)			
Impacts of pollution	Recreation management			
Impacts of competing land uses	Agricultural impacts (other than as already dealt with above) Forestry Illegal activities (e.g. rubbish dumping) Mines and quarries			
An unsympathetic culture	Attitudes to saving assets from salinity threats, conservation values & their contribution to human quality of life			
Insufficient resources to maintain viable populations/ asset value	Destruction of habitat (food, water shelter, oxygen, access to mates) Land clearing Removing buffer/riparian vegetation			

^a Column A: Probability that threat will cause goal failure with existing management

Probability that threat issue will cause goal failure with current management inputs: Spatial and temporal scales fixed as a basis for the probability analysis. The question being asked here is, 'Without additional management to that currently occurring, what is the probability that the specific threat-issue will result in non-achievement of the goal?' It is proposed that probabilities of greater than 0.25 need careful consideration with regard to the feasibility of their management.

^b Column B: Probability threat will cause goal failure with extra management

Probability that threat issue will cause goal failure with additional management inputs. The question being asked here is, 'What is the probability that, given a modest increase in management resources, the specific threat-issue will result in non-achievement of the goal?' It is proposed that probabilities of 0.2 or less represent a reasonable level of risk.

^c Column C: Assumptions underlying probability assessments

2.4 Assessing the technical requirements and costs of achieving the goal

Determining the feasibility of a salinity management option for an asset item requires consideration of some important aspects:

- How much will the management option cost?
- To what extent is it technically feasible to protect the asset from the most significant threats?
- Will the option achieve the goal?
- How long will it take for the goal to be achieved?
- Will the option be implemented or be supported by surrounding land managers?

The following specific tasks in assessing feasibility in relation to salinity were identified in the scope of work provided to URS Australia Pty Ltd in January 2004:

- Collate the required data and knowledge from government agency staff, maps and published literature.
- Establish the pressure and threats on each state asset in the south west agricultural zone.
- Ascertain the goal or goals for each asset with respect to salinity, i.e. contain / recover / adapt.
- Establish the options for intervention required to arrest the impact of salinity.
- Cost the intervention options.
- Provide provisional analyses and recommendations.
- Present the findings to the government agencies' working group of 'experts' at two meetings.
- Produce a draft and final report.
- Record all decisions, no matter how rough, to ensure a justifiable, auditable and transparent trail.

Subsequent to the completion of those tasks, the following were authorised in a additional scope of work in May 2004:

- Analyse the private benefits flowing to agricultural land in the vicinity of biodiversity and water resource assets that will occur as a result of the public investment in protecting/enhancing those assets.
- Determine the benefits from improving water quality in the Denmark River catchment.
- Determine the comparative value of industry development as a driver of land-use change that will be beneficial in achieving goals for public assets.

The next section documents the results of these 12 tasks. The main assumptions used in the analysis are presented in Appendix 1.

3 Results

3.1 Biodiversity assets

3.1.1 Introduction

During SIF Phase I, three types of biodiversity asset priorities were identified:

- *Threatened species*: rare³ plants and animals that, following assessment by a formal, State process, have been endorsed by the Minister for the Environment as needing special management action.
- *Threatened communities*: rare communities that, following assessment by a formal, State process, have been endorsed by the Minister for the Environment as needing special management action.
- *Representative landscapes*: living assemblages or communities of native organisms that contain representative samples of regional or subregional biota. Under SIF Phase I, both an expert panel and quantitative process were used to select the group of landscapes that are most threatened.

Although there is a range of other asset types — remnant natural environments, icon species, genetic diversity — that need to be considered in further developments of the SIF, only these three types were considered in SIF Phases I and II (see Phase I report for more detail concerning other assets and the selection processes used).

In the case of threatened species and communities, there are well-recognised processes for establishing priorities. Therefore, under Phase II, the only additional work undertaken was to establish threatened species and communities with occurrences at risk from high watertables and potentially, therefore, salinity. This generated lists of particular species and communities whose conservation should, as a matter of priority, be targeted for public investment. The lists and further details concerning threatened species and communities are provided in Appendix 4.

During Phase 2, the majority of effort focused on assessing the feasibility of managing the Tier 1, representative landscape assets identified under Phase 1. Within this categorisation, all were deemed to be of equal value in respect of their biodiversity values.

The Department of Conservation and Land Management defined the goal for each asset as being ‘To maintain the current species richness of the defined biodiversity asset for 30 years’. This containment goal focused attention on the asset only, and, although it was obvious that the scale of intervention could have positive impacts on the surrounding agricultural land, these secondary benefits of intervention were not calculated initially, or off-set against the total cost of intervention. The analysis and results reported are based on the work of URS (2004a).

The goal used provided the consultants evaluating feasibility with a clear goal for each specific asset. Note that the goal is aligned with a specific timeframe so that biophysical-threat analyses and related evaluations can be implemented. It is emphasised that, while this specific goal is one of containment, the intention would be to proceed to recovery if successful and sufficient resources are available.

³ The term ‘rare’ is generally used for something that is uncommon or unusual. This is the sense in which it is used here, and not the statutory meaning defined under the *Wildlife Conservation Act 1950*.

Also, an important aim for assessing biodiversity assets under SIF Phase II was to create a dataset that enabled relative comparisons to be made among all the representative landscapes. For this to be done, it was essential to apply a common goal across all assets. In practice, the goals for different representative landscapes will vary, and may be any one of the following depending on circumstances:

- Recovering species richness (or some other measure of species abundance, distribution and condition)
- Maintaining species richness (or some other measure of species abundance, distribution and condition)
- Slowing the rate of decline of species richness (or some other measure of species abundance, distribution and condition)

Therefore, to assess the relative feasibility of managing representative landscapes it was essential to state a single goal for all areas to ensure that results were accurate in relative terms.

3.1.2 Achieving the goal — recharge or discharge management

The first-order decision was in determining whether the intervention should deal mainly with catchment-wide recharge management, or mainly with targeted discharge management to remove water from the asset.

- For those assets where the main focus is on catchment-wide intervention, land-use change and surface water management was modelled to address *recharge management*. In general, recharge management was the main approach chosen for assets located west of the Meckering Line in the Zone of Rejuvenated Drainage, and along the south coast within the river systems such as the Pallinup, Fitzgerald, Young, and Lort rivers. Recharge management includes land-use change to higher water-using vegetation, and surface water management. The former will use soil moisture before it has the opportunity to go beyond the root zone to recharge groundwater stores.
- For those assets where the main focus is on targeted water removal from the asset, engineering intervention and perimeter plantings were modelled to address *discharge management*. In general, discharge management was the main approach chosen for assets located east of the Meckering Line, in areas with poor external drainage and catchments with low lateral groundwater flows. Discharge management included drains, production bores and surface water management.
- In nearly all cases, surface water management was modelled to redirect potential recharge away from assets, with discharge elsewhere in the environment. Surface water management is applied to approximately 2 km around and/or upslope from threatened vegetation in the asset, to capture overland flow and redirect it away from the threatened vegetation before it can recharge either in or close to the vegetated area. It is assumed that harvested surface water is directed out of the asset, and being fresh can enter either lakes or streams lower in the catchment. Alternatively it will be evaporated *in situ*. It is likely that surface water management and land-use change would occur on the same land area.

3.1.3 The technical feasibility and economic cost of conserving biodiversity in the assets

The assessment for each asset is shown in Table 3, which is drawn from URS (2004a). The estimated present value of costs to government to protect all 30 assets over 30 years is \$854 million, comprising

\$525 million for engineering options and \$329 million for achieving land use change. Planning and management costs total \$197 million. The cost per asset ranges from \$121 million for the Kojonup–Beaufort–Carrolup Flats to \$3 million for Target Landscape (TL) 67 (North Munglinup).

As described in later sections (3.1.6 and 3.1.7) there were obvious difficulties in undertaking this rapid ‘desktop’ assessment across a large number of assets using limited data. It is essential that the qualifications associated with interpreting this analysis outlined in Section 3.1.6 and the findings from the second analysis completed on a sub-sample of assets described in Section 3.1.7 below are understood before attempting to interpret these data. It is not valid to directly use this information as stand-alone findings.



Table 3. Protecting existing biodiversity

Asset	Area (km ²)		Main approach to management	Cost to Government (PV 30 years @ 5%)		Rating of technical success
	Asset	Catchment		Total \$M	Cost/ha (\$)	
TL46 (Yarra Yarra South)	880	3 130	Discharge/p*	29.59	336	Moderate
TL67 (N. Munglinup)	790	1 200	Recharge	2.61	33	High
TL80 (L. Bryde)	502	1 880	Discharge/p	58.41	1 163	High
TL91 (E. Pallinup)	384	1 260	Recharge	17.82	463	Moderate
TL92 (Wellstead)	856	3 060	Recharge	41.21	481	Low
TL94 (Young R)	2 270	3 900	Recharge	38.22	168	Low
Yinniebatharra	146	1 270	Recharge	12.29	840	High
Coonderoo–Moore	923	6 840	Recharge	15.43	167	Moderate
Mollerin Lakes	140	1 110	Discharge/p	25.86	1 849	Low
Mortlock River	27.6	1 340	Discharge/p	16.37	5 935	High
Kondinin Salt Marsh	192	2 620	Discharge/p	7.64	399	Low
Cowcowing Lakes	256	1 000	Discharge/p	4.74	185	Moderate
Kent Road	74.4	1 010	Discharge/p	29.79	4 003	High
TL 82 (Dunn Rock–Lake King)	903	3 430	Discharge/p	50.73	561	Low
Magenta	1 080	2 050	Discharge	11.75	109	Moderate
Chinocup	406	2 380	Discharge/p	40.13	988	Moderate
Fitzgerald River ^a	350	831	Discharge	10.21	293	High
Darkin Swamp	370	552	Discharge	7.83	212	High
Boyup Brook	156	404	Recharge	9.50	610	High
Kojonup-Beaufort	184	2 070	Discharge/p	121.50	6 616	Moderate
Coyrecup	95.4	1 230	Discharge/p	43.07	4 516	High
NE Stirling Ranges	332	1 450	Recharge	21.39	644	Moderate
Upper Lort River	1030	2 840	Recharge	26.02	253	Moderate
Lake Gore	19.1	1 480	Discharge	23.02	12 023	Low
Lake Champion	219	1 480	Discharge/p	25.66	1 169	High
Buntine–Marchagee	200	1 800	Discharge/p	89.21	4 450	High
Drummond	98.3	380	Recharge	8.19	833	High
Muir–Unicup	290	600	Recharge/p	9.24	318	High
L. Toolibin ^a	41.3	490	Discharge/p	6.71	1 623	High
L. Warden ^a	352	1 720	Discharge/p	50.24	1 427	Low
Total	13 567	54 807		854.38		

p* Denotes groundwater pumping modelled

^a Also waterscape asset

The scale of the investment to protect biodiversity needs to be put into context. The collective area of the assets is 1.36 million hectares.

An alternative approach to considering treatment costs is to consider the cost per hectare which accounts for the very large variation in asset size. Calculating this measure shows that, for most of the assets (18/30), the cost of protecting the biodiversity lies between \$100 and \$1000 per hectare. However, these numbers are almost certain to conceal significant errors; for example, in the:

- assessment of groundwater rise in the absence of data
- characterisation of the catchment and its response to different treatments
- cost and effectiveness of nominated land uses in specific locations
- assumptions about disposal options for abstracted groundwater.

The main use of these data should be to show the rank order of assets for economic and technical feasibility, highlighting those that need further analysis.

3.1.4 Categorising the assets

In Table 4 and Table 5 below, the biodiversity assets are ordered by the subjective assessment of technical success/sustainability, the cost per hectare of intervention, and the total cost for each asset. Tables in the Appendices present the information for the assets in each of the natural resource management regions. The assessment of technical success applies only to *threatened* sections of the asset, although the costing is spread across the whole area. In several cases, a large proportion of the asset is not threatened, requiring no intervention (e.g. Magenta, TL46, Fitzgerald River). Inclusion of these areas in the total asset reduces the calculated cost per hectare.

Table 4. Comparing all biodiversity assets for technical success and treatment cost per hectare

Costs	Rating of technical success		
	High	Moderate	Low
< \$500/ha	TL 67 (N. Munglinup)	TL 46 (Yarra Yarra South)	
	Fitzgerald River*	Coonderoo–Moore	TL92*
	Darkin Swamp*	Cowcowing Lakes	TL94 (Young River)*
	Muir–Unicup*	Magenta*	Kondinin Salt Marsh
		Upper Lort River	
Cost of intervention (PV 30 yrs @ 5%) \$500–1000/ha	Yinniebatharra	Chinocup	TL 82 (Dunn Rock–Lake King*)
	Boyup Brook–SE Collie*	NE Stirling Ranges	
	Drummond*		
> \$1000/ha	TL 80 (L. Bryde)		
	Mortlock River		
	Kent Road		Mollerin Lakes
	Coyrecup	Kojonup–Beaufort	Lake Gore
	Lake Champion		Lake Warden #
	Buntine–Marchagee		
	Toolibin Lake		

* Extensive areas of asset not threatened

Recent work at Lake Warden suggests that the asset may be treated with a high level of technical success at a much cheaper per ha cost than indicated here.

The allocation of assets in the table suggests that successful intervention in difficult situations is possible with high investment per hectare. Many of the assets in the ‘high’ success and ‘greater than \$1000 per

hectare' category are already quite seriously affected and will probably need groundwater pumping to achieve protection. At the other end of the cost scale are some assets that are already well vegetated, lie in externally-drained catchments, and where land use change will be beneficial and cost-effective.

Where intervention in any asset is relatively expensive and is estimated to have less than 'High' success/sustainability (e.g. Kojonup–Beaufort, Mollerin Lake), focusing attention on those parts of the asset that are either not threatened, or sites within the asset where intervention has a comparative advantage over less favourable parts of the asset could be considered. Determining where those areas occur will require further investigation and analysis. Note that the cost of work at Lake Warden is much less, and the success rating high, in the light of knowledge more recent than that used in this analysis. This highlights that the numbers derived from a desktop study must be treated as only a very broad indication. A good understanding of the relevant hydrological functions in relation to assets is an essential prerequisite for an effective feasibility analysis.

Table 5. Comparison of all biodiversity landscape assets for technical success and total treatment costs over a 30-year period

Total estimated management costs over 30 years (\$millions)	Technical feasibility		
	High	Moderate	Low
0–20	TL67 (N. Munglinup) Fitzgerald River Darkin Swamp Boyup Brook Drummond Muir–Unicup Toolibin Lake Yinniebatharra Mortlock River	Cowcowing Lakes TL91 (E Pallinup) Coonderoo–Moore Magenta	Kondinin Salt Marsh
21–40	Kent Road Lake Champion	TL46 (Yarra Yarra South) NE Stirling Ranges Upper Lort River Chinocup	Mollerin Lakes Lake Gore TL94 (Young R)
41–60	Coyrecup TL80 (L. Bryde)		TL92 (Wellstead) TL82 (Dunn Rock–Lake King) L. Warden
> 60	Buntine–Marchagee	Kojonup–Beaufort	

Another means of analysing the data is shown in Table 5 where Table 4 is reworked using the total cost of protecting an asset over 30 years, rather than the cost per hectare of asset. This second table is a more useful approach once the actual relative values of the assets themselves have been more accurately assessed because the areas of the assets do not have a linear relationship with the values of the assets. An asset that is relatively small in area may have a significantly greater value than a much larger (by area) asset.

3.1.5 Benefits of intervention for neighbouring agricultural land

Recent work has shown that the spatial impact of treatments located to reduce recharge or accelerate discharge is limited in extent if the treated area of a catchment is a low percentage of the total, or treatments are applied on a site-by-site basis. In the case of groundwater abstraction or deep drainage, drawdown occurs over a distance that may range from tens of metres to a few hundred metres from a bore or a drain, depending on factors such as the soil type and the position in the landscape. Woody and herbaceous perennial plantings can result in lowered groundwater levels below the treatments (as a result of reduced recharge), but in many landscapes the effect can only be detected close to the edge of the treatment (George et al. 1999). This is particularly the case where the transmissivity of the soil and regolith is low, and the landscape is relatively flat, as occurs east of the Meckering Line. The treatments are located to assist in managing the salinity threat to the asset: they are not located specifically to help prevent or ameliorate salinity impacts on agricultural land. The underlying assumption is that the treatments will be located as close to the asset as possible, or in the case of groundwater abstraction, within it.

On this basis, treatments to address salinisation of biodiversity assets will have limited impact on agricultural productivity away from the immediate area of implementation. In effect, spillover benefits are judged to be relatively small.

Information on areas of agricultural land protected from current or potential salinity impacts was combined with the appropriate discounted value for the economic benefit per hectare to the landholder to generate present values for salinity benefits to agriculture occurring as a result of the public investment in protecting/enhancing the assets. The calculation of economic benefits is shown in detail in Appendix 2.

The present value of the benefit for agricultural lands is estimated at \$51 million, which represents 5.6% private 'added' return on the total public investment of \$854 million committed to protection of the existing suite of biodiversity in these assets.

This low rate of return results from the generally limited impact of land-use change on agricultural land outside the area treated, and because the interventions are specifically targeted at protecting the biodiversity asset at risk, not agricultural land at risk. The most effective treatment in providing benefits to landholders is surface water management where the average benefit is estimated at \$190 (present value) per hectare, ranging from a low of \$106 per hectare to a high of \$306 per hectare. In most cases the private return compares favourably with the cost for implementing surface water control works of \$150 per hectare. The implication is that landholders could be expected to meet all or most of the costs of this treatment, which would reduce the cost to the government by about \$40 million — a 4.5% saving on the total cost.

Finally, it should be noted that the above calculations do not take into consideration non-salinity benefits of treatments, such as erosion control or stock protection.

3.1.6 Interpreting the results

A sensible interpretation of the results shown above in Table 3 requires that the context of the work and its limitations are fully understood. The key points are outlined below.

Firstly, to conduct a full feasibility analysis that included hydrogeological investigations would cost some \$500 000 per asset. This figure is based on experience with existing natural diversity recovery

catchments. It is not worth going to this level of expenditure until preliminary analyses have identified with confidence the top few candidates for selection and we are sure that we will use the work for planning actual on-ground works at some future time. In this context, the major outcomes of URS' work on biodiversity landscape assets are:

- a. a tested and developed desktop method for doing a feasibility analysis. This is a very important outcome in itself. Advantages of the method are that it is not scale-dependent and can be applied with a lot of, or little, information. Furthermore, the method may be readily adapted with new knowledge because it has clearly stated assumptions. Developing a method has also resulted in some consensus amongst hydrologists concerning the best salinity management tools for particular situations. Additional work by URS as part of a linked contract (URS 2004b) has also underlined some of the problems with a desktop study.
- b. estimates of the *relative* costs today of managing alternative, representative landscapes. The immediate task of SIF Phase II is to rank for management action a set of alternative landscape options. The accuracy of management costings is not as important as gaining a reasonably accurate picture of the *relative* costs (obtaining precise costings would be prohibitively expensive). However, note comments below on the accuracy of relative cost estimates.

Secondly, while the work provides indicative costs, without detailed knowledge of local hydrological systems, it is not possible to be confident of the solutions chosen in a desktop exercise. In addition, the biodiversity assets within landscape management units (catchments) were often poorly defined.

Both of these limitations have the following important consequences for the direct applicability of the consultancy work:

- a. In the case of at least one of the existing natural diversity recovery catchments — Buntine–Marchagee — the option of redefining the biodiversity asset to include, after research, only the most important areas for biodiversity, is being considered. This will almost certainly result in restricting on-ground works to a few of the highest-value assets within the catchment, with a significant reduction in management costs. This approach will be followed in other areas where the biodiversity asset is diffuse — for example, spread over a very large number of wetlands in a braided drainage system.
- b. At least some of the assumptions that have been used to generate the data will need to be amended in the light of new knowledge from on-ground planning. This will have significant implications for overall costs that may, as a result, either significantly increase or decrease. Even if the assumptions are valid, the actual on-ground situation may change costs dramatically. For example, the process used has rated both Lake Gore and Lake Warden as 'high cost' and as having a 'low technical success' using standard intervention methods (see Table 4). In practice, it is likely that both Lake Gore and Lake Warden may be successfully managed using mainly surface drains and pumping to the ocean with some revegetation in identified critical areas. The costs for this will be much less than that predicted by the consultants, and there will be a high probability of success. Large-scale interventions, such as pumping in the higher parts of the catchment, while valid, appear not to be required given current detailed knowledge (not available to URS) and understanding of processes. Thus these very expensive options would only have a minor role in the recovery of these two lakes.

The degree to which costs may change is shown by the amended estimated costs following a more sophisticated examination of five natural diversity recovery catchments by URS (Section 3.1.7 & Table 6) under which increases in estimated costs with more accurate information ranged from 22 to 378% above the previous estimates.

Thirdly, while the costs for managing a landscape seem very large, they do provide a real estimate of what it takes to manage at this scale. Also, it should be stressed that costs are calculated over 30 years — a very long planning horizon compared with other NRM estimates/planning. Very few people involved in NRM have thought through long-term costs, particularly where a stringent goal such as containment or recovery from salinity is involved.

Fourthly, the development of salinity solutions and science will gain significantly from work in natural diversity and Water Resource Recovery Catchments. These areas are the only sites where significant attempts are being made to manage whole landscapes with respect to salinity, and where these attempts are based on a commitment to long-term monitoring and scientific principles. It is likely that work in recovery catchments will also form the basis for long-term solutions to a range of land management problems. The importance of taking this opportunity is considerable.

Finally, the costs shown in Table 3 actually provide one measure of the downstream costs of agricultural land use, and emphasise the importance of helping all land users become sustainable as well as economic. Ultimately, actual landscape recovery should be based on sustainably returning catchments to a hydrological balance that is consistent with protecting both agricultural land and public assets. Following from this, where the costs of management are very high, this signals that we need to undertake industry development, as there is an obvious need for new industries, or new technologies for agriculture, that are commercially viable and redress the 'leakiness' of current systems. The work by URS has also emphasised that one means of significantly reducing costs is to make revegetation and water management economically viable at the farm scale (see Section 3.5.2).

3.1.7 A second assessment

To provide a check on the numbers generated by the desktop exercise discussed above, URS were contracted to assess in more detail five of the six existing Natural Diversity Recovery Catchments (reported in URS 2004b). The more detailed information on these five catchments had been withheld from the consultants under the original contract to ensure that the same level of information was used to assess all Tier 1 landscape assets (and thus better ensure that the relative costs of managing the landscapes were assessed).

The results from this work (Table 6) show that, when the consultants were able to generate more accurate figures for achieving a water balance with more data, the changes from the original study were highly variable. It should be emphasised that it was difficult to compare the two studies due to some methodological differences, so the figures shown are a comparison of engineering and revegetation costs for work in the immediate vicinity of biodiversity assets, and exclude land-use change costs higher in catchments. Despite the difficulty in comparing costs, it is clear that the costs and predictions of technical success derived from the first, desktop study are not sufficiently accurate to provide a sufficiently reliable measure of the cost of managing a range of landscapes, but may be suitable for assessing the relative costs of different assets. This issue is discussed in the recommendations below.

Table 6. Comparing costs of second study with first study

	L. Warden	TL80 (Lake Bryde)	Toolibin L	Buntine– Marchagee	Muir– Unicup	Total costs (\$ millions)
1 st study (\$ millions)	17.4	58.4	3.5	79.6	9.2	168.1
2 nd study (\$ millions)	38	71	11	150	44	315
% increase in costs	118	22	214	88	378	87

3.1.8 Provisional analysis, conclusions and recommendations

The conclusion from the more intensive analysis of five natural diversity recovery catchments is that a desktop analysis is inadequate to effectively assess the absolute costs of managing the Tier-1 biodiversity assets. With a more detailed assessment, all of the cost estimates increased substantially. However, the ranking of the asset protection costs was almost unchanged, so the desktop assessment may be suitable for an initial analysis to identify options for further study.

Overall, the initial report has stimulated wider discussion and provided good recommendations for how improvements for planning in natural diversity recovery catchments can be made. The fundamental problems with the initial analysis in terms of inadequate data and excessive assumptions were common in the second analysis. Unforeseen benefits from the studies, such as achieving better consensus on hydrological principles and confirmation of new approaches to recovery planning, are probably as important as the more tangible outcomes. The questions asked in the second report have provided some support, direction and clarity for future planning. Note that the implementation process recommended for the Department of Conservation and Land Management is essentially that which is currently being put in place — that is, identification of threats, goals and priorities in situation statements and work plans. URS (2004a & 2004b) also identified important knowledge gaps including:

- biodiversity information, including asset definition and values
- catchment soil types
- catchment surface water flows
- groundwater parameters.

The key conclusions from the work to date are:

- The method of assessing the technical feasibility of managing representative landscapes in response to salinity, as developed by URS, is sound; however, for efficiency and effectiveness, it needs to be used more comprehensively with fewer representative landscapes.
- A simple desktop assessment of the technical feasibility of salinity management is not sufficient to provide either absolute or relative costs for tackling landscape-scale management.
- A range of information gaps and planning needs must be redressed.
- It is essential to make a more comprehensive assessment of biodiversity asset values before undertaking a feasibility assessment. The outputs from the biological survey of the agricultural zone (Keighery et al. 2004) provide a firm basis for this step.

3.2 Water resource assets

3.2.1 Introduction

The two water resource assets identified for this study are the Collie and Denmark Water Resource Recovery catchments. In both cases, targets have been set for recovery of water quality so that these potential supplies can contribute to water availability needs in the south-west.

3.2.2 Collie Water Resource Recovery Catchment



Wellington Reservoir

The target for the Collie Water Resource Recovery catchment is to have the Wellington Reservoir reach 550 mg/L Total Dissolved Solids (TDS) by 2015. This catchment has been the subject of lengthy investigations and research into its hydrological properties (see Mauger et al. 2001). Several options have been evaluated for their capacity to deliver the target, and for their separate economic, social and environmental impacts (see AgInsight 2001, URS 2001, 2002, 2003 & 2004c).

In the original evaluation, 13 options were assessed for their technical feasibility, and their environmental, social and economic impacts. These included desalination at Buckingham on the Collie River East Branch; land-use change (tree plantations) on upper and lower slopes of the catchment; groundwater abstraction to lower watertables in the more saline parts of the river system; partial and complete diversion of saline flows at James Crossing or Buckingham for disposal in either mine voids, use in industry, or disposal to the ocean; partial catchment clearing; or combinations of the above.

This number of options was reduced to the five most favoured by all stakeholders with these being subjected to more rigorous technical and economic analysis for their relative benefits and costs. The five preferred options from the Collie Recovery Team workshop in order of preference were:

- *Option A*: 50% diversion at Buckingham into Muja voids (600 mg/L)
- *Option B*: Full diversion 9 km downstream from James Crossing (600 mg/L)
- *Option C*: Groundwater abstraction and land-use change on 3000 hectares (550 mg/L)
- *Option D*: 30% diversion at James Crossing and groundwater abstraction (600 mg/L)
- *Option E*: Land-use change on 16 700ha (550 mg/L).

Two other options were added. *Option F* is Option A with the addition of trees planted in Collie South to reduce salinity levels to 550 mg/L in the reservoir. A sixth, *Option G*, is Option A with the addition of

groundwater pumping in Collie South to reduce salinity levels to 550 mg/L in the reservoir. Social and environmental impacts were not specifically evaluated for these two additional options; however, they may be inferred from effects suggested for other options. A summary of the impacts of these options is presented in Table 7.

Table 7. Costs and benefits of recovery in the Collie Water Resource Recovery Catchment

Characteristic	Option						
	A	B	C	D	E	F	G
Actions							
Area pumped (ha)			1460	1000	-	-	1360
Number of bores			195	127	-	-	177
Area upland trees (ha)		1200			17100	4200	
Area lowland trees (ha)		700	3830		1500	3000	
Diversion at Buckingham	100%					100%	100%
Diversion at James Crossing		100%		30%			
Biophysical/Hydrology							
Reduced streamflow (GL/a)	15.4	10.9	11.1	4.3	19.9	28.0	16.2
Salinity in the Reservoir (mg/L TDS)	603	600	550	600	550	550	550
Financials							
Capital costs (\$m NPV)	10.2	128.9	46.7	80.1		10.2	53.7
Operating costs (\$m NPV)	10.3	32.0	5.4	17.4		9.6	14.5
Land use change/tree costs (\$m NPV)		4.6	14.0		40.9	18.1	
Total costs (\$m NPV)	20.6	165.5	66.1	97.5	40.9	38.0	68.2
Economic impact							
Maximum cost (\$m)	10	138	75	83	85	44	58
BCR	2.4	0.3	0.8	0.4	1.2	1.7	1.0
NPV (\$m)	28	-115	-13	-62	7	28	3
Benefits							
PV (water supply) (\$m)	44	45	45	29	18	41	44
PV (irrigation and agriculture) (\$m)	35	35	32	25	23	43	47
PV (environment and social)	-30	-29	-24	-19	6	-18	-20
Costs (includes contingencies 30%)							
PV (option cost) (\$m)	-21	-165	-66	-97	-41	-38	-68

Source: URS 2004c

In summary, the Collie Water Resource Recovery catchment is currently yielding a total of 134.8 GL/a with water quality in the reservoir modelled at a mean of 788 mg/L TDS. The analysis in the table above shows that the asset is recoverable, with diversion at Buckingham (Option A) being the preferred option. However, there still are a number of issues that need to be addressed to confirm the results and to confirm the use of mine voids as technically sound. These issues include:

- Engineering cost estimates are indicative only and cannot be improved markedly without specific designs. Likely variations will not alter the feasibility of Options B, C and D but may have an impact on Option G.
- the ability to use diverted water in industry

- the need for, and cost of a pipeline, to the coast
- the fact that this analysis based on average conditions does not account for seasonal variation and the capacity of each option to deal with a range of flows and salinities.

Further work is being done to determine whether the management of the diverted water can be integrated with management of mine dewater from the Collie Basin in industrial use.

3.2.3 Denmark Water Resource Recovery Catchment

The target for the Denmark Water Resource Recovery Catchment is water of 500 mg/L TDS passing the Mt Lindesay gauging station by 2020. This water will be available to meet a predicted shortfall in supplies along the south coast (Bari et al. 2004).

In 2001, the Denmark River catchment was delivering 23.5 GL of water, containing 14 500 tonnes of salt, at a weighted mean salinity of 603 mg/L TDS.

Extensive commercial Blue gum establishment in the Denmark catchment has improved water quality over recent years. Salinity is decreasing by about 8 mg/L TDS per annum. Modelling work for future catchment behaviour has considered scenarios with and without this recent land-use change. This is because many of these plantations are into their first harvesting cycle and decisions will be made by corporate managers about proceeding to a second rotation based on the productivity of the first harvest.

The *Salinity Situation Statement — Denmark River* (Bari et al. 2004) considered land-use change with trees and perennial pastures, groundwater abstraction and diversion of saline flows as means of improving water quality. Of the methods assessed, additional tree plantations, groundwater abstraction while retaining existing tree plantations, and diversion while retaining existing tree plantations provide the only technically feasible options.

- Rainfall in the Upper Denmark catchment is 700 mm per annum, which is marginal for commercial Blue gum production, but this is likely to be the preferred commercial species. An incentive will be required to drive further land-use change from grazing to tree production. The incentive is estimated to be about \$2100 per hectare present value.
- There is concern expressed that, based on lower productivity than predicted at the time of planting, areas currently under tree plantations will not be replanted for subsequent rotations. An incentive ‘up-front’ payment of \$1000 per hectare for each rotation may need to be provided to encourage second and subsequent rotation plantings if the aim is to keep the current level of tree-planting in the catchment.
- The Situation Statement notes that lucerne will be effective at lowering salinity levels by reducing the recharge rate, provided that rooting depth achieves 2 m and Leaf Area Index (LAI) is maintained at 2.1. However, the recharge rate is very sensitive to reductions in LAI: if it is reduced to 50% of that value (by heavy grazing), recharge levels will rise dramatically and as a consequence salinity levels will actually be higher than currently. Clearly this will be an issue for management. Given this sensitivity to management, lucerne is not really a sensible or reliable option for this asset given a lack of direct management control by the water resource manager (Department of Water).

Table 8 summarises the analysis of the options and shows that potable water in the Denmark River catchment is recoverable. The best option will be continued encouragement of commercial tree

plantations (mainly operated by the corporate sector) to ensure that the total area planted to Blue gums grows to and then remains at about 6000 ha (3900 ha currently).

Table 8. Costs and benefits of recovery in the Denmark Water Resource Recovery Catchment

Characteristic	Options			
	Tree-planting plus existing plantations	Lucerne plus existing plantations	Groundwater pumping plus existing plantations	Diversion at Mt Lindesay
Action				
Area newly planted to trees (ha)	2140			
Area of future tree rotations supported (ha)	1950	1950	1950	
Area established to lightly grazed lucerne (ha)		4440		
Number of bores @ 15 kL/day			127	
Volume of water abstracted			1905 kL/day	
30% diversion at Kompup				33 ML/day for 180 days
Biophysicals at Mt Lindesay				
Salinity (mg/L TDS)	500	380	476	500
Salt load (t/a)	10 500 (est.)	6824	10 853	12 300
Streamflow (GL/a)	20.29 (est.)	18.1	22.8	24.6
Economics (over 30 years)				
Capital costs (\$m NPV)			2.82	3.6
Operating costs (\$m NPV)			0.35	0.34
Tree establishment over 8 years (\$m NPV)	3.39			
Incentives for tree retention (\$m NPV) – 3 further rotations over next 30 years	3.14	3.14	3.14	
Lucerne establishment over 8 years (\$m NPV)		1.49		
Contingencies (30% of total) (\$m)	1.96	1.39	3.40	8.70
Total costs (\$m NPV)	8.49	6.02	14.75	11.32

The economic benefits to adjacent agricultural land of intervening to improve water quality in the Collie and Denmark River Catchments are presented in Appendix 2.

3.3 Rural town assets

3.3.1 Introduction

In 2004, thirty-eight rural towns in Western Australia were the subject of a rapid desktop analysis which assessed the risk of damage from salinity impacts as a result of rising groundwater levels. For several towns, the impacts are significant and being experienced now. For others, the impacts may not be realised for decades, with only small areas of townsites affected. For another group of towns, salinity was found to be of little or no risk. Previous analyses of the costs of salinity management in selected rural towns has

been done by the Department of Agriculture (2001) and Coyle et al. (undated). These were important sources of information in developing the generic assumptions and rules of thumb required to enable rapid assessments of the situations in the additional towns selected for this rapid assessment (URS 2004a).

3.3.2 The nature of townsite salinity

The detailed investigation completed for six towns in 2000–01 identified some common issues (presented below) to be addressed for all towns (Department of Agriculture 2001).

The causes of soil saturation are complex, and vary between the towns, but include:

- leakage from drainage lines that enter the towns from their wider catchments
- recharge from roofs, roads and other sealed surfaces within the towns
- recharge from water imported to the towns via piped water supplies
- reduction of total evapotranspirational demand within townsites.

The clearing of natural vegetation in the wider catchments containing these towns is considered to be a minor influence on the depth to groundwater table in the townsites, but it does promote higher surface runoff during peak rainfall events.

Most towns have many common issues related to water management. They include:

- Many towns receive surface water flows from their wider catchments via drainage lines, surface rocks, or from major roads into the town from higher in the landscape.
- Groundwater within some of the towns was used as a fresh water supply prior to the 1960s.
- Reticulated water from external sources was supplied to many of the towns for the first time in the 1950s and 1960s.
- Sewerage collection and disposal has previously been by pan and then septic tank.
- Reticulated sewerage collection and disposal has been implemented in the towns in recent years, but is not yet completed in some.
- Stormwater drainage predominantly uses unsealed and unlined open drains and road surfaces.
- The road pavements are relatively wide sealed pavements with kerbs.
- Building-roof rainwater runoff is very commonly discharged to the ground next to buildings in the towns.
- Treated sewage is used, when rainfall is low, to water parks and ovals.
- Collected stormwater is stored and returned for use to water public areas.
- Natural drainage lines are generally unsealed and often contain vegetation or debris that restricts natural flow, increases retention and increases local recharge to groundwater.
- High watertables occur at specific locations within the towns.
- Salt crusting on the ground surface can be seen in some towns, but the incidence is generally localised.

The infrastructure observably affected by this rise in watertable level and salinity comprises:

- roads and other pavements
- buildings — public, commercial, retail and residential
- parks, gardens and sporting fields.

3.3.3 Options in managing townsite salinity

This study was confined to investigating and costing the impact of rising groundwater alone. For those areas exposed to shallow watertables, improved surface drainage has been included as a defensive measure to prevent damage to infrastructure due to chronic dampness. However, this need for improved surface water management around buildings applies also to areas without rising groundwater tables. Where the groundwater table is currently deeper than 1.5 m at a given location, damage to buildings will be the result of poor surface drainage on the site and *not* the result of interaction with the groundwater table.

There are three general options to control groundwater rise within a townsite:

- Reduce the amount of imported water available to enter the groundwater table (more efficient use of water within the town).
- Intercept rain water before it can recharge the groundwater (use of improved stormwater drainage and trees).
- Remove water from the groundwater table below the most endangered areas of town (groundwater abstraction).

3.3.4 The costs and benefits of managing salinity in 16 towns

3.3.4.1 The objectives in managing townsite salinity

The analysis completed by URS (2004a) presented in this section assumed two ‘treatment extremes’.

- Under the ‘Do nothing differently’ strategy, no attempt is made to control the rate and eventual extent of groundwater rise within a townsite. Instead, the assumed strategy is to manage and repair the damage caused to buildings, roads and other fixed infrastructure and to accept any losses of land value associated with salinity impacts. These *damage costs* represent the maximum impact of salinity on the town.
- Under a groundwater control strategy, actions are taken to prevent groundwater rise to less than 1.5 m below the surface. If groundwater can be kept below this level, damage to surface infrastructure will be avoided. Actions include improved water use by residents, improved stormwater management and discharge, increased use of water by vegetation, and abstraction of groundwater using deep drainage and bores, with safe discharge outside the town. These *control costs* represent the level of activity to avoid any damage to town infrastructure and land values.

While strategies selected for different towns will probably use a combination of damage and control options, without further modelling of groundwater behaviour under different levels of treatments, it is only feasible to present the two extremes.

3.3.4.2 Methods and assumptions in the rapid assessment

The rapid assessment was undertaken as a desktop exercise in May 2004, and used two main sources of information in making a range of assumptions that simplified the desktop investigations.

- Information on the current and predicted groundwater status in the towns, and suggested control technologies was drawn from the hydrogeological investigations of the towns completed by the

Department of Agriculture (Resource Management Technical Report Series). This information was used in doing a desktop estimation of the areas of the townsites (and the type of infrastructure at risk) that are affected by shallow groundwater now and in the future. It was further assumed that full damage costs began to be incurred as areas of the town were exposed to groundwater levels that are less than 1.5 m below the surface.

- The reports also set out suggested control strategies which were used with little alteration. These included a varying mixture of drainage, groundwater abstraction and tree planting. Simple assumptions were made about the physical layout and dimensions of a groundwater abstraction network and applied in each situation.
- Damage and control cost estimates were developed for six towns in a detailed study completed in 2001 (reported in Department of Agriculture 2001). These costs calculated across six towns were converted into some generic estimates for damage for three different classes of infrastructure on a per hectare basis, and generic costs for installing a groundwater abstraction system (per bore including piping to a network), stormwater drainage (per hectare), and tree planting (per hectare).
- Earlier investigations (see Department of Agriculture 2001) showed that, in a number of situations, observed damage is not the result of shallow groundwater but is an effect of poor stormwater management around buildings, as in disposal of roof runoff to ground next to a building. For this reason, an assumption was made about the need to upgrade individual landholders' management of reticulation and surplus stormwater (via Waterwise advice) and link this to improved stormwater management in towns. A generic cost per hectare was used for the latter works.
- Except where there was specific information available on options for groundwater re-use from earlier studies, there was no assumption made about possible opportunities for desalination or industrial use of the dissolved salts, given that these are as yet unproven technologies. Therefore groundwater disposal to the environment relied on access to either sufficient areas of playa within an easy distance of the town, or use of evaporation ponds. Further assumptions were made about the area of evaporation pond required per volume of water being abstracted, with corrections made for the climatic variables across the agricultural areas.

3.3.4.3 Results

Table 9 presents summary information for each town assessed. The assumptions made in undertaking the rapid assessment require that these results be treated with extreme caution. In effect, they are a first-pass effort in considering some issues in the towns about the damage being faced and options for control. More recent work in specific towns (Jo Pluske pers. comm.) has questioned the generic assumptions used which highlights the need for town-specific diagnostics and tailored solutions. More importantly, they highlight an earlier observation (in 2001) that addressing salinity damage in towns requires a focus on whole-of-system water resource management, given that in most cases, control technologies on their own are not cost-effective. The need for integrated water resource management has been taken up by the *Rural Towns – Liquid Assets* program⁴, which is looking at how control technologies can be developed that deliver economic benefits to the town community through groundwater and waste water recycling, desalination for domestic supplies and extraction of industrial minerals from the groundwater.

⁴ A partnership involving rural towns, Department of Agriculture and the CSIRO.

Table 9. Summarised status for each town

Town	Time to impact (yrs)	Estimated area impacted (ha)*	Damage costs (PV @ 30 years % \$M)	Benefit/person (\$'000)	Control costs (PV @ 30 years 5%) (\$M)	Costs/person (\$'000)	B:C ratio
Lake Grace	4	25	0.93	0.90	0.62	0.60	1.50
Brookton	4	40	0.99	1.42	0.75	2.50	1.32
Katanning	1	300	7.45	1.79	7.61	1.83	0.98
Narrogin	4	80	2.98	0.63	3.66	0.78	0.81
Merredin	9	150	3.72	1.03	5.99	1.65	0.62
Bakers Hill	1	12	0.30	0.65	0.49	1.07	0.61
Pingelly	2	49	1.22	1.52	2.19	2.74	0.55
Wongan Hills	3	26	0.65	0.81	1.30	1.62	0.50
Perenjori	6	30	0.74	2.98	1.52	6.08	0.49
Narembeen	5	55	2.05	2.16	4.27	4.50	0.48
Tambellup	4	16	0.40	1.32	0.91	3.04	0.43
Wagin	1	129	1.60	1.10	4.01	2.77	0.40
Morawa	5	36	0.45	0.74	1.24	2.06	0.36
Moora	14	34	0.42	0.23	1.26	0.70	0.34
Boddington ^a	17	5	0.12	0.09	1.28	0.90	0.10
Darkan ^a	1	5	0.06	0.12			

^a incomplete data

* under 'Do nothing different' strategy

3.3.5 Categorising the towns

In Table 10, the fifteen towns with sufficient information are ordered according to the time to impact and the benefit:cost ratio (BCR) of action taken to control groundwater rise. Only two towns (Lake Grace, Brookton) have BCRs greater than 1.00. In the case of Brookton, this positive BCR is because the quality of the abstracted groundwater is high enough for it to be used in combination with stormwater as a replacement for imported scheme water on ovals and public facilities.

Towns with BCRs above 0.81 are Katanning and Narrogin. A large area of Katanning is being affected now, and the actions proposed are not much more costly than the damage being incurred. Narrogin is in a similar situation, with high-value infrastructure in the central business district predicted to be affected soon.

At the other end of the scale, towns where only low-value infrastructure or land is affected (e.g. outlying vacant land, light industrial areas, non-residential areas), damage costs will be lower per hectare with a weaker argument for investment in control technologies. These towns include Wagin, Wongan Hills and Moora. In other towns such as Perenjori and Narembeen, it has been assumed that evaporation ponds will be required for disposal of saline groundwater. This is an expensive option, and if the water can be disposed of safely into existing saline lakes or drainage lines the control costs will be reduced substantially.

The high control costs associated with groundwater abstraction and safe disposal are a barrier to adopting these control measures. Developing economic uses for the water either as a source of minerals, or in aquaculture or in desalination to produce potable supplies will enhance the attractiveness of control. This approach is being considered in the *Liquid Assets* Project launched in May 2004 through the Rural Towns Program.



Salinity-affected garden wall

Table 10. Comparing towns for time until impact and BCR

		Time until impact (years)		
		1 (effectively now)	2-7	More than 7
Benefit:Cost Ratio (BCR)	> 1.00		Lake Grace (AC) Brookton (AC)	
	0.51-1.00	Katanning (SCC) Bakers Hill (AC)	Narrogin (AC) Pingelly (AC)	Merredin (AC)
	< 0.50	Wagin (SWC)	Wongan Hills (NAC) Perenjori (NAC) Narembeen (AC) Morawa (NAC) Tambellup (SCC)	Moora (NAC) Boddington (SWC)

- NAC Northern Agricultural Catchments – 4 towns
- AC Avon Catchment – 7 towns
- SCC South Coast Catchments – 2 towns
- SWC South West Catchments – 2 towns

3.3.6 Recommendations for all towns

A general conclusion of this study is that the net benefits of salinity management vary widely from case to case and so assets for protection need to be very carefully selected. The analysis in this section strongly reinforces that conclusion for the case of rural towns. Although the analysis is not comprehensive enough to be used as the basis for actual investment decisions, it helps to focus attention onto a smaller number of towns where there are prospects of benefits from taking action. Only two of the towns have positive net benefits from fully preventing salinity rise, and two others have BCRs above 0.8. For the majority of towns, the benefits of full salinity prevention using the strategies evaluated are not nearly large enough to justify the costs. For many of those towns, the conclusion is that it is much less expensive to repair salinity damage as it occurs than to attempt to fully prevent it.

Any preventative strategies implemented in those towns would need to be low-cost, such as the following (taken from Department of Agriculture 2001):

- Use 'Water Wise' Coordinators and others to provide advice to householders, businesses and builders on all aspects of urban water balance management, including water conservation, domestic drainage, urban stormwater control and effects of trees.
- Progressively improve town drainage schemes to prevent runoff from within town entering the watertable beneath the town.
- Ensure complete coverage with sewerage systems, with careful re-use of treated water within the town to prevent seepage into the groundwater table.

3.4 Roads and railways

The analysis of roads and railways was undertaken using data derived from Land Monitor — a process of assessing the salinity of agricultural land. As a result, the calculated lengths of roads affected imply a relationship between an adjacent saline area and a road pavement. While the authors knew this was unlikely to occur in all cases, the approach provided a reasonable approximation of the road length likely to be affected. In addition, no prioritisation of options for managing salinity affecting specific pieces of road or rail was conducted. Instead, the Department of Agriculture undertook an analysis of the potential overall costs of repairs and maintenance, as an indication of the likely scale of costs (George et al. 2005). Inevitably, there will be very many lengths of road and rail affected in the future, and prioritisation of repairs using a SIF-like process will become essential.

3.4.1 Roads

About 252 km of highways and main roads (George et al. 2005) and 3850 km of local and unclassified roads are assessed to be currently affected by salinity. The annual cost of repairs and maintenance due to salinity (based on estimates by Main Roads WA) is assessed to be \$19 840 per kilometre for highways and main roads and \$6614 per kilometre for local and unclassified roads. The total combined current annual cost is around \$21 million. However, the length of highways and main roads with a high hazard is estimated to be 1194 km (likely to be an overestimate) and the length of local and unclassified roads affected is assessed to be 22 960 km. Assuming no change in the cost per kilometre repaired, and assuming all roads in need of repair are fixed, then the annual cost of repairs and maintenance due to salinity will increase to \$23.7 million for highways and main roads and \$151.9 million for local and unclassified roads. The combined annual cost will be \$175.5 million.



Salt-affected road

Allowing for the gradual increase in repair and maintenance of roads as salinity spreads, and assuming all affected roads are repaired then the present value of forecast road repair costs is \$1938 million, of which \$271 million is needed for highway and main road repairs. If only highways, main roads and local roads are repaired (i.e. unclassified roads are not repaired) then the present value of future repair and maintenance costs is forecast to be \$1355 million.

Around 80% of this cost is attributed to local roads rather than highways and main roads. Hence, an issue for many rural shire councils will be whether or not it is financially wise to maintain the current network of local and/or unclassified roads. Even halving repairs and maintenance expenditure will still mean that the impact cost of salinity on these roads will be higher than the farm-level benefits generated by the adoption of intervention strategies shown in George et al. (2005).

3.4.2 Railways

The length of railways in areas currently affected by salinity and within areas with a high hazard is estimated to be 210 and 1050 km respectively. The potential costs associated with this risk are defined by the depth to watertable (URS 2001). The likely cost range for currently affected railways is \$458 800–1 427 000 and for potentially affected \$2 242 000–6 977 000. The present value of ‘in perpetuity annual costs’ of rail repair and maintenance is \$176 million (George et al. 2005).

3.4.3 Summary — the costs of direct intervention to protect biodiversity, water and infrastructure assets

SIF Phase I identified threatened assets in these classes and allocated them to three ‘tiers’. ‘Tier 1’ assets are those considered to be of high public value and under a high level of threat from salinity, either currently affected or highly likely to be affected by 2020. For the 48 Tier 1 assets (30 biodiversity, 2

water supplies, 3 waterscapes (also identified as biodiversity assets), and 16 rural towns) a goal was set in broad terms of recovery, containment or adaptation. For roads and rail, the cost of salinity was calculated as the additional costs caused by salinity impacts for repairs needed to maintain functionality.

As described in following sections, agricultural land was treated differently — with a calculation of the net benefit of applying best-practice salinity management on different classes of land with differing salinity scenarios.

For each asset class, an expert panel selected a management strategy based on currently available salinity management techniques, and evaluated the feasibility of achieving the set goal for that asset (recover, contain or adapt). The cost of implementing the recommended treatments was calculated.

To carry out the analyses, many assumptions and estimates were necessary. These are open to debate, and indeed such debate is welcome. However, the results as presented provide indicative estimates of the cost to government of direct intervention to achieve the desired salinity goals for each of these assets.

The cost of managing to meet the goals for all 30 biodiversity assets is calculated at \$854 million (present value over 30 years at 5% discount rate), with the range for individual assets being \$3–121 million. The cost is not necessarily related to the size (area) of the asset, but reflects the level and nature of intervention required. Three of these assets were also defined as Tier 1 waterscapes⁵.

For the two water resource assets (Collie and Denmark rivers) a range of options was assessed and costed. The cost of the four options for the Collie which gave the lowest salinity in the reservoir ranged from \$38 to \$68 million with Benefit:Cost Ratios from 0.8 to 1.7.

The salinity control cost for the 16 rural towns varied between \$0.49 and \$7.61 million (present value over 30 years at 5% discount rate) and the net benefits in terms of damage avoided by undertaking control measures varied from \$0.12 to \$7.45 million. Control costs within the towns, which indicate the potential impost on local government in implementing management measures, range from \$600 to \$4500 per head of population.

The total cost of direct investment in these Tier 1 assets is shown in Table 11.

Table 11. Direct investment for high priority assets

Asset group	Present value cost (\$ m)	Comment
Water resources	60	Based upon achieving recovery targets
Biodiversity	854	Based on current and 'at risk' areas, and containment of present biodiversity values in 30 assets
Towns	37	Based on control of salinity in 16 towns. Cost net of benefits is \$13 million.
Roads	1938	Based on all roads either currently affected or at risk into the future. No priority assessment
Rail	176	Based on all rail either currently affected or at risk into the future. No priority assessment
Total	3065	

⁵ Lake Warden, Toolibin Lake and the Fitzgerald River were also defined as Tier 1 waterscapes

3.5 Salinity management on agricultural land

The area of agricultural land affected by salinity is predicted to expand from the current 0.82 million hectares to an estimated 2.9–4.4 million hectares, if trends established over the period 1975–2000 continue (George et al. 2005).

Pannell et al. (2001) recognised that direct government support for intervention on agricultural land aimed at managing agricultural land salinity will mostly provide a private benefit. Therefore, the Salinity Investment Framework encompasses investment on agricultural land in three different but complementary ways:

- a. public investment in changes in the use of land that directly contributes to the protection of priority assets identified in Sections 3.1, 3.2 and 3.3
- b. encouragement of private investment by farmers in recovering salt-affected land, containing the spread of salinity, and in adapting to salinity by changing land uses of saline land, as discussed in Section 3.5.1
- c. industry development, where public and private investment is used to develop new land uses, farming systems and salinity-related industries that can generate economic and environmental benefits for landholders and the WA community, as discussed in Section 3.5.2.

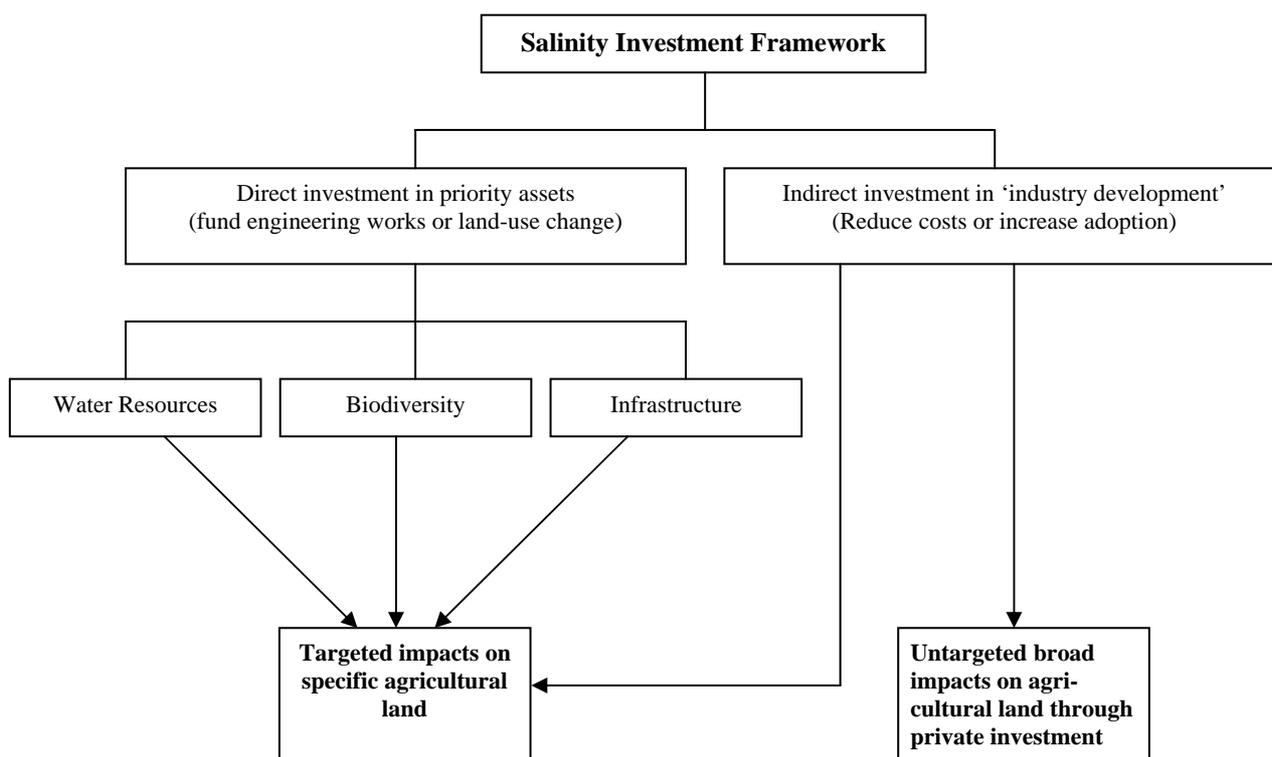


Figure 1. Forms of investment in salinity management

3.5.1 The value of private investment in salinity control

An assessment of salinity impacts on agricultural land and rural infrastructure undertaken by the Department of Agriculture for the SIF project (George et al. 2005). The following components were addressed:

- spatial representation of areas of land and infrastructure affected or with a hazard to be used to underpin all of the analysis in the Salinity Investment Framework
- value of land and infrastructure at risk (where possible)
- technically feasible treatments that are currently available
- probability of adoption of those options
- economic analysis.

The results showed that about 0.821 million hectares of 1.047 million hectares salt-affected land (which excludes the area of salinity-affected lakes and other water bodies) was owned privately. An area of between 2.9 and 4.4 million hectares was assessed to have a salinity hazard. The current cost of salinity to agricultural land is difficult to assess, but the current estimates are that the cost is approximately \$35 million per year, which could rise to between \$170 and \$260 million per year if the Land Monitor predictions eventuate. Using current salinity management practices and adoption patterns, it would be possible to recover 0.415 million ha of saline land, to prevent or delay salinisation (containment) of a further 0.445 million ha, and to actively manage 0.750 million ha of currently saline land using salt-tolerant species (adaptation). The private economic benefit of managing salinity in these areas using currently available technologies was estimated to be \$667 million (net present value), given a set of assumptions about hydrogeology, technology performance and farmer adoption of those technologies. In other words, the investment in salinity management is estimated to eventually generate a stream of additional benefits (profits gained and losses avoided) for farmers that, in present value terms, equates to \$667 million. While this will not negate all of the estimated losses to agriculture due to salinity, it demonstrates that there are opportunities for farmers to make profitable investments in recovering existing saline land, containing further salinisation, and adapting to the presence of saline land.

3.5.2 The role of industry development

Although there are some situations where suitable salinity management practices are available, there is generally a shortage of practices that can be adopted profitably by farmers at large scale, particularly in lower-rainfall areas. The Salinity Investment Framework includes the following principle:

4. Where the public priority is low but there are extensive private assets at risk, public investment should be aimed at industry development.

This section presents the rationale for this principle, identifies options for investing in industry development, and suggests immediate priorities. It complements Section 3.5, which describes the various roles of the SIF in supporting land-use change on private farmland. The support consists of relatively direct funding for land-use change, as described in that section and more indirect support through activities that are grouped in this section under the heading of industry development.

3.5.2.1 What is meant by ‘industry development’?

For the purposes of this framework, we consider the following elements to be included within industry development:

- Research and development (R&D) to identify, select, breed and evaluate new types of perennial plants that are economically competitive with existing land uses, or R&D to create profitable new uses for salinised land or water, or R&D to develop improved engineering options
- On-farm trials of new options that appear to be good prospects for wide adoption

- Support for off-farm aspects of industry development, potentially including transport services, processing, infrastructure provision, finance, and marketing
- Support for industry development through a whole-of-government approach. For example, this may include policy decisions that favour energy sources that advance salinity mitigating industries (e.g. bioenergy from oil mallees), even if they are not the cheapest in a direct financial sense. Reviewing policies to identify and remove impediments to industry development (e.g. tax issues).

It would not include R&D that provides information about causes, extent and future salinity hazard. This R&D may be useful in targeting industry development to particular high-priority locations or situations, but its use would not be limited to this. This is not to belittle its importance: sound technical underpinnings are essential for almost any aspect of decision making about salinity.

3.5.2.2 Rationale for prioritising industry development as a state investment

Reasons for public support for salinity-related industry development include the following.

- Successful industry development, resulting in the creation of new land-use options that are economically competitive with traditional annual land uses, can lead to the establishment of high-water-using perennials on large areas of land without the need for provision of financial incentives.
- Where new perennial land-use options are developed for land where incentive payments are being made to farmers to reduce damage to priority public assets, the level of subsidy can be reduced, potentially to zero if the new option is fully competitive financially.
- Where such savings are achieved, they allow funds to be re-allocated to additional salinity-related investments (or to other priorities). Industry development leading to successful new industries based on woody perennials will generate a range of social benefits from regional development of wood resources and products.
- Industry development leading to profitable new industries will enhance social welfare through higher and more diversified regional income.
- Innovation and technology development can produce new options for adapting to or living productively with salinity (both agricultural and non-agricultural opportunities).
- Investment in industry development in the past has been inadequate, so there are significant untapped opportunities. Most past salinity R&D has not taken an industry development approach, but instead has focused on understanding salinity processes or quantifying impacts under various treatments.
- A disadvantage of investing in industry development is the time lag between investment and the availability of new technologies. The lag can be substantial given the nature of the R&D process and industry development. Nevertheless, for diffuse or low-priority assets where salinity is not already approaching equilibrium and for management of saltland, industry development is the main option available to governments.
- New industries have the potential to ameliorate a wide range of threats to the sustainable use and management of natural resources. For example, revegetation with perennials can contribute to erosion control, carbon sequestration, and the management of eutrophication as well as diversification of industry.
- New, environmentally-sensitive industries may be required to manage discharge: in particular, to deal economically with excess water, salts and other solutes produced by drainage and pumping.

- The required R&D is unlikely to be funded by the private sector because (a) some of the benefits generated will be public good in nature, and (b) the necessary research skills are in limited supply, and are predominantly in the public sector. In addition, the required R&D is risky, long-term, involves many stakeholders, and any commercial position that may be developed is difficult to protect. All these diminish the attractiveness to investors.

3.5.2.3 Industry development activities currently underway

A range of industry-related activities is already underway solely or partly in Western Australia, including the following.

R&D to develop new farming options

The Cooperative Research Centre for Plant-Based Management of Dryland Salinity (CRC Salinity), funded by the Australian Government's CRC Program, with input from a number of Rural R&D Corporations, and involving The University of Western Australia, Department of Agriculture, Department of Conservation and Land Management, and CSIRO.

On-farm R&D programs with salinity elements

Research and development work within the Natural Resource Management program of the Department of Agriculture

Grain and Graze, funded by Land and Water Australia, Grains Research and Development Corporations, Meat and Livestock Australia, and involving farmer groups focusing on farming systems

Land, Water and Wool, funded by Australian Wool Innovation and Land and Water Australia

Sustainable Grazing from Saline Lands, funded by Land and Water Australia, Australian Wool Innovation, and involving CRC Salinity

Engineering Evaluation Initiative, funded by the Western Australian Government and the Commonwealth Government's National Action Plan for Salinity and Water Quality.

Catchment Demonstration Initiative, funded by the Western Australian Government and the Commonwealth Government's National Action Plan for Salinity and Water Quality.

Farmer-based groups for specific industries or farming systems

Oil Mallee Company and Oil Mallee Association

WA Lucerne Growers Association

Farming Systems Groups including the Leibe Group, The Facey Group, The Esperance Regional Forum, Mingenev-Irwin Group, WA No-Till Farmers' Association

Saltland Pastures Association

Targeted salinity interventions with industry development aspects

Toolibin Lake (CALM), including Oil Mallee industry development

Rural Towns Program (Department of Agriculture), including desalination trials

Support for commercial sawlog forestry development in the Collie River catchment for Wellington Dam (Department of Conservation and Land Management, Forest Products Commission, Department of Water)

3.5.2.4 Gaps or opportunities in industry development

There are numerous gaps and opportunities for industry development in Western Australia, in the areas of plant-based management, engineering responses, and productive use of salinised resources. No comprehensive analysis has been done to prioritise the opportunities for Western Australia. The SIF Steering Committee recommends that this should be done as a follow up to this report.

The prioritisation of potential industry development projects should consider the following factors:

- Area potentially suited to growing the relevant plant species/system or using the engineering method
- Likely increase in potential area due to each project activity
- Likely impact of the new technology compared to current practice
- Likely profitability status of plant-based systems relative to current land uses, or of engineering works relative to 'do nothing'
- The research resource demand
- The lag time before the research would eventually lead to land-use change or engineering works
- The potential scale of national and global markets to absorb the production of any new products
- The degree of current salinity and future salinity hazard in regions and landscape positions where the new technology is intended to be used
- The degree to which salinity can be recovered or contained in those regions and landscape positions
- Quantitative indicators of potential salinity benefits from industry development

To provide some indication of the potential benefits from investment in industry development, URS Australia Pty Ltd were engaged to analyse the likely cost savings from successful industry development. The savings reported here relate specifically to costs borne by governments to achieve adoption of perennials on a scale judged to be necessary as part of a package of works to protect a priority asset (URS 2004a).

Potential value of 'new industries'

The section discusses the results of using the data from the SIF II assessment to estimate one aspect of the potential value of 'new industries'. The approach is to estimate (a) the savings in public expenditure if high-water-using perennials that did not require incentive payments to ensure their uptake at specified levels, within packages of measures designed to protect each Tier-1 biodiversity asset were available, and (b) the value of options to gain financial returns from saline water pumped or drained as part of the asset-protection strategy. Supporting information is presented in Appendix 3.

Method

For each biodiversity asset considered by the SIF Phase II assessment the following tasks were undertaken:

- Determine the area and the timing of when engineering options can be replaced by a ‘new industry’ land-use option, assuming ‘new industry’ options are available now.
- Base the opportunity to replace SIF Phase II solutions on an assessment of the need to remove accumulated water to establish a new equilibrium level, and the time required for ‘new industry’ options to be effective in maintaining the desired equilibrium.
- Estimate the capital costs of required engineering solutions (with and without ‘new industry’ options).
- Estimate the maintenance and operating costs of engineering solutions for options that may need to be maintained indefinitely, and for those that may be replaced as ‘new industry’ land-use options become fully effective in maintaining desired equilibrium (for with and without ‘new industry’ options).
- Consider the costs of implementing ‘new industry’ option as zero to government as they are assumed to be financially competitive with other agricultural enterprises.
- Calculate the value of having ‘new industry’ land-use options as short- or long-term alternatives to ongoing costs of engineering solutions.
- Calculate the value of having ‘new industry’ options that can use the pumped saline water as a resource.
- Aggregate the net value across the 30 biodiversity assets considered in the SIF Phase II study.
- Summarise results and discuss the validity of extrapolating these results across other threatened biodiversity assets.

Results summary of SIF Phase II analysis — without ‘new industries’

The ‘base solution’ provided by the SIF Phase II analysis (results without new industries) is presented for the 30 priority biodiversity assets in Table 3.

In Table 12 the actions required for the 30 biodiversity assets have been aggregated to show the total amounts of each treatment and the total costs. The treatments include land-use change comprising 398 000 ha of lucerne establishment, 125 000 ha of trees, and 110 000 ha of saltbush, along with engineering solutions that include 365 km of deep drainage and 956 pumps that deliver into 3600 ha of evaporation ponds (as well as disposal into available saline lakes). The investment in land-use change is estimated to reduce ‘before treatment’ annual recharge of 333 GL by 52 GL. Drainage and pumping is estimated to reduce recharge and pump the saturated landscape at a rate of 117 GL per year.

The aggregate cost over all 30 assets is \$854 million. The single major cost item is in the disposal of saline water. The estimated cost of evaporation ponds is some \$185 million. The three types of land-use change cost approximately \$329 million. The present value of operating costs is \$66 million with pumping and maintenance assumed for a thirty-year period.

Table 12. Summary of base scenario for protection of 30 biodiversity assets

Activity	Total units
<i>Excess water kL/year before treatments</i>	333 235 000
Lucerne area (ha)	398 000
Trees area (ha)	125 000
Saltbush area (ha)	110 000
Drainage — length of deep drains (km)	365.5
Borefields — no. of bores	956
Evaporation ponds area (ha)	3600
<i>Recharge prevented - land use change (kL/yr)</i>	52 500 000
Recharge prevented — land use & surface management (kL/year)	64 350 000
Residual recharge net of land use and surface management (kL)	268 885 000
Drainage and borefield — water removed (kL/yr)	117 000 000
Saturated landscape — water to be removed (kL)	864 000 000
<i>Activity cost</i>	<i>Cost</i>
	<i>(\$,000)</i>
Lucerne	159 000
Trees	120 500
Saltbush	49 250
Surface water management	40 400
Drains	3 300
Pumps cost (\$,000)	10 000
High voltage line cost (\$,000)	6 900
Power to borefield cost (\$,000)	1 700
Transformer cost (\$,000)	160
Piping cost (\$,000)	14 500
Evaporation pond + land cost (\$,000)	184 000
Present value of operating costs (\$,000)	66 400
	Costs
	(\$m)
Total capital costs	590
Operating costs	66
Transaction costs	197
PV of total costs	854

Note: the base SIF II assessment assumed that transaction costs were 30% of capital and operating costs, the discount rate used was 5%, and it was assumed that pumping would continue for 30 years.

Summary discussion

Major savings could be made in cost to government if new industries provide land-use change solutions, or if new industries can be based on the use of saline water. Table 13 provides a summary of the possible savings to government should new industries avoid the costs of management options used in the SIF II assessment. Indeed, any set of new industries based on improved land-use options or the use of saline water will potentially provide huge cost savings to government. What is critical to the assets considered by this report is *when* new land use industries may become available.

Table 13. Summary of potential savings with new industries

New industry option	Saving (\$m)
Cost-neutral land use with hydrological functions equivalent to lucerne ¹	> 207
Cost-neutral land uses equivalent to assumed plantings of lucerne, trees & saltbush ¹	> 426 ^a
Cost-neutral land uses that allow pumping to be stopped after 10 years	32 ^c
New industries based on pumped or drained saline water	27–42 ^c
New industries based on pumped or drained saline water (NI:Govt cost share of 100:0)	145–289 ^{b, c}
New industries based on pumped or drained saline water (NI:Govt cost share of 50:50)	73–144 ^{b, c}

¹ To be further investigated

^a Saving in land use change incentives

^b Saving in capital costs of drainage and pumps

^c Saving in operation costs of drainage and pumps

Finding land-use options that can work in combination with short-term engineering solutions is estimated to save more than \$426 million. However, as the mix of land-use changes suggested for the SIF II base scenario does not totally eliminate recharge, the real saving to achieve a water balance would be expected to be greater than this estimate. The cost saving in catchments where land-use change can be preventative will be very significant, as land-use and engineering costs may both be avoided. This is probably not the situation for many of the assets considered by the SIF II assessment but potentially represents a major benefit for protection of assets not considered by this report.

Many of the assets studied face imminent threat from salinity and will require short- to medium-term engineering solutions. New industries based on land-use change will not avoid the cost of these engineering costs/solutions. They may allow the pumps to be stopped once recharge is in balance but the saving in operation and maintenance costs once engineering solutions have been invested in is small in the short-term compared with capital costs. However, over time, the annual maintenance and running costs of engineering solutions are significant, particularly where evaporation basins need to be replaced. Thus ultimately there will be significant savings from new industries, even when they are applied in areas where engineering solutions have already been implemented.

Substantial value in the short- to medium-term may come from profitable uses of saline water where engineering solutions are essential to address imminent threats from salinity. The analysis of the 30 assets indicates that some 120 GL needs to be removed annually from these areas. This presents a substantial resource almost three times the quantity of water planned to be produced in the new seawater desalination plant for Perth. The major costs associated with drainage and pumping interventions are disposal costs. A conservative approach has been taken. Experience from Toolibin Lake recovery is that the disposal costs



Narrogin IWP plant

could be significantly less. Any new industry that can avoid these disposal costs, and/or share the costs of drainage and pumping can reduce costs to government by up to \$290 million. For those assets requiring pumping rates exceeding 5 GL annually, or where recharge rates exceed 5 GL, the cost of pumping and drainage is only \$1.05 per kL. In these circumstances at least, it appears desalination of this water may be competitive with current water supply schemes in regional centres. A solution combining energy sourced from biofuel plants fuelled by mallees could present a greenhouse-gas-neutral solution to biodiversity protection and water supply needs.

It is suggested that potential synergies between outcomes from protection of biodiversity assets and values to be gained from using the saline water as a resource need to be further investigated. This will require an integration of multiple objectives and values across conservation and water resource agencies but the potential cost savings are significant. This probably presents the best short-medium 'new industry' option for reducing the net costs of protecting biodiversity assets.

3.6 Applying the SIF in the Avon region

To initiate and then complete these products, a series of steps were taken to ensure the engagement, and then the capacity, of all stakeholders to understand and use the SIF methodology to determine and prioritise investment in the Avon Region. Funds allocated to the Avon Catchment Council in SIF Phase I were used to conduct this.

At the same time, the Avon NRM Strategy was being developed by the ACC to ensure future investment by the Australian and State Governments. The complexity of the work involved meant that it took longer than first expected to complete and, while the proposed Strategy framework was being developed, took priority over most other activities across the Region. It was not until March 2004 that the links between the SIF and the NRM Strategy became clear and that work refocused onto the SIF processes.

For application of the SIF to the Avon catchment, see the Avon Catchment Council's NRM Strategy and the Investment Plan. View or download from www.avonicm.org.au

4 Conclusions

The work done in SIF Phase II examined two complementary strategies to pursue cost-effective salinity management investments:

- through direct investment in protection of particular assets
- through industry development — meaning the development of new technologies and land uses that restore more benign hydrological processes and contribute to profitable, sustainable land use in agricultural areas. Given that secondary salinity often arises from agricultural lands, better water management on agricultural lands will also contribute to the protection of public assets in many cases.

It is possible to draw conclusions about each of these strategies. Further, as a result of the work on these two aspects, some key conclusions can be reached about the SIF itself.

4.1 Strategies for investing in salinity management

4.1.1 Direct investment in protection of particular assets

The results of this study emphasise the enormous cost (up to \$3 billion) that would be involved in protecting biodiversity, water, and rural infrastructure assets from salinity, even if funding was limited to the highest priority assets. Given the available budget, only the most outstanding assets can be preserved via financial support for on-ground works, now or in the foreseeable future. This highlights the crucial role of the SIF in selecting the most important assets for investment. It also emphasises the importance of developing new industries to reduce, or eliminate, the costs of recharge control and discharge management. To achieve this, new industry development is essential.

4.1.2 Industry development

For protection of privately-owned assets (particularly farm land), the focus in this framework is on industry development. A key reason is that the per-hectare value of agricultural land is rarely competitive with the per-hectare values of the top-priority publicly-owned assets that will qualify for direct funding. A second reason is that in most cases governments prefer not to get directly involved with private business management decisions, as individual business managers are generally in the best position to judge the merits of an investment to prevent degradation of their own asset.

In summary, both direct investment in specific assets and industry development approaches can have beneficial impacts on publicly-owned assets. The benefits of direct investment are obvious, while industry development would be intended to reduce the level of direct investment required.

4.2 The Salinity Investment Framework

4.2.1 The value of the SIF analysis

The findings of these analyses strongly reinforce the insights that led to the State Salinity Council recognising the need for the SIF in the first place. These include that:

- The net benefits from on-ground works are highly variable and case specific.
- The cost of successful intervention to save any particular asset can often be very high.
- The available budget for support of on-ground works for salinity is a tiny proportion of the budget that would be required to protect all threatened assets. Indeed, it is a small proportion of the budget needed to protect only those assets judged to be of high priority.
- If public funds are poorly allocated, there is a high potential to dramatically reduce the cost effectiveness of public funding.
- Industry development has two crucially important roles to play: providing options for the majority of assets that are not of sufficient priority to warrant on-ground works, and reducing the cost of on-ground works where there are supported.
- Application of the SIF using a desktop approach based on current information and expert opinion is a useful first step. It begins the process of establishing broad priority rankings and highlights assets that are or are not worth investigating further.
- If overall salinity management is to be optimised, industry development should constitute a substantial share of the salinity budget.
- Without conducting a SIF-style analysis, it can be hard to recognise which of the assets should have high priority and which low (e.g. some towns with a high apparent salinity threat have a low net benefit from intervention).
- Prioritisation needs to consider all elements of the SIF framework: the value of the assets, the degree of threat, the availability of feasible management actions, the likely reduction in salinity from those actions, and their cost. Omitting any of these elements is likely to adversely affect prioritisation decisions.

To conclude, the success of SIF Phase II has been in establishing a robust methodology. The prioritised listings are provisional and will need further testing using more detailed data before any money could be spent on the ground. The provisional costings are indicative and can be used by State government and NRM agencies to assist in their financial planning.

The simple desktop analysis using available data was found to give useful information about relative priority, but unable to give accurate information about actual costs of intervention for specific assets. The prioritised lists need to be tested using more detailed analysis before any works are started.

4.2.2 Limitations of the analysis

SIF Phase II tested a rapid appraisal methodology or process for developing a prioritised listing to achieve a specified management goals for high public value NRM assets at high threat from salinity. The lists of assets in the South West Agricultural Zone were prioritised within a tight three-month timescale using easily accessed technical and financial information. The resulting water balances and costings are *generic estimates* and must be regarded as preliminary.

Some of the limitations of the analysis include the scale of analysis, implications of climate change, and possible changes to rate or acceptance of new industries.

The prioritised lists need to be tested using more rigorous methods before any works could be deployed on the ground. Any further feasibility studies would need to establish the pressure and threats on each state asset in the South West Agricultural Zone. For example, if aggressive weeds are introduced into a Wheatbelt biodiversity asset, then the value of the asset could be compromised by weeds more than by salinity, and public dollars needlessly expended.

In most of the analyses conducted here, salinity was examined independent of other natural resource threats, but all threats must be taken into consideration in a full analysis. In addition, since regional NRM bodies are aiming to achieve multiple benefits, the SIF analyses would ideally become part of a more comprehensive decision process. However, the SIF experience points to some potential concerns about the pursuit of multiple benefits:

- The high cost of achieving salinity prevention for specific high-priority assets indicates that in practice there is likely to be little scope for trading off salinity objectives with other NRM objectives. If salinity funding is spread more thinly among a larger number of assets in order to pursue multiple benefits, the likelihood is that none of the assets will receive worthwhile salinity benefits. The pursuit of multiple benefits needs to be done with great caution if salinity management is not to be badly compromised.
- If priorities are to be set across assets representing different objectives, then a higher-order goal and a set of criteria that apply across all asset types are required. See Appendix 5.
- The difficulty of determining accurate priorities for salinity management is apparent: the further difficulty of pursuing multiple benefits with a comparable analysis would be very substantial.

4.3 Future work

The SIF limits its focus to investment in on-ground works and industry development. There is in fact a broader range of potential responses available to governments and Regional NRM bodies, including extension/education/training and regulation. Within the category of on-ground works, there is currently no attempt to consider the most appropriate mechanism for funding (e.g. incentive payments or market-based instruments, direct investment in works on public lands).

The SIF provides a shell for guiding rigorous analysis without embedding any learnings from past experience or research.

At the regional level, the framework may also support investment in innovative schemes and programs that address regional priorities, such as support for farming systems groups or for pilot schemes to investigate new farming practices.

It is intended that, following publication of the Phase II report, the results will be presented to Regional NRM Groups and other key stakeholders who may wish to use the methods developed during SIF Phases I and II. These stakeholders will also be consulted to assess what form of 'kit' or information packages will enable them to use the data and analysis for their own investment prioritisation purposes.

Taking into consideration comments above, further development of the SIF could involve:

- further development of the method to provide the basis for more accurate feasibility analyses. An important means of achieving this is to ensure that the documentation of work in recovery catchments and similar landscape-scale activities builds a more robust foundation for natural resource management decisions, particularly with regard to hydrological parameters under different circumstances.
- elaboration of the biophysical threat analysis, including testing in a number of practical applications, so that all threats are integrated into the feasibility analysis
- devising effective mechanisms for setting priorities across assets representing different natural resources and objectives.

5 Recommendations

- Communicate the SIF Phase II analyses and methodology to key stakeholders and potential users, particularly NRM agencies and Regional NRM Groups.
- Further develop the SIF methodology and approach for salinity projects and for broader natural resource management application.
- Use the approach and methodologies for setting priorities for action and investment in managing salinity and natural resources at local, catchment and regional scales. Within reason, make the application of a rigorous but simple process a condition of funding.
- Analyse industry development opportunities.
- Based on the analyses contained in the report, encourage agencies, through the Senior Officer Group of state agencies involved in NRM (SOG) and Director General NRM meeting process, to jointly re-evaluate Government strategic direction and investment in the salinity area. Key considerations are:
 - Government to directly invest in implementing a number of targeted projects that protect high value, high threat assets (Tier 1).
 - Re-evaluate investment in salinity. The scale of direct investment required to achieve either recovery or containment for the high-value, high-threat assets is \$3.3 billion. There is a fundamental issue in salinity management of either protecting these assets with a substantial increase in funding or accepting that, with current resource allocations, adaptation will be required.
 - Industry development is a vital component of the response to salinity that needs to be expanded to include technologies aimed at discharge management (e.g. beneficial use of abstracted saline groundwater and engineering approach) as well as technologies aimed at recharge management (perennial-based farming systems).
 - In view of the potential of industry development to generate cost-effective options for salinity and the high cost of direct intervention, there needs to be targeted investment in industry development.
 - Given the evidence of a drying climate across south-western Western Australia, the assumptions about the rate and ultimate extent of salinisation and related costings undertaken in this study need to be part of any re-evaluation.
 - Invest in an ongoing watch and review of the feasibility assessment of high-value, high-threat (Tier 1) assets as new technologies are developed and as improved information about the assets becomes available.

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Appendix 1 - Key assumptions in the methodology

(Source: URS 2004a)

Biophysical assumptions

Rainfall information in the calculation of the water balance used long-term records in *Australian Rainfall and Runoff*, with data taken from the nearest site to the asset.

The water balance has been calculated over a 10-year period.

The water balance and rates of groundwater rise assume 'steady-state' behaviour in the catchment. While no consideration is given to the effects of episodic extreme events (floods, droughts) on the dynamics of catchment behaviour, assets that may be subject to floods have been identified.

Where an area of the asset is assessed as being fully saturated, groundwater level is assumed to be at the surface.

Technical assumptions

The land-use and engineering technologies used were common across all domains.

The information on technical performance and costings was taken from a review of literature, engineering standards and from consultations with experts.

Financial and economic assumptions

The costs for the technologies used were common across all domains.

The costs presented for the separate asset domains are costs to government only. The assumption is that implementing the treatment will be done on a cost-neutral basis with respect to any affected private entities. Where cost-sharing is embedded within the estimates, costs to private entities are assumed to equal returns. Additional costs are therefore borne by government.

The engineering capital and operating costs are fully commercial, representing industry-standard costs for professional design, installation and operation.

The costs for land-use change are conservative, in that they are on the 'high side' of expectations. In calculating costs for land-use change such as conversion from annual crops and pastures to perennial pastures, woody perennials grown in alleys, and trees grown in blocks, the change was assumed to be on a 'no regrets' basis for the landholders; that is, the land-use change can be implemented at no net cost and no net return to the landholders. They are no better off and no worse off, after transaction losses, as a result of the land-use change on their property which is contributing to a public benefit. The intent is to show the dollars required to persuade/compensate landholders to implement involuntary land-use change, assuming no separate private benefit from the change.

Setting the costs on the ‘high side’ for the ‘no regrets’ outcome recognises that many of the land-use change options (such as sawlogs, oil mallees) are unproven, and that others (e.g. saltbush, lucerne) are generating variable results in practice and may require specialist management skills and motivation not available given the scale of the changes modelled for some assets.

The costs of implementing and managing the planned interventions will be high, so a management cost was added to the aggregate cost of the intervention to cover transactions, negotiations, ongoing management and administration. This cost was calculated as 30% of the capital and operating costs of the intervention.

All costs for all assets are treated in the same way. These analyses assume that capital costs for land-use change (e.g. up-front payments) and engineering works (e.g. borefields, evaporation ponds) are incurred in the immediate future (normally in year 1) with operating costs assumed to be a constant annual cost over a 30-year period. The total cost is presented as a present value with future costs discounted at 5% per annum (used as a real discount rate)

Appendix 2 - Calculating private benefits of protecting biodiversity and water resources

(Source: URS 2004a)

Biodiversity assets

Recent work has shown that the spatial impacts of treatments to reduce recharge or accelerate discharge are limited. In the case of groundwater abstraction or deep drainage, drawdown occurs over a radius of a few hundred metres from a bore or a drain. Woody and herbaceous perennial plantings lower groundwater levels below the treatments (as a result of reduced recharge), but in many landscapes the effect can only be detected within metres of the edge of the treatment (George et al. 1999). This is particularly the case where the transmissivity of the soil and regolith is low, and the landscape is relatively flat, as occurs east of the Meckering Line. The treatments are sited to help manage the salinity threat to the asset — not to help prevent or ameliorate salinity impacts on agricultural land. The underlying assumption is that the treatments will be located as close to the asset as possible or, in the case of groundwater abstraction, within it.

On this basis, the benefits of treatments planned to address salinisation of biodiversity assets will have limited benefit on agricultural productivity away from the immediate area of implementation. The individual treatments, their implementation for biodiversity protection and their spatial impacts on agricultural productivity are discussed below.

Woody perennials

Tree plantings either in blocks (maximum 34% of area) or alleys (maximum 10% of area) will prevent recharge *in situ*. Provided that the plantings are located as close to the asset as practical, they will have a minor beneficial effect on groundwater flows into the asset, with this benefit being more significant in catchments west of the Meckering Line. However, at these upper percentages for area of establishment, in most cases this level of planting will have limited effect on the salinity scenario at farm scale outside the area of establishment. Exceptions are Boyup Brook-Collie East, Darkin Swamp and Drummond, Yinniebatharra assets located on westward-flowing rivers, and TLs 91, 94 along the south coast. In these areas, it can be assumed that there is a 0.13-ha reduction in the saline discharge area in the catchment for every hectare planted to trees. This ratio is based on modelled impacts of tree plantations on the area of seepage land in the Collie River catchment, as shown in Tables 8.4 and 8.11 in Mauger et al. (2001). The benefit for this area can be assessed based on the economic factors presented in following sections. It is assumed that the benefit is realised after year 10.

The conceptual model for treatment uses saltbush to prevent recharge in areas immediately adjacent to the asset to prevent localised recharge that can damage the asset. In some cases this land will already be affected by waterlogging and shallow groundwater and in other cases it could be predicted to experience these impacts in coming years. The financial assumptions are that, after accounting for establishment costs, the saltbush stands will achieve the same return as existing land uses. This ignores the possibility that establishing saltbush may prevent land from losing productivity as a result of localised rising groundwater levels. The assumption is made that 50% of the saltbush stands will benefit in this manner, with the benefit being experienced after year 10.

Herbaceous perennials

The situation is similar to that for the woody perennials, although there is no assumption about any benefits in salinity avoided elsewhere on the farm as a result of the establishment of lucerne.

Ground water abstraction and deep drainage

The radii for impacts in lowering groundwater through the use of pumping and deep drainage are limited to 100 to 300 m. Given that these treatments will be located within sometimes extensive biodiversity assets, it is unlikely that they will provide measurable benefits for neighbouring agricultural land except in marginal situations. No benefits are assumed.

Surface water management

Surface water treatments are located adjacent to assets and along flow lines to direct surface water away from situations where it can recharge groundwater close to the assets. Some of this land will benefit from better surface water control, with, in lower parts, elimination of seasonal waterlogging which will be inhibiting productivity. It is assumed that implementation of surface water control on these areas will ensure that they retain productivity at full rates under existing land uses. For areas already affected by low productivity (as estimated by visual estimation of *Land Monitor* data), the benefit is modelled to occur in year 1. For areas predicted to be affected by salinity in coming years (using visual estimation of *Land Monitor* data), the percentage of the area to be treated by surface water control where there will be a benefit in terms of land productivity is estimated. These estimates range from 20 to 100% of the area subject to surface water control works. For these areas, benefits will begin to be realised in years 10 and 20. Note that areas for surface water treatment are assumed to be in addition to areas planned for saltbush planting which will also have surface water management works built.

The overall impacts of the treatments on agricultural productivity are shown for each asset in Table A2.1. The analysis assumes the effects are additive, which may not always be the case but, without detailed mapping, is really the only possibility.

Table A2.1 Impact of treatments on preventing salinisation on non-treated agricultural land

Asset (surface)	Area of agricultural land either prevented from salinisation or where salinity is ameliorated by treatments to protect biodiversity asset (ha)				
	Tree-planting Year 10	Saltbush Year 10	Surface water management		
			Now	Year 10	Year 20
TL46 (Yarra Yarra South)		7500	1600	7200	7200
TL67 (N. Munglinup)				1600	1600
TL80 (L. Bryde)		2500	1500	3900	3900
TL91 (E. Pallinup)		1500	1000	3100	3100
TL92 (Wellstead)	520	983	700	5000	5000
TL94 (Young R)	1690		100	7900	7900
Yinniebatharra	1300		200	900	900
Coonderoo-Moore		3000	15 000	4500	4500
Mollerin Lakes		16 000	2000	1500	1500
Mortlock River			1600	1300	1300
Kondinin Salt Marsh			5000	800	800
Cowcowing Lakes			2000	500	500
Kent Road			2000	800	800
TL 82 (Dunn Rock – Lake King)			900	3800	3800
Magenta			3500	2100	2100
Chinocup		10 000	5000	2400	2400
Fitzgerald River ^a			2000	800	800
Darkin Swamp	455		200	300	300
Boyup Brook	455		500	1000	1000
Kojonup-Beaufort	1560		5000	2700	2700
Coyrecup		2000	5000	1200	1200
NE Stirling Ranges			1000	1200	1200
Upper Lort River				3800	3800
Lake Gore			1000	800	800
Lake Champion		5000	2000	4300	4300
Buntine-Marchagee		6000	4000	3500	3500
Drummond	260		500	900	900
Muir-Unicup				4000	4000
L. Toolibin ^a		250	1000	800	800
L. Warden ^a			1000	2700	2700

^a also a waterscape

Calculating the economic costs of salinity

Three methods were used to estimate the costs of salinity to landholders of agricultural land.

Gross benefits methodology

Kingwell et al. (2003) present figures for the areas of land affected by salinity and the gross benefits from salinity amelioration at GRDC Region-scale. The appropriate measure for gross benefits is an estimate of the increase in profits attainable from costlessly correcting dryland salinity, constrained by impacts from soil sodicity and acidity. As shown in Table A2.2, these figures can be used to calculate a measure of the gross benefit per hectare for each of the four zones. The appropriate numbers for gross benefits per hectare per annum were used in calculating private benefits per hectare for land adjacent to each asset, as shown in Table A2.2.

Table A2.2 *Gross benefits from correcting dryland salinity*

GRDC Region	Gross benefit from correcting soil salinity (\$'000/yr)*	Predicted area of salinity in 2020 ('000 ha)	Annual gross benefit (\$/ha affected land)
WA Central	17 601	1142	12.78
WA Eastern	9 497	374	25.39
WA Northern	2 317	280	8.27
WA Sandplain	6 444	522	12.34
Total	35 859	2318	15.47

Source: Kingwell et al. (2003), pp. 3, 17, 18

* Limited by sodic and acid soils

Audit methodology

Work done for the National Land and Water Resources Audit (2001) estimated the area in the south-west of WA with a high potential of developing salinity from shallow watertables. An estimate was also made of the annual cost due to shallow groundwater and salinity carried by agriculture — \$80 million per year, or \$22 per hectare affected. The costs were derived from benchmark data collected across WA by BankWest (BankWest undated). The approach used the figures presented for Operating Profit (\$/effective ha) as a measure of land productivity. Average figures for the years 1996/97 to 1999/00 for seven farming regions were used. These numbers were discounted by 50% as an estimate of the costs of salinity on land productivity. This percentage discount brings the average cost down to the same as that shown in Audit (\$22 per hectare). This information is presented in Table A2.3. The appropriate numbers were used in calculating private benefits per hectare for land adjacent to each asset, as shown in Table A2.4. In some cases where assets lie across two regions (e.g. TL46 Yarra Yarra South), an average of the two costs was used.

Table A2.3 Estimates of costs of salinity

BankWest region	BankWest districts	Average operating profit 1996/97–1999/2000 (Effective ha/yr\$)	50% reduction for cost of shallow water levels and salinity
Central Midlands	Northam	46	23
	Moora		
Great Southern	Narrogin	40	20
	Katanning		
	Kojonup		
	Wagin		
North-Eastern Wheatbelt	Koorda/ Nungarin	40	20
	Merredin		
	Narembeen		
Northern Wheatbelt (> 350 mm rainfall)	Geraldton	59	29.50
	Carnamah		
South Coast	Esperance	41.5	20.50
	Plantagenet		
	Jerramungup		
	Ongerup		
South Eastern Wheatbelt	Lake Grace	42	21
	Bruce Rock/ Corrigin		
	Kondinin		

Source: BankWest (undated)

Land valuation methodology

The third method of calculating the economic impacts of salinity was to use average land values for the area near the asset, and assume that land with shallow watertables and salt-affected land now would be worth 50% of the value of fully productive land that will never be affected. Average market values for dollars per cleared hectare for 2001 were obtained from the Department of Agriculture. These were available from Dalwallinu in the north to Ravensthorpe in the south-east. These have been inflated by 20% to account for land price increases over the last three years. Advice was sought directly from Departmental officers about land prices for the areas near the few assets outside that range. The land values were depreciated by 50% and then annualised over 30 years using 5% discount rate. The numbers are shown in Table A2.4.

Comparing economic impacts

As shown in Table A2.4, the three methods generate quite different estimates of salinity cost across the assets. The Gross Benefit method has the most conservative estimate of the benefits of correcting salinity, with very low numbers for benefits in the Northern Wheatbelt. Conversely, the Audit method, based on benchmark data, suggests salinity will be relatively more costly in the higher rainfall Northern Wheatbelt. Agreement between these two methods is best in the North-Eastern Wheatbelt. The land valuation method generates figures that are approximate to those by the other two methods across a number of assets, where these are located in the medium rainfall areas. Where assets are located in areas closer to Perth, or the south-west, locational factors are evident in increasing the land value above its production value alone.

The method selected for this assessment used the Audit methodology (Table A2.3) for the following reasons:

- The land valuations for areas close to the coast and the metropolitan area are overvalued by factors unrelated to agricultural productivity. Conversely, more areas are undervalued. The intent of this analysis was to consider impacts on agricultural productivity.
- The Gross Benefit method is presented at a coarse scale with the whole of the Wheatbelt subdivided into four regions. This will obscure subregional variation.
- The Audit methodology is based on real assessments of average agricultural productivity across seven regions, although the choice of a 50% depreciation for the cost of salinity is arbitrary.

Table A2.4 Three methods of valuing salinity impacts compared (\$/ha)

Asset	Method		
	Gross benefit	Audit	Land valuation
TL46 (Yarra Yarra South)	8	27	16
TL67 (N. Munglinup)	12	20	16
TL80 (L. Bryde)	13	21	31
TL91 (E. Pallinup)	12	20	34
TL92 (Wellstead)	12	20	23
TL94 (Young R)	12	20	16
Yinniebatharra	8	27	18
Coonderoo–Moore	8	26	31
Mollerin Lakes	25	20	12
Mortlock River	13	20	31
Kondinin Salt Marsh	13	21	16
Cowcowing Lakes	13	20	23
Kent Road	13	21	16
TL 82 (Dunn Rock – Lake King)	13	21	16
Magenta	13	21	16
Chinocup	13	21	16
Fitzgerald River (waterscape & biodiversity)	12	20	16
Darkin Swamp	13	23	55
Boyup Brook	13	23	94
Kojonup–Beaufort	13	23	78
Coyrecup	13	23	27
NE Stirling Ranges	13	20	27
Upper Lort River	12	20	31
Lake Gore	12	20	31
Lake Champion	25	20	12
Buntine–Marchagee	8	25	20
Drummond	13	23	55
Muir–Unicup	13	20	94
L. Toolibin (waterscape & biodiversity)	13	23	31
L. Warden (waterscape & biodiversity)	12	20	31
Average across all assets	13	22	31

Discounting for future impacts

Some agricultural areas adjacent to the biodiversity assets are fully affected now, further areas will be affected in the next 10 years, and other areas will be affected after year 20. Discounting the current cost of salinity at 5% can be used to estimate the present value of salinity impacts over the next 30 years, for the areas impacted now, where impacts will commence in year 10, and where impacts will commence in year 20, as shown in Table A2.5.

Table A2.5 Costs of salinity depending on time of first impact

Annual cost of salinity (\$/ha)	PV \$/ha discounted at 5% over 30 years		
	Affected now	Affected Year 11	Affected Year 21
20	314	154	58
21	330	161	60
22	345	169	63
23	361	177	66
24	376	184	69
25	393	192	72
26	408	200	75
27	424	207	78

The economic benefit for agricultural lands

The information on areas of agricultural land protected from current or potential salinity impacts (Table A2.1) is combined with the appropriate discounted value for the economic benefit per hectare to the landholder (using figures in Table A2.4 and Table A2.5) to generate present values for salinity benefits to agriculture occurring as a result of the public investment in protecting/enhancing the assets. The economic benefits are shown in Table A2.6.

The present value of the benefit for agricultural lands is estimated at \$51 million, which represents 6% private ‘added’ return on the total public investment of \$854 million committed to protection of the existing suite of biodiversity in these assets.

This low rate of return results from the generally limited impact of land-use change on agricultural land outside the area treated, and because the interventions are specifically targeted at protecting the biodiversity asset at risk, not agricultural land at risk. The most effective treatment in providing benefits to landholders is surface water management where the average benefit is estimated at \$190 (present value) per hectare, ranging from a low of \$106 per hectare to a high of \$306 per hectare. In most cases the private return compares favourably with the cost for implementing surface water control works of \$150 per hectare. The implication is that landholders could be expected to meet all or most of the costs of this treatment, which would reduce the cost to the government of about \$40 million — a 4.7% saving on the total cost.

Table A2.6 Economic benefits to agriculture from investments in protecting biodiversity

Assets	PV \$m (30 years @ 5% discount)			
	Trees	Saltbush	Surface water control	Total
TL46 (Yarra Yarra South)		1.55	2.73	4.28
TL67 (N. Munglinup)			0.34	0.34
TL80 (L. Bryde)		0.40	1.35	1.76
TL91 (E. Pallinup)		0.23	0.97	1.20
TL92 (Wellstead)	0.08	0.15	1.29	1.52
TL94 (Young R)	0.26		1.72	1.98
Yinniebatharra	0.27		0.33	0.60
Coonderoo-Moore		0.60	7.36	7.96
Mollerin Lakes		2.46	0.95	3.42
Mortlock River			0.78	0.78
Kondinin Salt Marsh			1.82	1.82
Cowcowing Lakes			0.73	0.73
Kent Road			0.83	0.83
TL 82 (Dunn Rock–Lake King)			1.13	1.13
Magenta			1.62	1.62
Chinocup		1.61	2.18	3.80
Fitzgerald River ^a			0.79	0.79
Darkin Swamp	0.08		0.15	0.24
Boyup Brook	0.08		0.43	0.51
Kojonup–Beaufort	0.28		2.46	2.74
Coyrecup		0.35	2.10	2.45
NE Stirling Ranges			0.58	0.58
Upper Lort River			0.80	0.80
Lake Gore			0.48	0.48
Lake Champion		0.77	1.53	2.30
Buntine–Marchagee		1.15	2.51	3.66
Drummond	0.05		0.40	0.45
Muir–Unicup			0.86	0.86
L. Toolibin ^a		0.04	0.55	0.59
L. Warden ^a			0.89	0.89
TOTAL	1.10	9.33	40.67	51.09

^a also a waterscape

Water resource assets

The Collie River catchment

The *Salinity Situation Statement: Collie River* (Mauger et al. 2001) presents data on the impacts of different land-use options on the area affected by saline discharge. This land will have shallow groundwater levels and be subject to varying degrees of salinisation. Under normal conditions, productivity will be about the same as is shown in Table A2.4 for the Boyup Brook–SE Collie asset.

The additional area predicted to be affected by saline discharge varies significantly between options, up to a maximum of 3900 hectares under the ‘Do nothing differently’ scenario.

Assuming this land becomes ‘salt affected’ it will lose productive values and will depreciate as an asset. The cost is estimated as a loss of land value of \$1200, which is approximately half the market value for that class of land (Bob Hall pers. comm.). However, to maintain consistency with the method selected for assessing impacts adjacent to biodiversity assets, the cost of salinity is estimated at \$23 per hectare per year.

The options assessed in Section 3 are presented below in Table A2.7 with an assessment of the area that will be affected by saline discharge, taken from Mauger et al. (2001).

Table A2.7 Area of land affected by saline seepage

Treatment	Area affected by saline seepage (ha)	Benefit to landholder compared to BaU case (\$'000/yr)	Benefit PV 30 yrs @ 5% (\$'000)
Business as usual (BaU)	3900	Nil	Nil
Option A: 50% diversion at Buckingham into Muja voids (600 mg/L)	3900	Nil	Nil
Option B: Full diversion 9 km downstream from James Crossing (600 mg/L)	3900	Nil	Nil
Option C: Groundwater abstraction and land use change on 3000 hectares (550 mg/L)	Estimate 1800	48.3	759
Option D: 30% diversion at James Crossing and groundwater abstraction (600 mg/L)	3400	11.5	181
Option E: Land use change on 16 700 ha (550 mg/L)	1100	64.4	1011
Option F is Option A with the addition of trees planted in Collie South to reduce salinity levels to 550 mg/L in the reservoir.	Estimate 2900	23	361
Option G is Option A with the addition of groundwater pumping in Collie South to reduce salinity levels to 550 mg/L in the reservoir.	Estimate 2900	23	361

The analysis suggests that the benefits to private landholders in terms of increased agricultural productivity will be a maximum of \$1 million in present value.

The Denmark River catchment

The *Salinity Situation Statement: Denmark River* (Bari et al. 2004) presents some data on the areas with shallow watertables and the areas of seepage under the different treatments. This land will be subject to varying degrees of salinisation. The economic impact of shallow water levels and salinisation will be reduced productivity. If the land is used for grazing, under normal conditions, productivity will be about the same as is shown in Table A2.4 for the Muir–Unicup asset.

The additional area predicted to be affected by saline discharge varies significantly between options, up to a maximum of 2300 hectares under the ‘Do nothing differently’ scenario, and with 30% diversion at Mt Lindesay. The areas of shallow watertable and seepage for the other treatments have had to be extrapolated from specific modelled situations shown in Tables 8, A5.1, A5.2 and A5.3 in Bari et al. (2004).

Assuming this land becomes ‘salt affected’ it will lose productive values and will depreciate as an asset. The cost is estimated as a loss of land value of \$1200, which is approximately half the market value for agricultural land in that area. However, to maintain consistency with the method selected for assessing impacts adjacent to biodiversity assets, the cost of salinity is estimated at \$20 per hectare per year.

The options assessed in Section 3 are presented below in Table A2.8.

Table A2.8 Options for recovery in the Denmark Water Resource Recovery Catchment

Treatment	Area affected by shallow watertable (ha)	Area affected by saline seepage (ha)	Benefit to landholder compared to BaU case (\$'000/yr)	Benefit PV 30 yrs @ 5% (\$'000)
Business as usual (BaU)	3500	2500	Nil	Nil
Tree-planting plus existing plantations	1000 (est.)	600 (est.)	38	598
Lucerne plus existing plantations	800	500 (est)	40	628
Groundwater pumping plus existing plantations	Not known	Not known	Estimate 38	598
Diversion at Mt Lindesay	35	23	Nil	Nil

The analysis suggests that the benefits to private landholders in terms of increased agricultural productivity will be a maximum of about \$600 000 in present value.

Appendix 3 - Assessment of the value of industry development in addressing salinity threats

(Source: URS 2004a)

The section discusses the results of using the data from the SIF Phase II assessment to estimate the potential value of 'new industries'. The aim is to assess determine the value of land use options that should they be financially competitive and hydrologically neutral, or options to gain financial returns from saline water pumped or drained from the asset areas. The approach taken is to value the cost saving in the currently available land-use change and engineering options, should they be substituted with a 'new industry'.

Method

For each biodiversity asset considered by the SIF Phase II assessment the following tasks were undertaken:

- Determine the area and the timing of when engineering options can be replaced by a 'new industry' land-use option, assuming 'new industry' options are available now.
- Base the opportunity to replace SIF Phase II solutions on an assessment of the need to remove accumulated water to a new equilibrium, and the time required for 'new industry' options to be effective in maintaining the desired equilibrium.
- Estimate the capital costs of required engineering solutions (with and without 'new industry' options).
- Estimate the maintenance and operating costs of engineering solutions for options that may need to be maintained indefinitely, and for those that may be replaced as 'new industry' land-use options become fully effective in maintaining desired equilibrium (for with and without 'new industry' options).
- Consider as zero to government costs of 'new industry' options as they are assumed to be financially competitive with other agricultural enterprises.
- Calculate the value of having 'new industry' land-use options as short- or long-term alternatives to ongoing costs of engineering solutions.
- Calculate the value of having 'new industry' options that can use the pumped saline water as a resource.
- Aggregate the net value across the 30 biodiversity assets considered in the SIF Phase II study.
- Summarise results and discuss the validity of extrapolating these results across other threatened biodiversity assets.

The potential benefits of financially competitive new land uses are in:

- the reduction of incentive payments to encourage adoption of currently available but non-competitive industries in target areas
- the reduction of ongoing pumping and maintenance costs if land-use change can negate net recharge (for the assets considered as part of the SIF Phase II assessment it is assumed that pumping will be needed for a minimum of 10 years to remove water from saturated landscapes — land-use change will at best be too slow)
- options for better targeting recharge areas and providing increased interception efficiencies

- greater levels of adoption and capacity to address recharge in more areas
- reducing recharge rates close to that of the original native vegetation (the current solutions estimated for the SIF Phase II assessment do not necessarily provide a balanced water use across the catchment).

Reduced cost of perennial pasture incentives

The most immediate opportunity is improving the productivity and feasible distribution of existing options over a greater range of soil types and rainfall zones. For example, lucerne is one perennial pasture option that is indicated to provide water-balance improvements over annual crops and pastures. However, because profitability is often lower than current annual pasture and cropping enterprises, this analysis has assumed a cost of \$400 per hectare to government to provide an incentive payment to farmers to gain required adoption. Should profitability be improved then the level of incentive payment could be lowered.

The base analysis assumes a cost of \$400 per hectare to encourage establishment of lucerne on private agricultural lands. Lucerne is also assumed to intercept 50% of indicated recharge in each area. Should a 'new industry' be developed, or the productivity of lucerne be improved, (to substitute to the level of function assumed for lucerne) then the following savings could be made on estimated aggregate cost of activities to protect the biodiversity assets.

Table A3.1 shows the saving on total budget as the cost of implementing the planting of lucerne is incrementally reduced from \$400 per hectare (plus 30% transaction costs for project management-type expenses) to zero. If a 'new industry' can be found that is financially competitive for farmers, and is as hydrologically efficient as lucerne then up to \$207 million could be saved off the estimated cost of protecting the listed priority biodiversity assets.

Table A3.1 Effect of reduced net cost of lucerne subsidy

Lucerne subsidy (\$/ha)	NPV (\$m)	Saving on cost to Government (\$m)
400	854	
300	803	51
200	751	103
100	699	155
0	647	207

Note this analysis assumes some 398 000 hectares of lucerne are planted across all the assets (3% of cleared land). This, along with assumed areas of tree plantings, is not sufficient to reduce net recharge to a point where there is no net impact on the biodiversity assets without ongoing pumping. This cost also includes the 30% transaction costs imposed on top of the \$400 per hectare.

Reduction of ongoing pumping and maintenance costs

Should land-use change 'new industries' become available that allow pumping to be stopped once groundwater in the saturated area is pumped out to a depth of two metres, then the savings indicated by Table A3.2 could be realised. If pumping is required for only 10 years then \$35 million may be saved in ongoing pumping and maintenance costs. It is assumed that it would take 10 years for the widespread adoption of these new land uses to have their full effect on the catchments' hydrology. There may also be an additional salvage value reimbursement (reduction in net cost to government) should it be possible to completely do away with the pumping and water-disposal infrastructure. Pumps

are the major asset that may be removed and resold, with an initial capital cost of \$11 million and a salvage value, of say, 25% this may return \$2.75 million — a relatively small amount.

As the SIF Phase II analysis stands it is assumed that the pipe and pumping infrastructure lasts for thirty years. This assumption has not been fully tested. If the life of this infrastructure is less than thirty years then the benefits from new industries would be greater than the indicated \$35 to \$40 million (including salvage values). Should the cost of replacing this infrastructure be included and the value of land use change budgeted over a longer time horizon then the relative value of new land use industries increases.

Table A3.2 Saving with reduced years of pumping

Years of pumping	PV of operation and maintenance costs (\$m)	Saving with reduced years of pumping (\$m)
30	66.40	Nil
20	56.31	10.09
15	46.90	19.50
10	34.89	31.51

Improved interception rates

The assumed average interception rate is 50% for lucerne, and 100% for trees and saltbush. By having an option with higher interception efficiencies than lucerne the area of establishment and associated costs can be reduced. Similarly, if improved technologies can allow land-use change to be targeted to increase interception efficiencies then the areas to be planted can be reduced. This can also reduce costs, even if the land use options are not cost neutral with current farming enterprises.

Having cost-neutral substitutes for lucerne, trees and saltbush

Should new industries be available to substitute for the assumed plantings of lucerne, trees and saltbush then some \$426 million $((\$159 + \$120 + \$49) \times 1.3)$ could be saved off the base-scenario cost. However, as the base scenario does not adequately reduce recharge such that ongoing pumping can be stopped (once the groundwater in the saturated area is pumped out to a depth of two metres), then the real saving to achieve a permanent solution would be greater than this estimate. However, it should also be noted that having viable land-use change options will not preclude the need for pumping and drainage for many of the assets investigated as part of the SIF II process. Indications are that there simply is not the time to wait for these options to be discovered and implemented. So pumping will be required in the short term even if land-use change options become available in the long term.

Benefits of new industries — using saline water

The benefits of having new industries that can profitably use saline water, pumped or drained as part of the protection of the biodiversity assets, were modelled by reducing evaporation pond and pumping costs to varying degrees. Because any industry based on saline water will require economies of scale to be efficient, the assets with critical minimum flows or infrastructure were selected from the list of 30 to determine where such industries could most likely occur. Table A3.3 shows the base costs, and cost summaries for assets selected where:

- evaporation ponds are included as part of the solution

- pumping rates exceed 5 GL annually
- ongoing recharge rates into the asset exceed 5 GL (assuming 33% of estimated total recharge reaches the asset).

Assets with lower pumping rates were assumed to be less likely to be viable for enterprises based on the use of saline water. Varying the ‘cost-share’ that these new industries may contribute to the capital or operating costs of the biodiversity asset protection works may be taken to reflect the varying profitability of these new industries.

Table A3.3 Cost summaries for base solution and assets subjected to high flow rates

Activities	Base solution	Assets		
		With evaporation ponds	With pumping rates > 5 GL	Where 33% of recharge > 5 GL
Lucerne cost (\$,000)	159 254	33 200	19 600	90 000
Trees cost (\$,000)	120 500	35 600	39 600	62 400
Saltbush cost (\$,000)	49 250	9 450	27 900	22 034
Surface water mgt cost (\$,000)	40 400	9 220	11 040	14 846
Drains cost (\$,000)	3 290	288	0	738
Pumps cost (\$,000)	10 000	3 885	7 455	4 274
High voltage line cost (\$,000)	6 900	2 560	4 912	2 816
Power to borefield cost (\$,000)	1 700	725	853	600
Transformer cost (\$,000)	160	70	70	60
Piping cost (\$,000)	14 500	5 422	9 882	5 856
Evaporation pond + land cost (\$,000)	184 266	184 266	12 4787	70 224
Present value of operating costs (\$,000)	66 400	24 460	46 881	26 939
Capital costs — land use & surface water management (\$m)	369	87	98	189
Capital costs — pumping and drainage (\$m)	221	198	148	85
Total capital costs (\$m)	590	285	246	274
Operating costs (\$m)	66	24	47	27
Transaction costs (\$m)	197	93	88	90
PV of total costs (\$m)	854	402	381	391

Should viable industries be based around the water pumped from these assets, then potential savings by government avoiding the cost of pumping and drainage operating costs may be in the order of \$27–42 million (see Table A3.3). Table A3.4 presents a summary of potential savings to government should partnerships be developed with operators paying a share of capital and operating costs of pumping and drainage costs (these numbers include the 30% transaction costs). Essentially these are the costs exclusive of land-use change costs. This matrix indicates the potential saving to be substantial even with a 50:50 cost share basis. Savings may be in the order of \$73–144 million.

Table A3.4 New industry benefits over a range of cost-share ratios (\$m)

Cost-share of pumping and drainage costs (New industry:government)	Base solution (\$m)	Potential savings		
		Assets with evaporation ponds (\$m)	Assets with pumping rates > 5 GL (\$m)	Assets where 33% of recharge > 5 GL (\$m)
100%	373	289	253	145
75%	280	217	190	109
50%	186	144	127	73
25%	93	72	63	36

Potential industry

Table A3.4 provides a summary of drainage and pumping costs per kL of water removed for a combination of the scenarios discussed above — where evaporation ponds are included as part of the solution, or where pumping rates exceed 5 GL annually, or where ongoing recharge rates into the asset exceed 5 GL (assuming 33% of estimated total recharge reaches the asset). ‘With evaporation pond’ and ‘without evaporation pond’ costs are compared. For example, for the set of assets requiring evaporation ponds, the cost of pumping and drainage per kL is \$5.75. Should a solution be found that avoids the need for evaporation ponds then the average cost across the 18 assets is reduced from \$3.59 to \$1.05 per kL. Note that land-use change options are indicated to be much more expensive than drainage and pumping options.

Table A3.5 Per kL costs for selected assets

Management option	Base solution	Assets with evaporation ponds	Assets without evaporation ponds
Land use change cost (\$/kL)	11.20	6.61	6.61
Surface water mgt cost (\$/kL)	16.08	12.89	12.89
Drainage and pumping cost (\$/kL)	2.19	3.59	1.05
Average costs (\$/kL)	9.45	5.75	3.76
Number of assets in each classification	31	18	18

Suggestions are that operating costs for desalination vary between 60 cents and \$2 per kL, depending on salinity, impurities and the volume. The cost of providing water to regional areas through current water schemes with water pumped from the coast is suggested to vary between \$4 and \$8 per kL depending on distance and volume. If water can be pumped consistently from these assets at a cost of \$2 per kL or less then it appears desalination of this water may be competitive with current sources even at full cost. Cost sharing between the value of biodiversity benefits and water supply values could reduce this cost of supply further. A solution in combination with energy for desalination coming from biofuel plants fuelled by mallees could present a greenhouse-gas-neutral solution to biodiversity protection and water supply needs.

Appendix 4 - Biodiversity asset priorities — Threatened species and communities

(Source: Unpublished work by the Department of Conservation and Land Management in 2004)

Goal

The goal for the management of threatened species and communities is the State biodiversity conservation goal of:

‘To protect, conserve and, where necessary and possible, restore Western Australia’s natural biodiversity’ (Corporate Plan 2002–2005 Department of Conservation and Land Management)

Biophysical threat analysis

As discussed in SIF Phase I, there are already methods for assessing the level of extinction threat in relation to rare species and communities. These methods — which take into consideration all threats, not just that of salinity — generate various categories of threatened species and communities. The *critically endangered* and *endangered* categories are the most vulnerable to extinction.

As a measure of salinity hazard, SIF Phase I identified (using Land Monitor data) the low-lying areas and valley floors which may become permanently saline and/or waterlogged if the watertables rise sufficiently, or temporarily waterlogged if there is sufficient run-off following heavy rainfall. These were intersected using GIS with locations of threatened species and communities, and maps of threatened species and communities were generated.

To provide more specific information, under SIF Phase II the same data from Land Monitor was used to generate actual lists of threatened species and communities potentially at risk from salinity and waterlogging (within the limitations of Land Monitor).

Technical capacity and costs of intervention

Given the number of species/communities involved, it was not practicable to assess the feasibility of managing each individual species/community. With regard to threatened species, those that are critically endangered require urgent attention, and it is clear that they should be a priority for funding, and those that are endangered are a second priority. If, after examination, it were found that they could not be feasibly managed, then it would be appropriate to explore *ex situ* conservation.

With regard to threatened communities, many of the critically endangered and endangered communities lie within existing or potential natural diversity recovery catchments. For example, three⁶ out of the four *critically endangered* communities are represented within existing or potential natural diversity recovery catchments. Morilla Swamp is the exception, and is now considered to be extinct (John Blyth pers comm.). Only one (Bentonite Lakes) of the three *endangered communities* lies within an existing or potential natural diversity recovery catchment. The remaining two — those within the South Branch of the Mortlock River, and the Three Springs Mound Spring — are located outside existing or potential natural diversity recovery catchments, and their case needs to be more closely examined.

Provisional analysis, conclusions and recommendations

With regard to rare species and communities, those with highest management priority are within the *critically endangered* (highest priority for management) and *endangered* (second highest priority for management) categories. Results are in Attachment 1.

Therefore it is recommended that:

1. The initial priorities for expenditure of salinity funds in relation to rare species and communities are:
 - (a) *Critically endangered* species of plants and animals (Attachment 1)
 - (b) *Critically endangered* communities. However, it is further recommended that *critically endangered* communities be dealt with through natural diversity recovery catchments or similar landscape approaches.
2. The second highest priorities for expenditure of salinity funds in relation to rare species and communities are:
 - (a) *Endangered* species of plants and animals (Attachment 1)
 - (b) *Endangered* communities.
3. These priorities are reviewed and amended if appropriate before October 2006.

⁶ At Toolibin, Lake Bryde and Chinocup

ATTACHMENT 1

Populations of critically endangered flora at risk from salinity/waterlogging

Species name	No. of occurrences
<i>Acacia aprica</i>	3
<i>Acacia auratiflora</i>	8
<i>Acacia subflexuosa</i> subsp. <i>capillata</i>	2
<i>Acacia vassalii</i>	2
<i>Acacia volubilis</i>	1
<i>Adenanthos pungens</i> subsp. <i>effusus</i>	3
<i>Banksia brownii</i>	2
<i>Caladenia bryceana</i> subsp. <i>bryceana</i>	5
<i>Caladenia drakeoides</i>	18
<i>Caladenia elegans</i>	7
<i>Caladenia melanema</i>	2
<i>Chorizema humile</i>	1
<i>Conostylis dielsii</i> subsp. <i>teres</i>	1
<i>Conostylis micrantha</i>	3
<i>Drakaea confluens</i>	2
<i>Drakaea isolata</i>	2
<i>Dryandra mucronulata</i> subsp. <i>retrorsa</i>	1
<i>Eremophila lactea</i>	1
<i>Eremophila nivea</i>	5
<i>Eremophila scaberula</i>	3
<i>Eremophila subteretifolia</i>	5
<i>Eremophila verticillata</i>	1
<i>Eremophila viscida</i>	8
<i>Eucalyptus cuprea</i>	2
<i>Frankenia conferta</i>	9
<i>Gastrolobium hamulosum</i>	1
<i>Grevillea dryandroides</i> subsp. <i>dryandroides</i>	4
<i>Grevillea maxwellii</i>	1
<i>Grevillea pythara</i>	3
<i>Grevillea scapigera</i>	3
<i>Hemiandra gardneri</i>	1
<i>Hemiandra rutilans</i>	1
<i>Hemigenia ramosissima</i>	2
<i>Isopogon uncinatus</i>	1
<i>Jacksonia pungens</i>	4
<i>Lambertia orbifolia</i> subsp. <i>orbifolia</i>	1

Species name	No. of occurrences
<i>Myoporum turbinatum</i>	12
<i>Persoonia micranthera</i>	1
<i>Philotheca basistyla</i>	1
<i>Pterostylis</i> sp.Northampton(S.D.Hopper 3349)	2
<i>Rhizanthella gardneri</i>	1
<i>Synaphea quartzitica</i>	1
<i>Thelymitra manginiorum</i> ms	1
<i>Verticordia albida</i>	2
<i>Verticordia fimbriolepis</i> subsp. <i>fimbriolepis</i>	5
<i>Verticordia spicata</i> subsp. <i>squamosa</i>	6

Populations of endangered flora at risk from salinity/waterlogging

Species name	No. of occurrences
<i>Acacia ataxiphylla</i> subsp. <i>magna</i>	1
<i>Acacia depressa</i>	1
<i>Acacia insolita</i> subsp. <i>recurva</i>	1
<i>Acacia trulliformis</i>	1
<i>Adenanthos pungens</i> subsp. <i>pungens</i>	7
<i>Anigozanthos bicolor</i> subsp. <i>minor</i>	6
<i>Banksia cuneata</i>	10
<i>Banksia oligantha</i>	5
<i>Boronia clavata</i>	1
<i>Caladenia christineae</i>	14
<i>Caladenia dorrienii</i>	3
<i>Caladenia wanosa</i>	1
<i>Centrolepis caespitosa</i>	9
<i>Conostylis drummondii</i>	4
<i>Conostylis seorsiflora</i> subsp. <i>trichophylla</i>	1
<i>Conostylis wonganensis</i>	1
<i>Cooperhooikia georgei</i>	1
<i>Darwinia acerosa</i>	2
<i>Darwinia</i> sp.Carnamah(J.Coleby-Williams 148)	6
<i>Daviesia dielsii</i>	2
<i>Drakaea micrantha</i>	1
<i>Dryandra pseudoplumosa</i>	1
<i>Eremophila resinosa</i>	14
<i>Eremophila virens</i>	2
<i>Eucalyptus brevipes</i>	1

Species name	No. of occurrences
<i>Gastrolobium appressum</i>	4
<i>Glyceria drummondii</i>	1
<i>Goodenia integerrima</i>	3
<i>Grevillea bracteosa</i>	3
<i>Grevillea christineae</i>	3
<i>Grevillea dryandroides</i> subsp. <i>hirsuta</i>	5
<i>Grevillea elongata</i>	1
<i>Grevillea murex</i>	6
<i>Hakea aculeata</i>	5
<i>Leucopogon marginatus</i>	1
<i>Muehlenbeckia horrida</i> subsp. <i>abditata</i>	3
<i>Myoporum cordifolium</i>	2
<i>Ptilotus fasciculatus</i>	7
<i>Schoenia filifolia</i> subsp. <i>subulifolia</i>	3
<i>Spirogardnera rubescens</i>	2
<i>Thelymitra stellata</i>	1
<i>Verticordia fimbriolepis</i> subsp. <i>australis</i>	1
<i>Verticordia hughanii</i>	1

Populations of endangered fauna at risk from salinity/waterlogging

Group name	Family name	Scientific name	Common name	No. of occurrences
Spiders	Ctenizidae	<i>Aganippe castellum</i>	Tree Stem Trapdoor Spider	2
Marsupials	Dasyuridae	<i>Parantechinus apicalis</i>	Dibbler	3
Marsupials	Dasyuridae	<i>Phascogale calura</i>	Red-tailed Phascogale	12
Parrots	Psittacidae	<i>Cacatua pastinator pastinator</i>	Western Long-billed Corella	5
Parrots	Psittacidae	<i>Calyptorhynchus latirostris</i>	Carnaby's Black-Cockatoo	11
Lizards	Scincidae	<i>Egernia stokesii badia</i>	Western Spiny-tailed Skink	25

Populations of critically endangered fauna at risk from salinity/waterlogging

Group name	Family name	Scientific name	Common name	No. of occurrences
Spiders	Dipluridae	<i>Teyl</i> sp (BY Main 1953/2683, 1984/13)	Minnivale Trapdoor Spider	2

Appendix 5 - Assessment across assets

Introduction

The need to rank across the main types of assets – biodiversity, land, water, and rural infrastructure – has been recognised throughout work on the Salinity Investment Framework (SIF). Clearly, to rank such disparate assets they need to be assessed, as a group, against some overarching goal that applies equally to all assets, and thus provides a common or shared basis for developing standard criteria against which all assets may be measured.

The only overarching statement in the State Salinity Strategy (2000) is (page 10):

‘to reduce the impact of salinity in the south-west agricultural region of Western Australia’

This statement is followed in the strategy by five goals, four of which refer to specific assets (biodiversity, land, water and rural infrastructure), while the fifth relates to community capacity and is thus an activity to help achieve the four asset related goals. Further comments on priority setting (pages 28–29 of the Strategy) are useful, but add little to the definition of overarching goals or criteria. Thus there is little guidance in the Strategy on what overarching outcomes and criteria might be used to rank priorities across all assets. This issue is returned to in the ‘Conclusions’ and ‘Recommendations’ sections below.

Assuming that there are adequate overarching goals/criteria for ranking across all asset types, there are broadly six types of decision tools that might be used. This summary draws largely on the work of Black and Burton (2002) and Burgman (2005). The former represents a more economic view of decision tools, the latter focuses on decisions in the context of conservation and environmental management.

Political judgement, where a process such as the SIF is used to generate priorities within particular asset types, then the selection of across-asset priorities could be left to Ministers as public representatives with statutory powers. The State Steering Committee rejected this approach because they decided that they should provide Ministers with as much information and assistance as practicable. Thus this option is not considered further here.

Economic tools, ‘which essentially follow the priorities of the market, in which prices are derived directly or indirectly from market prices or are assessed from the willingness of individuals to pay. The central intent of the tool is to maximize economic efficiency’ (Black & Burton 2002). Cost-benefit analyses are the standard economic decision tool.

Multiple criteria tools, that ‘revolve around preferences of decision makers. These tools try to consider simultaneously many conflicting criteria. Economic efficiency is not considered the only aim of the analysis, and many different objectives can be considered’ (Black & Burton 2002). Note that a somewhat different definition is provided by Burgman (2005) who defines multi-criteria decision-analysis (MCDA) as where ‘preferences are measured by eliciting and ordering judgments from people affected by a decision’⁷.

⁷ That the emphasis in one case is on the decision makers, and in the second on those affected by decisions, underlines the various structures and definitions that may be used to classify decision tools.

Deliberative tools, which ‘are based principally on the inputs from and decisions by “ordinary” people, rather than experts’ (Black & Burton 2002). For example, forming a committee of those affected by a decision, including representatives of the range of interest groups, and allowing them to reach a consensus decision, is an example of a deliberative approach.

Expert systems, where individuals who are considered to have expert knowledge in relation to a decision are selected and taken through a process to arrive at a decision, or decision options. Expert systems may form part of either of the previous two processes, or form the basis for other decision tools such as the Delphi technique. Burgman (2005) has outlined working with experts as including:

1. ‘Defining necessary knowledge and skills for the problem at hand (deciding who might be considered and expert)
2. Selecting the experts
3. Eliciting information
4. Evaluating the reliability of the information
5. Combining information from different experts
6. Using the information in estimation, calculations or decisions.’

One expert approach was used during work on the SIF. This involved using a GIS to overlay maps of assets for interpretation by experts (see below).

Other mathematical/logic systems have also been developed as decision tools. For example, Burgman (2005) discusses a range of other decision tools including Monte Carlo methods and Logic trees. None of these were considered during the development of SIF. While these decision tools are not as directly relevant to SIF as the previous five, knowledge of them provides a broader context for thinking through the use of decision tools. These methods are not considered further here.

Analysis of decision tools

Given the Committee’s lack of expertise on decision tools, a highly specialised topic, J Black and M Burton from the School of Agricultural and Resource Economics at the University of WA were contracted to assess the decision tools that might be useful in SIF, and their work has been drawn on for some of the definitions provided above. Their final report was circulated to the Committee on 23 August 2002.

Black and Burton (2002) compared a number of decision tools (see Table A5.1 below) and concluded that a form of multi-criteria decision-analysis was the most appropriate decision tool to set priorities across SIF assets.

Multiple criteria or Multi-criteria decision-analysis (MCDA)

Following their conclusions concerning MCDA, Black and Burton (page 46 of their report) made three recommendations to the Steering Committee:

1. ‘Multiple criteria tools provide a sound framework for complex decision making problems. They are particularly suited to NRM because the tool: (1) distinguishes a broad set of criteria used in NRM decisions, (2) can effectively identify trade-offs between conflicting objectives, and (3) deal adequately with non-monetary, qualitative and uncertain information. *A multiple criteria decision tool should be applied to the Salinity Investment Framework for prioritising investment.*

2. The main criticism levelled at multiple criteria tools is the arbitrary nature of their weighting systems. A logical progression in overcoming the problem is to incorporate either economic or deliberative techniques to generate the weights. *Leading researchers and practitioners in this new area should be consulted on the relative merits of deliberative multiple criteria analysis and choice-weighted multiple criteria analysis.*
3. Design is the most crucial stage in any application of the multiple criteria tool, particularly with regards to: (1) structuring of objectives, (2) setting the management alternatives, (3) determining the decision criteria, (4) filling in the performance matrix, and (5) eliciting weights. *Clear guidelines should be prepared for the practical application of the multiple criteria tool to the Salinity Investment Framework.'*

The Committee accepted these recommendations in principle at its meeting of 2 September 2002. It was decided to investigate further, and in particular, to assess whether the different processes used to develop asset priorities within each of the main asset classes (that is, biodiversity, land, water and rural infrastructure) were amenable to MCDA.

Table A5.1 Performance of decision tools in relation to principles for effective NRM (as outlined in Land and Water Australia 2001, cited in Black and Burton 2002). Ticks reflect an ordinal ranking.

To what extent can the decision tool be used to:	Economic tools	Multi criteria tools	Deliberative tools
Optimise environmental, social and economic benefits?	✓ <i>Optimises economic efficiency, but possibly falls short on social and environment elements</i>	✓✓ <i>Can accommodate conflicting objectives, so trade-offs between these elements are explicit.</i>	✓✓ <i>Rather than an 'optimal' result, a consensual outcome is desired.</i>
Ensure that some values are not consistently favoured over others — in particular that environmental values are not marginalised?	✓ <i>Difficulties in dealing with benefits and costs which are not valued in markets.</i>	✓✓✓ <i>Can accommodate environmental, economic and social issues.</i>	✓✓ <i>Participants have ability to directly express their values.</i>
Encourage the genuine and orderly participation of a wide range of stakeholders and interested parties?	✓ <i>No clear rules on setting boundaries for who counts when calculating costs and benefits</i>	✓✓✓ <i>Weightings can be elicited through a participatory approach.</i>	✓✓✓ <i>Jury will be selected to represent various elements of the relevant population.</i>
Ensure that different kinds of knowledge are fully taken into account?	✓ <i>Requires values to be expressed in monetary terms.</i>	✓✓✓ <i>Construction of the impacts matrix draws on wide range of knowledge and in various forms.</i>	✓✓ <i>Expert witnesses can be called upon to provide detail on particular issues.</i>
Facilitate clear and transparent agreement on the allocation of roles and responsibilities?	✓✓✓ <i>Costs and benefits clearly defined in analysis aiding formulation of cost-sharing arrangements.</i>	✓ <i>Not a necessary outcome of the analysis.</i>	✓ <i>Only will if the jury has been charged to do so.</i>
Develop an outcomes-based hierarchy of goals, objectives and plans, linked in a logical way?	✓ <i>Not a necessary component of the analysis. Link is provided by comparison to the base case or the 'do nothing' scenario.</i>	✓✓✓ <i>Especially the Analytic Hierarchy Method.</i>	✓ <i>Not a necessary component of the analysis.</i>
Apply the precautionary principle?	✓ <i>Debate over whether irreversible loss can be valued.</i>	✓✓✓ <i>Thresholds or a criteria for risk can be built into procedure.</i>	✓✓ <i>Jury can be charged to do so.</i>
Operate at a bio-regional scale?	✓✓ <i>Issues on whose preferences to include in non-market valuation.</i>	✓✓✓ <i>So long as this is part of setting the context for decision makers.</i>	✓✓✓ <i>So long as this is part of setting the context for participants.</i>
Reflect the inherent complexity of NRM systems?	✓✓ <i>Putting all value dimensions into a single axiological scale can mask complexity.</i>	✓✓ <i>It relies on information to be presented in a way that can be usefully considered by decision-makers. This can lead to over-simplification.</i>	✓✓ <i>It relies on information to be presented in a way that can be usefully considered by decision-makers. This can lead to over-simplification.</i>
Use systems and techniques that contribute to enhanced adaptive management?	✓ <i>Does not adequately capture socio-political concerns in the process so results are often ignored.</i>	✓✓✓ <i>Amenable to treating policy formulation as on ongoing process.</i>	✓✓✓ <i>Amenable to treating policy formulation as on ongoing process.</i>
Use systems that enhance 'policy learning' by individuals and within organisations?	✓ <i>Analysis lends itself to be 'ruled by experts'. Has been described as a 'black box' approach.</i>	✓✓✓ <i>The performance matrix unravels complexity of decision, clearly identifying trade-offs and complementarities.</i>	✓✓ <i>Deliberation involves reflective elements.</i>

After receiving Black and Burton's report, the Committee had the opportunity on 17 March 2003 to meet with Stefan Hajkowicz from Queensland who had developed a MCDA for natural resource management in that State (Hajkowicz 2002). This provided a valuable opportunity to assess MCDA and gain an appreciation of the resources and difficulties in applying such a decision tool.

While the work by Hajkowicz and others in Queensland suggests interesting possibilities, the specific work presented to the Committee had a number of weaknesses including:

- a. There was no clear, overarching goal to drive the allocation of weightings among the key objectives/criteria, namely agricultural profitability, soil health, environmental and cultural value, water quality, water use, ecological pressures and geographic extent.
- b. In discussion, types of overarching goals were proposed that were inconsistent with some of the objectives/criteria used, such as 'agricultural profitability' and 'environmental and cultural value'. This underlines the importance of a strong goal framework to drive development of a coherent, comprehensive set of criteria.
- c. Some objectives/criteria — particularly 'agricultural profitability' and 'soil health' — would be more appropriately combined into one criterion. This further underlines the need to develop effective criteria. In particular, they need to be mutually exclusive and cover the full range of important criteria from the perspective of the stakeholders conducting the analysis.
- d. The method used to allocate weightings amongst the objectives/criteria was based on stakeholder 'gut feeling' in the absence of any over-arching goal to drive a more specifically qualitative or quantitative approach.
- e. Significant resources are required to develop and apply the method.

The Steering Committee recognized that they also would have to deal with matters such as (a) to (e) above to effectively apply MCDA. At the subsequent State Steering Committee meeting of 27 March 2003, it was acknowledged that there had been no real conclusion on the applicability of MCDA to the SIF, but that it might be relevant to the Natural Resource Management allocation project being developed at that time under the auspices of the Natural Resource Management Council to assist with setting priorities for the Natural Heritage Trust (NHT) and National Action Plan for Salinity and Water Quality (NAP). Informally, it was decided to defer to that project, which was already in process, as the forum in which the MCDA should be trialled as a means of ranking different types of assets⁸. At this stage the State Steering Committee focused on the more pressing need to develop feasibility analyses as part of the SIF framework, and decided that a GIS-based approach — termed the GIS Overlay Analysis, an expert decision tool — should be used to examine the interaction between assets as a first step to identifying locations that have multiple asset values.

Expert system approach – GIS Overlay Analysis

From quite early in the SIF (Phase 1) project, it was decided by the Steering Committee that the first step to develop across-asset priorities was to use GIS methods to overlay highly ranked assets from all asset classes. This is essentially an expert system approach aimed at achieving synergies between moderate to high value assets that overlap or adjoin, and thus delivering more cost-effective outcomes for salinity management. Several areas of synergy were revealed by this work.

⁸ This work was initially undertaken by an investment subgroup of the NAP/NHT Joint Steering Committee (WA). The Joint Steering Committee now has significant questions as to whether the high costs of developing an MCDA would be justified by the likely improvements in resource allocation in comparison with informed, subjective allocations. At the time of writing (2004), these concerns had not been resolved.

Conclusions

The difficulty of ranking across very different asset types is widely recognised, and the State Steering Committee, even following the work of Black and Burton (2002), could not find a decision tool that has been objectively applied to rank across quite different classes of assets. From work to date, only the GIS Overlay Analysis has provided any guidance within SIF concerning across asset assessments. While crude, it has at least identified one or two areas where synergies between important assets lend themselves to partnership projects. However, in its current form, it is not really a ranking process that can be used to set priorities beyond this.

A key lesson to date is that, to effectively rank across all asset types, it is essential to develop an overarching goal and associated assessment criteria that apply across all the assets to be ranked. Without these, there is no common basis for assessing the relative importance or value of particular assets. One example of how this might be achieved is given in the Attachment.

Table A5.2 Examples of principles/criteria for expert assessment and application

Principles/criteria	Application
1. Those assets that, once lost to salinity, cannot be recovered, or are most difficult to recover, should have the highest priority for funding.	Biodiversity assets, particularly those at risk of extinction, are the highest priority for protection and/or recovery where this is feasible. Water assets, particularly those that are potable, are the second highest priority for protection and/or recovery where this is feasible. Rural infrastructure (highest ranked) should be accorded the third highest priority for protection and/or recovery where this is feasible.
2. Privately held land assets will be covered by industry development, not by direct investment unless this is required to protect biodiversity, water, or public rural infrastructure.	See research and development principle/criterion below.
3. Potable water assets are so important in the south-west that they need to be accorded a very high priority among all assets.	Assets that represent the two highest ranked, most salinity threatened potable, water assets should be protected as a matter of highest priority.
4. Research and development that provides the greatest protection and potential for recovery of assets should be accorded the highest R&D priority.	Assess R&D priorities (see industry development section) and fund to the level necessary, and from the appropriate sources, to achieve new industry outcomes. See Section 3.5.2 of the main report.

Having developed an overarching goal and related criteria, there are really only two options for going forward.

Firstly, substantial resources⁹ could be allocated to further developing a MCDA approach, probably incorporating an expert panel as well as a committee of interest groups. Such an approach would need to be based on the type of goals and criteria described in the Attachment, although it must be emphasised that this is but one of several approaches. Burgman (2005) provides a very good review of decision tools, and is recommended reading together with the work of Black and Burton (2002) for those who wish to gain a better understanding of the current options in this regard. Although there is no guarantee that expending resources on an MCDA will result in an effective decision tool, the process of developing such a tool would provide an important opportunity to explore and document relevant issues. This would allow those involved in decisions to develop a much better understanding of both the processes involved and the range and types of priorities that exist.

⁹ It is estimated that the work required to develop a robust analysis framework would be a minimum of two full time equivalent positions for 12 months. This would cost a minimum of \$200 000 given that there would be some need to employ consultants, and expert panels (with some sitting fees required) would certainly be used.

An alternative approach is to develop a set of critical decision-making principles for expert amendment and application. Some examples are given in Table A5.2.

It is emphasised that the criteria outlined in A5.2 are indicative only — they would require further development, including additional criteria, before being applied by a group of experts to provide alternative funding options as a basis for Ministerial decision. Also, they need to be developed in the context of an overarching goal that relates to all asset types.

Note that the application of such criteria/principles could be managed in two broad types of ways, that is, either by:

1. Tabulating alternative funding scenarios (see Table A5.3 for a simple example), from which one is selected using the criteria/principles as a guide

or by

2. Tabulating, by asset category, priority assets and use criteria/principles to select from these sufficient to match the available funds. Table A5.4 shows how an asset table might be constructed.

Table A5.3 Alternative projects ranked by selecting one funding scenario among four alternatives to meet the available funds (in this case \$4.8 million).

Criteria/principles (such as those in Table A5.2) and cost-effectiveness calculated from feasibility work used to develop the scenarios.

Scenario 1	Scenario 2	Scenario 3	Scenario 4
Water asset/project 1, protects potable water supply High cost effectiveness \$2000K	Biodiversity asset/project 1, protect 50 threatened species High cost effectiveness \$750K	Biodiversity asset/project 1, protect 50 threatened species High cost effectiveness \$750K	Infrastructure asset/project 1, protect 12 rural towns Medium cost effectiveness \$600K
Biodiversity asset/project 1, protect 50 threatened species High cost effectiveness \$750K	Water asset/project 1, protects potable water supply High cost effectiveness \$2000K	Biodiversity asset/project 2, protect four new recovery catchments \$1450K	Water asset/project 1, protects potable water supply High cost effectiveness \$2000K
Biodiversity asset/project 2, protect four new recovery catchments \$1450K	Infrastructure asset/project 3 Low cost effectiveness \$600K	Water asset/project 1, protects potable water supply High cost effectiveness \$2000K	Water asset/project 2 Medium cost effectiveness \$1450K
Infrastructure asset/project 1, protect 12 rural towns Medium cost effectiveness \$600K	Water asset/project 2 Medium cost effectiveness \$1450K	Water asset/project 3 Medium cost effectiveness \$600K	Infrastructure asset/project 3 Low cost effectiveness \$750K

Table A5.4 Alternative projects ranked within asset categories, priority projects selected to meet the available funds (in this case \$4.8 million)

Ranking within asset categories on the basis of relative asset value and cost-effectiveness calculated from feasibility work. Ranking across assets based on criteria/principles such as those in Table 2. The resulting priority projects might, for example, be those shown in italics.

Water resources	Infrastructure	Biodiversity	Land (Industry development)
<i>Water asset/project 1</i>	<i>Infrastructure asset/project 1</i>	<i>Biodiversity asset/project 1</i>	<i>Recharge control/project 1</i>
<i>High cost effectiveness</i>	<i>Medium cost effectiveness</i>	<i>High cost effectiveness</i>	<i>High cost effectiveness</i>
<i>\$2000K</i>	<i>\$600K</i>	<i>\$750K</i>	<i>\$900K</i>
Water asset/project 2	Infrastructure asset/project 2	Biodiversity asset/project 2	Discharge control/project 2
Medium cost effectiveness	Medium cost effectiveness	Medium cost effectiveness	High cost effectiveness
\$500K	\$900K	\$150K	\$400K
Water asset/project 3	Infrastructure asset/project 3	Biodiversity asset/project 3	Multi asset/project 3
Low cost effectiveness	Low cost effectiveness	Low cost effectiveness	Low cost effectiveness
\$1000K	\$600K	\$1100K	\$800K

Developing an over-arching goal, elaborating principles/criteria based on those in Table A5.2, and using them and other information to establish funding priorities using the types of methods shown in Tables A5.3 and A5.4, are early steps in evolving a full MCDA. Thus it would be useful to experiment with various combinations of Tables A5.2, 3 and 4 as a decision system for resource allocation. Not only will this provide an interim means of allocating resources, it will provide the basis for developing more complex (MCDA) decision systems if this proves necessary.

Recommendations

The State Steering Committee for the Salinity Investment Framework recommends that:

1. An expert panel is established to develop the principles and concepts outlined in Table A5.2 and apply them (for example, using methods based on Tables A5.3 and/or A5.4) to identify the most important assets for intensive effort over the next two years. This will provide a ranking process in the short term, and contribute to development of longer-term, decision tools.
2. Based on the experience from work under (1), a decision is made in 12 months whether to pursue developing a more complex, MCDA tool for allocating salinity resources.

ATTACHMENT

An example of an overarching goal and criteria

The importance of an overarching goal and related criteria to provide a common basis for ranking assets is emphasized above. There are many forms that an overarching goal might take. One possibility is:

‘To ensure that in 50 years our State community can continue to access the full range of human values from natural resources currently threatened by salinity.’

Such a goal implies that opportunity, ecological service and philosophical/intrinsic values will be the main focus for priority setting¹⁰. One basis for developing criteria that can be equally applied to all asset types is to work from the human values that we currently take from natural resources threatened by salinity. These values, properly constructed, will reflect the needs humans have in relation to the natural components of the environment. Note that such a list of values should form a coherent set as defined by Rogers (1999, cited by Burgman 2005). That is, that the set has the following properties:

1. ‘Stakeholders are indifferent to alternative actions if they rank them the same against all criteria (implying the set is exhaustive).
2. An action will be preferred to others if it is substantially better than all others on one criterion and equal on all others (implying the set is cohesive).
3. The set is understood and accepted by all stakeholders.
4. The conditions above may be violated if any criterion is omitted (implying the set contains no redundant elements).’

Taking into consideration all the above, and the public asset focus of SIF, criteria that might be used in MCDA and/or expert analyses to assess each asset against the above goal are shown in the Table A5.5 below.

Table A5.5 Types of criteria to assess asset values

*Note that weightings reflect human value in relation to specified goal, and also public asset focus of SIF. Thus, for example, consumptive and productive use values are rated lowest assuming that potable water is covered under ecosystem services.

Human value/criterion (see Wallace et al. 2003 for definitions)	Criterion weight (multiply asset score by)	Score Asset 1	Score Asset 2	Score Asset 3	Score Asset 4
Consumptive use values*	0.2				
Productive use values*	0.4				
Opportunity values	2				
Ecosystem service values	2				
Amenity values (including aesthetics)	1				
Scientific and educational values	1				
Recreational and tourist values	0.8				
Spiritual/philosophical/moral/sense of place values	2				

¹⁰ This is because these values are the most vulnerable to salinity.

It is emphasised that the weightings in Table A5.5 are illustrative only. While it is extremely difficult to weight such different values against each other, this is an essential part of decision-making, and is often undertaken intuitively. Therefore, despite the difficulties of using and weighting such values, the process at least makes explicit the assumptions and values brought to the decision process by the individuals involved.

Note that the criteria in Table A5.5 may be applied to all asset types used in SIF, and all reflect the overarching goal. However, to properly apply such criteria would require a more comprehensive definition of values and also the land asset¹¹.

¹¹ For example, definition of the geomorphological land values, and not solely soil values.

