DEPARTMENT OF
PRIMARY INDUSTRIES

Innovative Salinity and Nutrient management Technologies for Victorian NAP Catchments

A Site Selection Method

Final - February 2006

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Published by

Primary Industries Research Victoria
Department of Primary Industries
Tatura
Private Bag 1
Ferguson Road
Tatura
Victoria 3616
February 2006

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www.dpi.vic.gov.au

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ISBN 1 74146 627 X

Executive Summary

This report

This report is the final output from a Multi-regional NAP funded project that commenced in 2003 - 2004 financial year. The primary objective of the project was to develop a systematic approach to test the suitability of known dryland salinity priority areas to engineering based salinity control options. A second stage of the project was originally proposed, but has not proceeded. Under this second stage and following the development of a workable site selection process, three sites within Victoria were to be selected for detailed investigation. The ultimate goal was to prove whether innovative salinity and nutrient management technologies can be soundly based, well supported and successful, and thus seed further works in the state. These solutions would then sit alongside agronomic options as a way of treating dryland salinity across the country.

Terminology

In this study, a starting premise is that an 'Innovative Management Technology' (IMT) solution to be applied to a dryland salinity or surface water quality problem will invariably involve collecting and extracting groundwater by an 'engineering' means (ie a groundwater pump, sub-surface drains or surface drainage system). The 'innovation' element is how that water would be used or disposed of. In this report, use of the term 'engineering option' refers to the method of extracting groundwater. This is a necessary precursor to development of any 'innovative technology' system. IMT is an all encompassing term used to cover a comprehensive system of technical management of a salinity problem.

In referring to an 'integrated engineering-agronomic option', the main premise is that the extracted water (and contained salt and nutrient load) is used productively and safely within a production system that can contain the salt load for the long term. Water quality and any assets downstream are thus protected from damage or loss by the operation of the system.

Review of IMT options

The work by SKM (2001b) for the NDSP was the first systematic attempt in Australia to consider the prospects for engineering based dryland salinity solutions. A highlight of this work was the development of a web-based decision support tool and the review of 17 engineering based examples from around Australia. While this work improved the knowledge base upon which IMT solutions might be developed, there has been no apparent increase in applications of such options in dryland areas.

It appears that key reasons why IMT options are not proceeding in dryland areas are that:

- Economics are not favourable
- Social considerations are proving difficult
- Environmental impacts are not being dealt with, and
- Regulatory aspects are not favourable.

In reviewing Victorian examples of engineering based trials, most have focussed only on the extraction process, and monitoring has not shown salinity benefits that can be clearly attributed to the works.

Regulatory Issues

A review of Governance, regulations and legislation undertaken as part of this study identified a range of aspects of any potential IMT schemes that could be subject to regulations. Given that IMT solutions are rare and each one has so far been unique, standard regulatory responses do not exist. Any regulatory response would be dependent upon the scale and design of the proposal. During the feasibility study stage of any IMT option development process, a systematic assessment of regulatory requirements should be undertaken. The proposal would then either be designed to eliminate any need to invoke regulations or be designed to meet existing regulations.

Reference Group and Stakeholder Input

At the commencement of this project, contact was made with a range of stakeholders with the intention of forming a reference group to oversee progress in the project and provide input. A number of meetings were arranged during the earlier stages of the work, and input that helped frame the study was obtained.

This input was valuable in providing examples of priority salinity areas within catchments and in providing context and CMA staff perceptions of locations that might be suitable for IMT options. The work carried out by each CMA to prioritise locations on the basis of salinity risk provided a range of locations upon which this study could consider. The meetings were especially useful where they involved visits to salinity problem sites and helped define the biophysical aspects of the study.

Site Selection Method

Having reviewed the current state of engineering options knowledge and considered the regional picture, the study developed a methodology to systematically assess the suitability of sites for an IMT option.

Underpinning this approach was the assumption that CMAs have already identified priority dryland salinity areas and that sufficient information about each area was available. On this basis, the project team weighed up possible methods of assessment and the relevant criteria.

The site assessment process developed is based on the principle of a filter. This involved developing a series of targeted questions to which “yes” or “no” responses are given based on expert knowledge. The fundamental point of the questions is whether the characteristic is favourable or unfavourable to the development of an IMT option. The development of these questions required the identification of the important factors that determine whether a site has favourable or unfavourable characteristics. These were targeted at four key aspects:

- Knowledge about the site
- Assets at risk (including the value or importance of the assets and degree of risk)
- Hydrogeological conditions
- Intercepted water re-use

An important information source now available to CMAs is the groundwater flow systems concept. This gives a good start to the process by providing ready access to salinity related hydrogeological data. Information on assets and salinity occurrence is variously available and was obtained through CMA discussions and in previous salinity prioritisation work reports.

Sites can be easily ruled out if there is insufficient information. However, a key difficulty encountered in testing of the filter approach was the high level of expert judgement, subjectivity and uncertainty involved in the consideration of the assets at risk, the hydrogeological conditions, the type of control option to select and potential re-use options. This subjectivity in many respects is the Achilles heel of the original intent of the project. It also underpins the reasons why there are so few successful engineering based control options in dryland sites.

Site Filter Tool

Following the development of the site selection tool logic, the chosen questions and process were tested on North Central CMA salinity priority catchments. Through some trial and error, a workable spreadsheet was compiled and this was then tested in Corangamite CMA and Glenelg-Hopkins CMA priority salinity sites. In the Glenelg-Hopkins CMA, the 'sites' were groundwater flow system (GFS) types. This testing showed both positive and negative aspects of the process.

Having tabulated results for the salinity priority areas in each CMA, the project was able to consider the implications and subsequent actions that arise from having identified several sites (or GFS) that have favourable characteristics for an IMT option.

Difficulties of Scale

In considering suitable engineering based options for a sub-catchment, the diffuse nature of dryland salinity discharge and the different scales at which it can be managed are critical issues. Will a single, large scheme be practical? Would a large number of separate, small schemes targeted at each known discharge system be more effective? Is an integrated system of control points at every discharge location possible? Any engineering based scheme will involve works of some sort at one or several locations, however the filter process as applied at the NAP catchment scale was not able to resolve to sufficient detail such sites specific details. To improve resolution at a sub-catchment scale, the filter tool could then be used compare a number of discrete salinity occurrence areas in a favourable sub-catchment with respect to their suitability for IMT options, assuming there is sufficient data to do so.

Selecting 3 Sites for a Stage 2 Study

The project objective was to find three favourable sites for further assessment and business case development. At the outset, this seemed attainable. However, having worked through the logic of the issues and put together a site selection process, the sheer complexity of the task has become apparent.

While there are dryland salinity sites throughout the CMAs that scored favourably in the filter process developed, it was not clear that any of these locations should have additional investment to investigate an IMT option. In this respect, the project has failed to meet its original objective.

However, what has been learned through this process is significant and of great value to CMAs, communities and funding organisations.

What has been found?

Foremost among the findings of value from this project is a clearer understanding of the probability of engineering based solutions for dryland salinity problems being viable in Victoria. The study has also generated a systematic process that contains targeted questions that can be used whenever an engineering based solution is proposed.

The complexity involved in the consideration of IMT solutions in dryland salinity impacted areas makes building a sound 'business case' for their development a significant challenge. The main uncertainties include:

- The practicalities of groundwater extraction
- The availability of suitable disposal or reuse options.
- Uncertainty about future levels of salinity
- Inadequate suitable data at the spatial resolutions required for site assessment.

The scenarios where an IMT solution may be favourable are:

- ❑ Where there is a well defined asset clearly at risk from salinity
- ❑ Engineering systems can intercept water effectively and efficiently
- ❑ The intercepted water can be productively and sustainably used
- ❑ At the farm scale, where a simple, small-scale salinity occurrence can be treated by a basic collector system and the water re-used on site to contain the salt or nutrient.

Recommendations

- ❑ There is a very low probability that widespread adoption of engineering based solutions for dryland salinity will be justifiable in Victoria.
- ❑ At the farm scale, the most likely circumstance where a system could be feasible is that of a small site with simple and favourable hydrogeology. Such a site would have to be amenable to an efficient collection system and an agronomic system that can sustainably contain salt or nutrient on site. Implementation of such systems should aim to achieve multiple outcomes such as biodiversity enhancement.

- The only circumstance where an engineering based solution has potential is where a highly valued asset is at substantial direct risk of salinity damage that cannot be more efficiently resolved by other means.
- The existence of potentially viable sites for implementation of engineering options for dryland salinity and water quality management is not precluded by the inability of this project to identify them.
- Data at the catchment scale on dryland salinity and water quality problems is largely inadequate or unsuitable to resolve down to the level necessary to support the catchment wide approach to assessing suitability for IMT options.
- That Stage 2 of this study as originally proposed not proceed.

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Acknowledgements

This study was funded under the Multi-Regional Grants program of the National Action Plan for Salinity and Water Quality. It was conceived in a project proposal developed by Michael Morris and Mark Reid and was successful in attracting funding in part because its focus was on innovative solutions to dryland salinity.

The Project team consisted of Michael Morris, Mark Reid, Bruce Gill, Peter Hekmeijer and David Heislers

Input and discussion with staff from several Victorian CMAs including Corangamite, Glenelg Hopkins, North Central, Goulburn Broken and the Mallee as well as regional DPI staff was valuable in focussing the study on CMA priority salinity problem areas.

Abbreviations

CAS	Catchment and Agricultural Services (of DPI)
CLPR	Centre for Land Protection Research
CMA	Catchment Management Authority
CSIRO	Commonwealth Scientific and Industrial Research organisation
DPI	Department of Primary Industries
DSE	Department of Sustainability and Environment
EOV	End of Valley (salt load targets)
EPA	Environmental Protection Authority
GFS	Groundwater Flow System
GMA	Groundwater Management Area
ICM	Integrated Catchment Management
ICSRP	Integrated catchment salinity risk and prioritisation
IMT	Innovative Management Technologies
LWSMP	Land and Water Salinity Management Plan
L&WMP	Land and Water Management Plan
MDBC	Murray Darling Basin Commission
NDSP	National Dryland Salinity Program
NAP	National Action Plan (for Salinity and Water Quality)
NHT	Natural Heritage Trust
NLWRA	National Land and Water Resources Audit
NRM	Natural Resource Management
PIRVic	Primary Industries Research Victoria
PPA	Pest Plants and Animals
RWA	Rural Water Authority
RCS	Regional Catchment Strategy
SKM	Sinclair Knight Merz
WSPA	Water Supply Protection Area

1. Introduction

1.1 Project Background

This project was conducted under National Action Plan for Salinity and Water Quality Victorian Multi-Regional grants program with the following objective (from the proposal):

> *'To develop and impart a greater science-based knowledge of the potential applications (type and location) of engineering/agronomic salinity and nutrient management techniques, in order to better inform, target and stimulate future catchment management investment and policy development. This is completely in accord with the main goal of the NAP, which is to motivate and enable regional communities to use coordinated and targeted action to (a) prevent, stabilise and reverse trends in salinity, particularly dryland salinity, and (b) improve water quality and secure reliable allocations for humans, industry and the environment.'*

In establishing the basis for this project and articulating why it has been a valuable investment in dryland salinity management, a recent, comprehensive review (SKM, 2001) described the technical and economic aspects of dryland salinity engineering options and provided case studies from across Australia. A key conclusion from that study was:

> *'It is considered that further knowledge is needed to assist communities in assessing the impacts, such as salt loads, impact on downstream water quality, and the economic costs of disposal. Part of this should involve establishing procedures, including institutional guidelines, to document the catchment priorities and generate targets for downstream water quality. Decisions need to be clearly made under a structure that provides responsibility and accountability for the assessment of the need for actions and the appropriate implementation.'*

Much knowledge about potential management options for dryland salinity already exists. Considerable effort over the past few years has also been invested in developing decision support tools to guide development of engineering solutions for dryland salinity problems. (NDSP website) However, little uptake of engineering solutions in dryland areas has occurred in Victoria. Factors responsible for this limited uptake include:

- engineering options need to be tailored to each site,
- the ideas are new and relatively untested,
- significant technical assessment and expertise may be required for success,
- drought,
- changing farm economics, and
- a sound business case (ie. systematic addressing of the practical and financial aspects of the solution) needs to be established to justify implementation of capital intensive schemes, especially if public investment and social impacts are likely.

This project was therefore very much focussed on testing the potential of engineering approaches to dryland salinity management by working through the issues identified in the conclusion comment (above) from the SKM study. By focussing on a number of catchments in central and western Victoria with substantial dryland salinity problems, the project aimed to identify where innovative salinity and nutrient management technologies could be soundly based, well supported and successful.

The project aimed to develop a consistent and rigorous approach that could be used to take catchment communities through the first step of the process, that is, the identification and prioritisation of potential sites where an engineering based option would be the best solution.

While the overall study focus was on trying to take science and engineering principles to a complete, working solution, it was evident that the science and engineering aspects must favourably converge with social, economic and practical aspects. If one or more of these aspects is unfavourable, then there is significant likelihood that a successful integrated engineering - agronomic option will not result. A possible outcome from this work is a realisation that although engineering based options are possible in theory, there are very few cases in Victoria where all the necessary elements occur in alignment.

1.2 This Report

This report documents the work carried out from October 2003 to June 2005. This is the stage 1 milestone report as described in the Project proposal (Appendix 1).

The main outcomes proposed in the proposal at the completion of stage 1 were:

- Establishment of a project stakeholder reference group
- A review of relevant legislation, regulation, institutional aspects and review of potentially applicable Engineering based innovative management technologies.
- Development of a site selection methodology endorsed by stakeholders.
- Testing of the site selection methodology in identifying potential sites within the participating catchments and documenting the process and results.
- Endorsement of the selected site by the project stakeholders.

A key output attached to this report is the spreadsheet developed to accumulate site information and filter the sites to identify the most prospective ones. A copy of this site selection tool is available by visiting the Victorian Resources Online website:
http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/vrohome

1.3 Terminology

In discussing 'innovative technologies', for salinity and water quality management, a starting premise in this study has been that an innovative solution will usually involve collecting and extracting groundwater by an 'engineering' means (ie a groundwater pump, sub-surface drains or surface drainage system). The 'innovation' is in how the extracted water is managed. In general, use of the term 'engineering option' refers to the method of extracting groundwater. This is a necessary precursor to development of any 'innovative technology' system, the overall term used to cover a comprehensive system for technical management of a salinity problem.

In referring to an 'integrated engineering-agronomic option', the main premise is that the extracted water (and contained salt and nutrient load) is used productively and safely within a production system that can contain the salt and nutrient load for the long term. Water quality and any assets downstream are thus protected from damage or loss by the operation of the system.

2. Review of IMT Options

2.1 The national perspective

SKM (2001b) assessed the efficacy of engineering options for the management of dryland salinity nationally. They concluded that there were only a minimal number of case studies that were adequately documented to allow considered assessment of the engineering option. Of the 17 case studies, at least four were taken from designated irrigation areas or where irrigation was the substantive cause of a neighbouring dryland salinity issue.

Many of the case studies were taken from the extensive salinised landscapes of the Western Australian wheat-belt. Pannell (2001) argues that even here, despite the groundswell amongst farmers in deploying predominately deep surface drains to combat salinity, that significant uncertainty remains amongst the farming and scientific communities in regard to the economic and environmental viability of this solution.

Pannell (2001) also suggests that intended broad-scale salinity control solutions, whether of an agronomic or engineering type, are unlikely to achieve their outcome unless this can be achieved through a focus on economics. He emphasises that the most efficient public investment is in strategically targeting the protection of specific assets. Further to this, Pannell (2001) suggests the importance of developing improved methods for productive use of saline land and water and is therefore an advocate of targeted innovative solutions.

In dryland salinity management, numerous engineering based solutions are possible. These are outlined in detail in SKM (2001b) and can be broadly categorised as:

- Groundwater pumping (single bore, multiple bores, spear points and relief bores)
- Shallow surface drains for recharge control (spoon drains, “W” drains)
- Deep surface drains for watertable management (open drains)
- Sub-surface drainage systems (mole, tile, biopolymer and interceptor drains)
- Construction approaches (construction standards and corrosion resistant materials)

SKM (2001b) also produced the first systematic attempt to spatially classify the landscape at the national scale with respect to possible engineering options. The range of possible engineering solutions were broadly attributed against the classification of Australian Groundwater Flow Systems of Coram (1998). This work was developed as a guide only, because local site conditions control what is technically possible at specific sites. Though this was a significant advancement in placing potential engineering options in a catchment context, it is only when one focuses at the site scale that one understands the full and unique complexity of contemplating an engineering solution.

Guidance about the range of engineering solution choices is embedded in a web based decision support tool found on the NDSP site (http://www.ndsp.gov.au/). This also considers the likely success criteria for a particular engineering option as well as a preliminary assessment of the economic and environmental effects of particular options. The economic evaluation within the decision support tool does not include the environmental cost of disposal (Nolan ITU 2005). It allows simple hydrogeological modelling (spreadsheet based) of an idealised engineering option. SKM (2001a) state that *“If a particular option looks favourable for the local site, salinity managers need to investigate future ways of detailed evaluation which consider the ultimate objectives, the scale, cost and other regional factors such as disposal.”*

Apart from this broad contexting of engineering solution efficacy, there are few examples where a systematic approach to dryland engineering solutions have been undertaken at a site level. At the site level, additional considerations quickly emerge that complicate the decision (aside from the technical feasibility of the groundwater extraction technology itself). Four key issues are:

- Economic considerations pertaining to the extraction and then reuse of groundwater. The relationship between groundwater extraction and degree of asset maintenance is often more difficult to estimate and therefore to economically justify in dryland settings. The separation of public and private benefit from public investment can also be obscure.
- Social considerations arise in landscapes where engineering solutions for dryland salinity control are not usual.

- Environmental impacts, especially of groundwater disposal
- Regulatory aspects, such as groundwater licensing, planning requirements, disposal constraints, new irrigation development controls.

In contrast, the relative success of engineering solutions in irrigation regions can be put down to a range of reasons:

- Economic factors in the irrigation areas have been generally more favourable and more straightforward to quantify (or the investment that enables it to be done has been made?)
- Hydrogeological conditions are more often suitable and consistent.
- Engineered infrastructure is part of the irrigation landscape.

2.2 The Victorian dryland experience

Engineering solutions to salinity management have a long history in northern Victoria. From the first shallow groundwater pumps in the Shepparton Irrigation region in the early 1970's to the salt interception schemes along the Murray River near Mildura and the Barr Creek pumping and diversion system near Kerang, engineering solutions have been demonstrated and proven to be effective in managing salinity problems. However, these instances have historically been limited to irrigation regions, where large contiguous areas of salinised soils or high watertables have impacted upon often high value agricultural productivity or assets.

In the Victorian dryland, sporadic attempts have been made to strategically install groundwater extraction systems upslope from discharge sites in order to reduce groundwater discharge in dryland areas. Table 1 catalogues a number of examples. Much of the interest in engineering solutions has occurred in the fractured rock aquifers of the Goulburn Broken dryland region. Recent investigations have also occurred along the granite colluvial slopes of the western Victorian uplands. Some activity has also historically occurred in south west Victoria to alleviate high recharge associated with waterlogged landscapes. Some key conclusions that can be drawn from this work are that:

- Many of the trials (particularly the early ones) have focussed on the groundwater extraction potential rather than the issues or opportunities associated with disposal. Apart from the Donald Seaweed Project, none of the trials holistically assessed the technical and economic potential of an IMT solution
- Only one trial, the Donald Seaweed Project, is explicitly linked to an innovative solution, but its focus is more on the productive use of a saline water resource. Trials along the Colbinabbin Range and Dookie Hills were typically linked to vineyard irrigation supply with only a vague possibility of beneficial impact on associated saline land.
- Though justified on the basis of salinity control, few of the Victorian case studies have incorporated any monitoring to assess the impacts on salinity discharge per se' (as opposed to monitoring of groundwater levels surrounding the extraction site). Notwithstanding, these impacts can be difficult to quantify given other causal factors such as climate.

Table 1 Examples of sites across Victoria where engineering solutions have been trialled for salinity control.

Site	Application	Status	Comment
Lurg, GBCMA region	Fractured rock groundwater pumping trial to alleviate down-slope salinity discharge. ASCM (1993) Mark Reid (pers. comm.) June 05	Trial during 1990s. Now abandoned.	Hoped to encourage landholder uptake of groundwater supplies.
Tatong, GBCMA region	Single bore groundwater pumping from weathered fractured rock aquifer to alleviate down-slope salinity discharge. SKM (2001b) Mark Reid (pers. comm.) June 05	Trial 1991-2000. Now abandoned.	Significant elliptical cone of depression measured during pumping. Cause and effect between pumping and salinity discharge extent not clearly established (climate influence)., although landholder believed there was improved productivity. No long-term onsite solution developed for disposal. Innovative use of air-lift pumping
Colbinabbin Range and Dookie Hills, GBCMA region	Groundwater pumping investigations for both agricultural (typically vineyard) and salinity discharge benefit SKM (2002, 2003)	Ongoing investigation related to FEDS (Farm Exploratory Drilling Scheme)	Viable water supply augmentation for at least two wineries. Economic analysis uncertain about link between demonstrated groundwater reduction and salinity discharge/economic benefit
Goulburn Broken Dryland	Investigation currently being conducted to understand and prioritise groundwater extraction potential for salinity management in dryland sub-catchments. Nolan ITU (2005)	Stages 1 and 2 completed. Recommended further investigation needed in order to understand the potential for engineering solutions.	Study has yet to look at groundwater disposal options. Detailed business case development to occur in later stages
Langi Ghiran, WCMA region	Single bore groundwater pumping from granite alluvial slopes to alleviate downslope salinity discharge and to supplement vineyard water supply. Hekmeijer and Hocking (2001)	2000 NHT funded project. completed. Ongoing viable water supply for vineyard.	Some ongoing bore monitoring, but salinity impact is not yet known.
Dundas Tablelands, GHCMA	To investigate whether sub-surface drainage in recharge areas at 2 sites on the Dundas Tablelands controls dryland salinity on farms. SKM (1997)	Sites established in 1993 and monitored through mid 1990s.	Groundwater drawdown impacts and waterlogging control clearly indicated in vicinity of drains. Impacts on downstream salinity not concluded. Drainage effluent of better quality than receiving streams.
Upper Hopkins, GHCMA region	Groundwater pumping potential investigated at three sites on granitic slopes for amelioration of salinity discharge. Hocking et al. (2004)	2003/04 NAP funded project. Now in formal monitoring phase. However no actual monitoring of salinity impacts.	Focus on the groundwater extraction potential (yield and quality) rather than detailed consideration of salinity impact.
Cooriemungle (Heytesbury), CCMA	To investigate recharge control from mole drainage in the Heytesbury. David Heislers (pers. comm.) June 05	Site established in 1993 but trial abandoned late 1990s. No formal reporting.	Waterlogging control unofficially reported though no conclusion as to recharge and therefore local salinity control. The trial brought to focus effluent disposal issues.
Donald, NCCMA	Establishment of production bore(s) to extract groundwater for cultivation of seaweed in small production basins. http://www.phildyson.com.au/	On-going trial. Community led innovation co-funded through NAP.	Technical feasibility issues being addressed in relation to damming of saline groundwater. Focus more on productive use of saline water resource. Salinity impact not yet known.
Everton Upper, NECMA region	Single bore pumping groundwater from fractured rock aquifer to alleviate adjacent salinity discharge. Cheng (2004)	Trial period 1999-2003 Bore still being used for production purposes	Long term impact on watertable concluded to be only minor. Cheng (2004)

Of the current activity in Victoria, Goulburn-Murray Water is investigating the options for engineering solutions to reduce salt load contributions from key sub-catchments of the Goulburn Broken dryland region (Nolan ITU 2005). This comprises a hydrogeologically based technical assessment of sub-catchments as well as consideration of:

- Landholder views of technically feasible solutions;
- Capital and operating costs of the engineering option;
- Additional site-specific investigations on the geology, hydrology and water quality; and
- An improved understanding of the potential agronomic options that might work in tandem with the engineering option

The work to date demonstrates the diverse and detailed level of information required to form a business case to justify an engineering related solution in a dryland setting. This further emphasises the many challenges associated with employing such solutions.

Nolan ITU (2005) have been attempting this task at the sub-catchment level in the Goulburn - Broken Catchment. Even in circumstances where a 'reasonable' amount of hydrogeological knowledge and data were available, they still expressed the need to have more highly resolved (local scale) information before the technical merits of an engineering option could be quantified for stream salt load management justification.

2.3 Governance, Regulation and Legislation

2.3.1 Governance

It is considered likely that any potential IMT based solution would need to gain the support of a range of agencies and authorities if it was to become a practical reality. In a large operation, this might be approval in a legislative sense. For smaller operations it might have to occur within the guidelines of local planning schemes or to meet new irrigation development guidelines and approvals. It would be desirable that legislative, regulatory or planning requirements be considered in the feasibility study stage of a proposed option so as to add some confidence and certainty to the outcome.

Governance of disposal and drainage issues from IMT developments in Victoria would be expected to be undertaken in the integrated catchment management (ICM) context. Planning and implementation of ICM in Victoria occurs on a regional catchment level with overall policy direction and investment provided at the state level (DSE 2005). The primary tool of integrated catchment management arrangements are the Regional Catchment Strategies (RCSs). These set out a vision for the management of a region's land and water resources, establish long-term objectives and identify priorities for action and investment amongst the various natural resource management issues. Under the broad policy umbrella provided by the RCSs, detailed action plans for priority land and water resource management issues are developed.

The plans underpinning an RCS address a range of Government policies including Victoria's Salinity Management Framework, Murray Darling Basin Salinity Management Strategy, New Irrigation Development Guidelines, Memorandum of Understanding for Irrigation Drainage Management and Water Quality, Nutrient Management Strategy for Victorian Inland Waters, SEPP Waters of Victoria and others as required. Land or water action plans must include a detailed analysis of the key issue(s), develop detailed objectives and targets, investigate management options and consider environmental, social and economic benefits and costs of options (DSE 2005).

In the irrigation regions, engineering options have generally developed under the auspice of the relevant regional rural water authority. Typically with State, Federal and/or Murray - Darling Basin funding, engineering options for salinity control have been either large scale (Murray River Interception works), or as part of a well supported, regionally integrated land and water management plan. A good example are the surface water management schemes and groundwater pumping program in the Shepparton Irrigation Region's Land and Water Salinity Management Plan. Some municipal based urban salinity mitigation systems have also been developed by councils and state agencies (eg Wagga in NSW and the wheat-belt town of Merredin W.A.).

In NDSP (2001) examples of engineering based options for dryland areas have generally developed as trial sites organised by the relevant state agency. Some surface drainage options have been developed and implemented by landholders, primarily in Western Australia. The approval of relevant agencies is not specifically covered in the examples given, but it is very likely that some level of agency support and regulatory approval was required, especially if off site impacts were expected. In NDSP (2004) a note of caution about surface drainage schemes is given:

> *'Problems encountered include the highly variable impact of deep drains, managing saline and acidic groundwater flows and soil bio-geochemical changes that can occur where drainage lowers watertables. There is also debate about the need for regional drains and about legal and institutional processes associated with such drainage programs. Requirements for major expenditure on infrastructure further constrain adoption'.*

In terms of institutional support for engineering based options, any scheme that has off-site impact or that requires public financial support will require some level of institutional approval if it is to proceed to implementation.

2.3.2 Regulatory or legislative triggers

Innovative management technologies for dryland salinity control will clearly interact with legislation or regulatory guidelines when:

- Site earthworks are undertaken to prepare an engineering solution
    - potentially invokes the Victorian Planning and Environment Act (1987)
- Groundwater is to be extracted
    - licensing requirements as specified under the Water Act (1989)
- Extracted groundwater is to be dealt with, as in:
    - Disposal to the environment or contamination triggers the Environment Protection Act (1970).
    - Disturbance of native vegetation invokes the Victorian Planning and Environment Act (1987).
    - New irrigation developments invoke rural water authorities' guidelines.
    - Additional salt load transport implicates End of Valley Targets and therefore dryland catchments in meeting their MDBC agreements.

Development of small scale salinity management schemes are unlikely to meet much in the way of legislative or regulatory hurdles. Large scale schemes (eg. Pyramid Creek groundwater interception scheme near Kerang currently being implemented) do require significant regulatory approval. The observation of lesser impediment to smaller schemes is drawn from experience with the implementation of salinity and drainage related planning controls in the Shepparton Irrigation Region

A question that arises is the style of development that ought or ought not be controlled. In many respects, no one scheme will be quite like another, so each would need to be assessed individually. For example, a groundwater re-use scheme irrigating salt tolerant trees in an up-slope recharge area to primarily manage a salt affected site should perhaps be treated differently to a normal commercial irrigation development. Strict application of controls and guidelines can stifle innovation and knowledge generation, so some flexibility would be desirable on the part of regulatory authorities.

The Water Act (1989) and Environment Protection Act (1970) would be central to the consideration of IMT developments.

<u>Water Act 1989</u>

A summary of the Victorian Water Act 1989 is taken from the Environment Victoria website:

The Victorian Water Act provides the framework for allocating surface water and groundwater throughout Victoria. It is arguably the most powerful piece of legislation in use in Victoria impacting on rivers, streams and groundwater. The Water Act details the Crown's entitlements to water and private entitlements to water from all rivers, streams and groundwater systems in Victoria. The Act allows authorities and individuals to use water either through bulk entitlements, providing authorities with bulk amounts of water, or licences or sales water, which allow people to access water for mainly commercial or irrigation purposes. Some licences enable withdrawals of water directly from streams, others from groundwater. Domestic and stock water access is also addressed in this Act. The Water (Irrigation Farm Dams) Act 2002 amended the Water Act 1989 to also cover irrigation and commercial dams on or off waterways. These dams are now required to either be licenced or registered under the Water Act. The environment's access to water in this Act is addressed once all *existing water uses are met. The environment is then allocated the "left over" amounts of water to provide its flow.*

Environment Protection Act 1970

Invoking State Environment Protection Policy (Waters of Victoria) 2003 and associated Schedules.

A summary of the Environment Protection Act 1989 is taken from the Environment Victoria website:

The Environment Protection Act enables the EPA to improve air, land and water environments by managing waters, controlling noise and controlling pollution. It is focussed on protecting the environment through reducing human impact on our air, land and water. Sitting under the Environment Protection Act are State Environment Protection Policies (SEPPs). SEPPs are important as they provide goals and blueprints to protect the environment for the community both now and into the future. The SEPP Waters of Victoria details the uses and values of our water environments (beneficial uses), sets measurements and indicators so we know how well they are being protected (environmental quality objectives) and outlines what needs to be done to protect them (attainment program).

2.3.3 Local planning requirements

Apart from strict legislative and regulatory requirements specified above, local planning processes will need to consider a range of key issues and questions including:

- Will the proposed development require planning scheme approval, usually due to land use change or development impacts off site?
- Will there be any possible impact (real or perceived) on adjoining landowners or further a field that could require or make use of the planning process to gain approval and acceptance?

The permitting of activity on a local basis can be gauged through understanding the requirements of the Victoria Planning Provisions (VPP 2004), administered through the Planning and Environment Act (1987)

Planning and Environment Act (1987)

The Victorian Planning Provisions (VPP) is best considered as a state-wide reference document or template from which planning schemes are sourced and constructed in relation to the Planning and Environment Act 1997. It is a statutory device to ensure that consistent provisions for various matters are maintained across Victoria and that the construction and layout of planning schemes is always the same. The VPP offers a comprehensive set of standard planning provisions and provides a standard format for all Victorian planning schemes. The provisions invoke planning activities that relate to areas of both local and state government responsibility.

Possible scenarios where planning approval might be required include an evaporation basin system, significant water storage, aquaculture pond or other impoundment, diversion drain, tile drain and other works that may need to be assessed through a local planning permit. The requirements to be dealt with by the local planning system will only be known once the design of works is known and assessment of offsite impacts can be gauged. Well designed and innovative schemes developed in association with local communities would likely face little difficulty in meeting the necessary VPP approvals.

Developments of an agricultural nature in the Rural Zones will not generally require any planning approvals. However a large control scheme involving a number of landholders may seek planning approval where the process can help facilitate the development. Possible scenarios arising from this project would need to be tested to decide whether any planning issues might apply. Vegetation clearance controls may apply depending upon scheme design and intent. However, such issues are best dealt with during the early design stage to avoid creating any need for clearance. A useful framework for dealing with potential VPP issues is through the irrigation development guideline approach (see above).

New Irrigation Development Guidelines

New irrigation development regulations apply where surface water transfers to green-field sites are proposed. New developments reliant on groundwater supply are also being increasingly required to meet these requirements, for instance, in the mid-reaches of the Loddon Valley Deep Lead where guidelines developed by G-MW apply. Not all rural water authorities have irrigation development guidelines currently in place (Tom Maher[1] pers. comm.). However, in 2004/05 funding under the White Paper, *Securing our Water future Together*, the development of Statewide New Irrigation Development Guidelines (DSE 2005) is supported.

As an example, Goulburn-Murray Water facilitate and support the development of sustainable irrigated agriculture through implementation of *new irrigation development guidelines* (G-MW 2002). These articulate that all parties will do their utmost to ensure that irrigation developments involving the transfer of water entitlement, activation of a previously unused water entitlement or access to groundwater produce minimal on-site and off-site impacts.

Goulburn-Murray Water will not approve the transfer of water entitlements to new developments until the statutory requirements, approved policy and approved standards of the authority and other stakeholder organisations have been met. The various authorities and their roles in this process are outlined in Table 2. These would be relevant to other regions of Victoria. Other authorities possibly to be engaged would be electricity and gas, communications, urban and other rural water businesses.

As far as Goulburn-Murray Water is concerned, applications for transfer of water entitlement must also pass the following checks prior to approval being granted:

- Supply feasibility (including resource assessment on unregulated waterways)
- Channel capacity
- Salinity and drainage criteria

2.3.4 Multi-state salt disposal agreements

End of valley targets for salt loads are either in process, or are now agreed between Victorian CMAs and the Murray - Darling Basin Commission. This process is described in the Murray-Darling Basin Salinity Management Strategy (MDBC 2001). Because each catchment contributes an amount of salt to the combined lower Murray salt load and river salinity levels, agreements are being put in place to prevent rises and to encourage actions that will reduce loads over time. South of the Victorian Great Divide, that same imperative for salt load reduction does not exist, though river health strategies may recognise salinity impacts and the need to limit them (e.g. targets for the Hopkins River in the Glenelg - Hopkins CMA).

In terms of justification for an engineering based option, prevention of salt load impact downstream is theoretically a major consideration. Especially in the Murray-Darling Basin, salt load impact downstream has a recognised cost that must be borne by the community in the area of salt origin. Loads mobilised after 1988 must be paid for to offset costs of interception works on the Lower Murray. If an upper catchment area can install works that prevent a significant salt load, then the economic incentives for the works can be quite positive. In the Murray-Darling Basin there are two major salt reduction schemes (taken from MDBC website) currently under development that need to be financially accounted for:

- Work is currently progressing on the construction of the Waikerie Phase 2a project. This project is estimated to cost $3.4 million and is conservatively expected to intercept (on average) an additional 23 tonnes of salt every day.
- A $10 million project to intercept groundwater entering the Pyramid Creek in Northern Victoria is currently under development. It is anticipated that this scheme will stop about 30,000 tonnes of salt entering the Murray River each year. Negotiations with a commercial salt harvester are proceeding to improve the financial viability of this project for the Basin partner Governments.

As the amounts of salt released by dryland salinity discharge and downstream salt export are generally poorly defined and seasonally controlled, accounting for salt loads as credits would require significant work to quantify and establish. If an engineering based system proposed for a site could prevent a known amount of salt being mobilised down the catchment, the EC credits system of economic justification (as applies to the Murray River schemes) could be a significant factor in supporting such development. However, no scheme has yet been devised in the dryland to test this possibility.

[1] Tom Maher (Irrigation development officer, DPI-CAS) May 27 2005.

Table 2 Agency roles and responsibilities outlined in Goulburn-Murray Water's interim irrigation development guidelines.

Authority	Role (will vary depending upon size and nature of proposed development)
Goulburn-Murray Water	• Administer and approve transferable water entitlements process • Assess feasibility of irrigation supply to the development • Administer and license groundwater extraction • Co-ordinate approval process inputs from other organisations • Water resource management and licensing of works on waterways • Comply with native title requirements • Evaluation of salinity and nutrient impacts on drains and waterways • Evaluation of ground water impacts • Identify surface and groundwater monitoring requirements • Referral authority for subdivisions and easements • Approval of inclusions into districts, excisions from districts, irrigation supply and drainage discharge locations
Department of Sustainability and Environment	• Provision of case manager to assist proponents with irrigation developments • Sustainable regional development • Evaluation of environmental impacts against objectives of regional land and water management plans and government legislation • Environmental monitoring requirements • Assessment of remnant vegetation requirements • Biological diversity • Ensure that Irrigation, Drainage and Environmental Plan meets required standard • Determine proposals in Proclaimed Water Supply Catchments
Aboriginal Affairs Victoria	• Heritage assessment • Protection of Aboriginal sites and places
Local Government	• Planning requirements • Subdivisions of land • Infrastructure requirements • Roadside vegetation
Environment Protection Authority	• Air, soil and water contamination • Waste management • Water quality
Heritage Victoria	• Assessment and protection of historic sites
Catchment Management Authorities	• Land and water management plans • Flood plain and waterway management • Water quality • Regional roadside vegetation

The closest that such a scheme has been to development is at a location on the Goulburn River between Nagambie and Murchison. Here, groundwater with a salt load of about 5000 tonnes per year discharges along a section of the river. Investigations into the feasibility of interception and capture in a re-use scheme concluded that the benefit to cost ratio of diverting the salt load was not favourable, despite the presence of EC credits (S. Feiss, G-MW pers com. and SKM 2004)

2.3.5 Summary

Regulatory approvals are not considered likely to be a factor that would stifle development of a dryland salinity engineering option. The key proviso is that any proposals would need to be designed from the outset to either minimise cause for regulatory approval or would obtain required clearances at the relevant stages of planning.

As each scheme and site would be unique, the range of normal approvals processes would need to be addressed for any specific aspects for which approvals are required. The key issues would be where off-site impacts are likely or where licensing is required under legislation.

However, given the un-common nature of dryland IMT developments, it would be hoped that that the merits or otherwise of any IMT proposal that tackles salinity or water quality problems be given some leeway. The potential planning issues that do arise need to be addressed proportionally to the scale of the proposal. Another key criteria that should be assessed during the planning process is the 'net protection of natural resources'. It is likely that any trade-offs arising from an IMT will have some flexibility such that they can be successfully managed.

3. Project Reference Group and Stakeholder Input

3.1 Stakeholder reference group

At the commencement of this project, contact was made with CMAs and regional departmental natural resource management staff (including EPA and Rural Water Authorities). The intention was to form a reference group to oversee progress in the project.

A project inception meeting was arranged and held in October 2003 to inform potential stakeholders of the nature of the study and seek their input.

At this meeting, the following were discussed:

- Background to the project
- How catchment management strategies deal with dryland salinity management
- An overview of engineering techniques
- Saline agronomy and aquaculture options
- Legislative and regulation issues
- Data available for the study.

The main outcome from the meeting was that direct discussions with CMAs were desirable to obtain more detail about how dryland salinity sites are considered with respect to their management and priority within catchment strategies. Other salient points raised to be considered in the study included:

- the processes of engaging 'entrepreneurs' in developing innovative engineering solutions
- ways of managing risks, timeframes and expectations of an IMT solution

3.2 CMA discussions

During November and December 2003, direct discussions were held with five CMAs. One of the main outcomes from these discussions was the recognition that dryland salinity problem areas in each catchment are all quite different in terms of extent, severity, cause and potential treatments. In one respect, this highlighted the potential value of a systematic method for deciding where an engineering option was most favourable.

CMAs use different means of assessment to determine dryland salinity priorities. In most CMAs, the approach has been via a systematic appraisal of sub-catchments (eg. North Central and Goulburn Broken CMA regions), with varying degrees of relation to asset risk. In contrast, the Corangamite CMA has based salinity investment prioritisation on non-catchment defined boundaries drawn around a rasterised assessment of asset risk to salinity. Salinity prioritisation has generally been part of the process of preparing Second Generation Salinity Management Plans required for the accreditation of Regional Catchment Strategies (RCSs) under the National Action Plan for Salinity and Water Quality.

Given the substantial work already completed by CMAs in determining their salinity priority zones, a general principle adopted by this project was to use these as input into the IMT case study selection process. Some discussion of the prioritisation methodologies used in the NAP funded CMA regions and the IMT implications of these is provided below.

3.2.1 North Central CMA

The first GIS data assisted attempt to prioritise salinity investment in Victoria occurred in the North Central CMA (CLPR 2001). The intention behind this was to identify priority areas with the focus on initiating several targeted salinity “implementation” projects under the Natural Heritage Trust (NHT) program.

The priority setting approach, known as ICSRP (Integrated catchment salinity risk and prioritisation) had three major elements:

- A GIS-based decision support tool to identify and rank priority sub-catchments using a number of physically based datasets to define salinity hazard.
- An expert based feasibility assessment to determine whether a priority sub-catchment was suitable for a farming systems based implementation or research project.
- A multi-criteria analysis process to assign final priorities of sub-catchments lying within the high risk category.

Recently a more advanced prioritisation tool, ASSALT (as in ASS-assets, SALT-salinity), was developed and prototyped in the North Central CMA region (Clifton and Heislers 2004). ASSALT is based on a more explicit process of spatially referencing salinity hazard and assets to identify risk.

Sub-catchment priorities emergent from CLPR (2001) were the basis of the salinity investment targeted approach adopted in the 2nd generation dryland salinity management plan for the region. Ten targeted sub-catchments have been identified for investment (DPI 2003 - see scanned image, Figure A1, Appendix 2). Individually these reflect:

- An asset base worthy of protection from salinity,
- A groundwater flow system capable of responding to a change in landuse, and
- A perceived capacity of the community to be able to modify their farming systems to achieve more favourable land use change.

Knowing CMAs have already invested significant time into selecting salinity priority sites, it was considered opportune to use these sites as a test bed for development of a site selection methodology.

3.2.2 Corangamite CMA

The prioritisation of salinity investment within the Corangamite CMA region recently occurred through the selection of 13 interim target areas as part of the development of the Corangamite Salinity Action Plan 2003 (Dahlhaus 2003). These areas were delineated for further investigation and development of salinity management strategies. Selection of these was largely underpinned by a rasterised asset-risk assessment process known as GSHARP (Heislers and Brewin 2003). GSHARP comprises the following components:

- The intersection of spatially explicit salinity hazard and asset datasets to generate a rasterised surface of asset risk. Salinity hazard layers included salinity discharge, groundwater depth, groundwater salinity, stream salinity and groundwater flow systems.
- Attention was paid to matching the asset classes with the appropriate salinity hazard product.
- The construction of individual asset risk layers (based on defined asset classes), and, only if required, a summation of these based on expert derived weightings.

Salinity risk to infrastructure and utilities was observed to be clustered in the Moriac area, north of Winchelsea, in an arc from the north-east to south-east of Colac, adjacent the northern and eastern perimeters of Lake Corangamite, Lough Calvert, Derrinallum-Lismore and north and west of Mt Mercer (Heislers and Brewin 2004, see Figure A2 in Appendix 2 - Salinity Hazard rating).

Field verification of the highlighted asset risk zones from the GSHARP output occurred before selection of the interim target areas. The boundaries of these areas were delineated on the broad zone of asset risk rather than interpretation of a physical management boundary such as a surface sub-catchment.

Identified specific regional issues relating to salinity and water quality in the Corangamite CMA encompasses a range of groundwater flow system types in three main landscape systems (northern uplands, basalt plains and southern (Otways) uplands). Urban infrastructure is known to be at risk in several towns including Camperdown, Colac and Derrinallum. Water supplies are thought to be at risk from upland gravel caps containing significant salt stores in the Moorabool target area and increasing salinities are being observed in the Lal Lal reservoir. A different problem with acid sulphate drainage is being observed in the upper Barwon River.

In the Pittong area, possible interception of fresh water upslope of discharge areas has been considered. Unstable soils and aluminium toxicity issues also need to be addressed there. In the Lismore - Derrinallum areas, landholders generally occupy larger farms and interest in managing salinity is likely to be better received there than in areas with smaller holdings closer to Geelong.

Groundwater extraction from the basalt aquifer has been previously considered as a way of intercepting saline groundwater that flows from Lake Murdeduke to the Barwon River (Heislers, pers comm). Surface drainage schemes in poorly drained areas have also been developed by landholders. These drains provide improvements in waterlogging conditions and leaching potential, most probably by reducing recharge over winter. The main concern with such unplanned developments relate to lessons learned in Western Australia, where downstream landholders or water-bodies may be put at risk by water quality decline and salt load impacts.

3.2.3 Glenelg-Hopkins CMA

Heislers and Brewin (2003) undertook a salinity asset risk prioritisation for surface water sub-catchments across the Glenelg Hopkins CMA region. The prioritisation process was an advancement on the ICSRP process previously implemented in the North Central CMA. It had the following key characteristics:

- A salinity risk classification was determined for 143 surface sub-catchments defined across the Glenelg-Hopkins region. Asset risk generalised to sub-catchment level was determined for a range of asset classes.
- Salinity hazard datasets comprised salinity discharge, groundwater depth, stream salinity, groundwater flow systems and previously defined salinity investment rankings.
- The ranking of sub-catchments for salinity investment involved summing classes of the key asset risk categories.

This process determined that the highest risk areas were primarily scattered across the central and northern sectors of the GHCMA region. An arc of maximum sub-catchment salinity asset risk occurs from the east Dundas Tablelands through Hamilton, Glenthompson, Maroona then east to Beaufort. The least overall asset risk is attached to sub-catchments along the Victorian-South Australian border and the coastal fringe. Risk was then categorised according to groundwater flow system responsiveness to generate priority areas for salinity management across the region. (see Figure A3 in Appendix 2).

The Glenelg-Hopkins Salinity Plan (GHCMA 2002) recommends the consideration of engineering options if significant assets are at risk from salinity. Apart from the degradation of agricultural land, salinisation has impacted upon a range of assets across the region. Koonongwootong Reservoir has been decommissioned as a result of water supply salinisation. A number of other infrastructure assets including roads and towns such as Lake Bolac, Ararat and Beaufort are known to be impacted. Numerous wetlands across the region have become salinised due to change in hydrological regimes.

3.2.4 Goulburn-Broken CMA

SKM and CLPR undertook salinity prioritisation studies on the 69 sub-catchments of the Goulburn-Broken Catchment dryland in the late 1990s (Cheng, 1999, SKM, 1999). These studies scored and ranked the sub-catchments based on an assessment of the severity of salinity risk. Factors included were land salinisation, stream salinity, watertable depth and trend, groundwater salinity and percentage of land cleared. Data availability and quality was also taken into account.

The analysis indicated that high salinity risk catchments mainly occur in the south-west Goulburn and northern and western plains, with medium rated sub-catchments occurring throughout the central region.

However, subsequent work on salt load generation rates (tonnes per hectare yield) has highlighted that the uplands of the south west Goulburn are a priority focus for dryland salinity management (Goulburn Broken Regional Catchment Strategy). This has led to more detailed assessment of the range of options, including engineering based solutions, suited to reducing salt load generation form this area. In this regard Nolan ITU (2005) has undertaken preliminary assessment of engineering solutions in key sub-catchments of the south west Goulburn in addition to others across the dryland plains. Key sub-catchments being considered include Honeysuckle Creek (Plains and Uplands), Lower Broken Plain, Gardiners Creek, Mollisons Creek, Sheep Pen Creek (Plains and Uplands), Sheepwash Creek and Whiteheads Creek.

An analysis of the economics of groundwater pumping in the Goulburn - Broken dryland (SKM, July 2003) for the CMA and Goulburn-Murray Water concluded that if the salinised land reclaimed as a ratio of the groundwater extracted is greater than 0.35 ha / ML /annum, then grant assistance is justifiable. Up to the time of the study, 24 sites had been tested for pumping potential at a cost of

$200,470. Five sites were developed at a cost of $60,788 to irrigate 442 ML of water onto about 160 ha of vines and pasture per year. Grants totalling $121,000 were provided for these developments.

Recommendations from the study concluded that further work should focus on quantifying the benefits to the wider community of groundwater interception, and that a suitable case study area would require stream salinity and groundwater monitoring to assess benefits from such pumping and re-use.

3.2.5 Mallee CMA

The key feature of the Mallee CMA area is that significant engineering works already reduce salinity impact along the irrigated fringe of the Murray River. In this example of engineered salinity control, a series of groundwater pumps along the river intercept saline groundwater discharging from the regional groundwater system. The collected water is sent to evaporative disposal basins remote from the river, thus protecting Murray River water quality for downstream users.

In dryland areas, secondary salinity manifestations are often associated with the low-lying areas between dunes. In some cases, the salinity is localised, and sometimes associated with poor surface drainage. However, the Mallee is also dominated by a large regional groundwater system, that together with its flat topography, land-use change, climatic variation and natural, extensive primary salinity, has produced broad salt affected areas after periods of higher rainfall.

Some towns, roads, reserves and wetlands are recognised as being at risk. The communities of Ouyen and Manangatang have a strong appreciation of the potential for salinity degradation of town assets from salinity, protection of which could be considered necessary by engineering based options. Environmental assets at Hattah Lakes and on the Raak Plains have also been identified at risk, though it is important for the distinction to be drawn between primary saline assets and secondary impacted assets.

Where significant local assets such as town infrastructure or sites of high environmental value are at risk, engineering solutions may be justified. However, the potential for more than very localised engineering based solutions for managing salinity in the dryland parts of the Mallee CMA is low. This conclusion is based on the nature of the groundwater systems and the widespread distribution of salinity impacts.

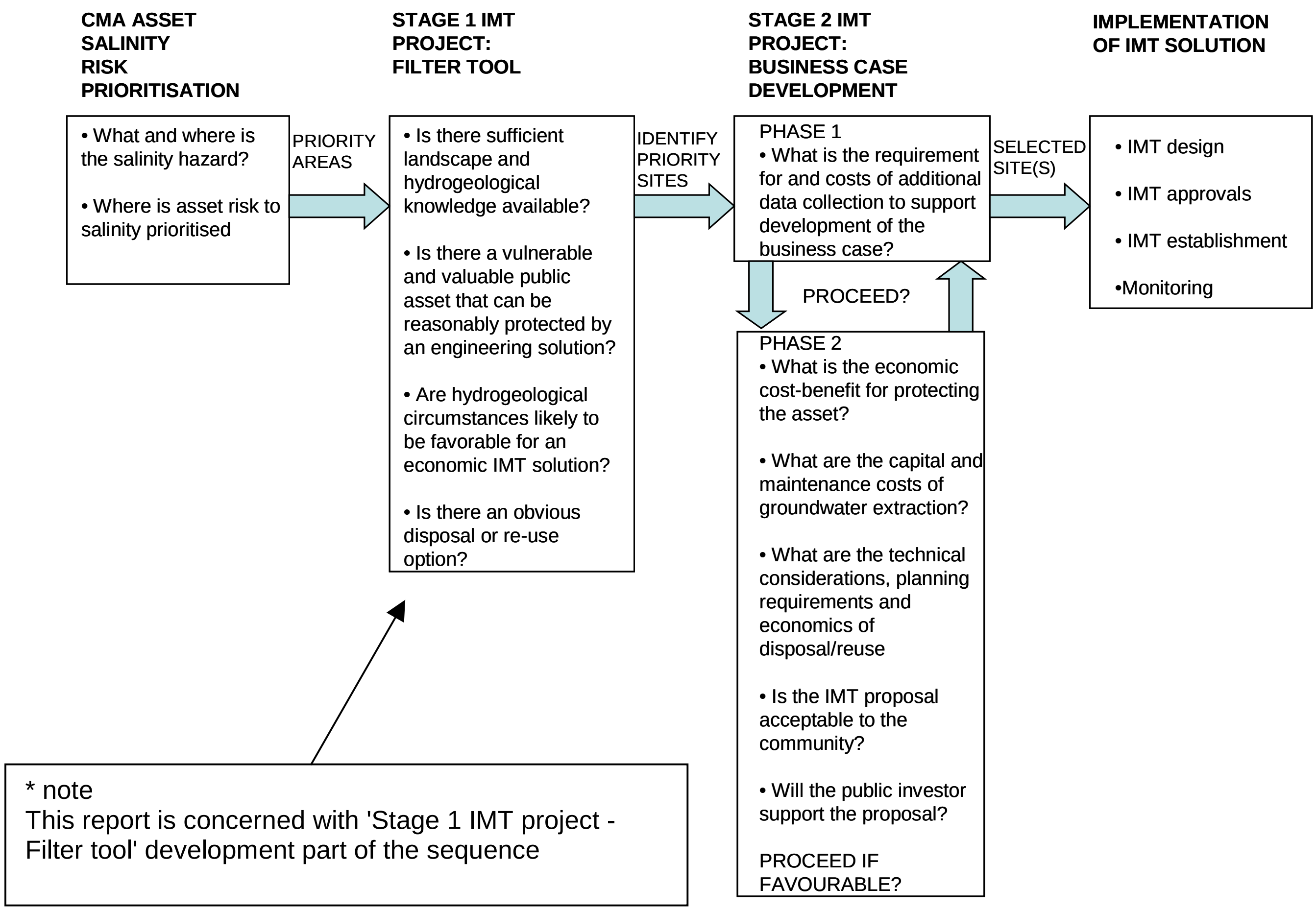
4. Site Selection Methodology

4.1 Requirements of the method

The intention of the site selection methodology was to provide a rapid assessment tool that could be applied to known salinity impacted areas from several NAP catchments. The method was intended to select the most prospective locations for an engineering based solution that could then be considered for a detailed business case analysis. The primary context of this rapid assessment tool was that:

- The areas to be considered were those already identified by the respective salinity prioritisation activities undertaken in different CMA regions (as discussed in Section 3).
- It provided a first level filter and ranking procedure for priority salinity areas on the basis of
    - knowledge status
    - nature of asset protection
    - engineering option technical feasibility and groundwater usage options
- No filter was applied to social or economic aspects at this stage in order to keep the appraisal process as simple as possible. Economic criteria and social aspects would be considered later in the business case development stage. In the rapid appraisal process, economic factors play a part in the reasoning (at a qualitative level). For example, the assets questions do include implicit valuing of the assets at risk.

Figure 1. Overall site selection sequence*.



4.2 Method Development Considerations

This section describes the context within which the site selection method was developed. The major factors can be grouped into:

- prior salinity studies supporting site selection
- groundwater flow system information and
- the need for expert judgement

4.2.1 Initial site selection

Identification of salt affected areas in most catchments has occurred at varying levels of sophistication over recent years. Primarily, this identification process has been based on mapped groundwater discharge and surface water salinity readings that indicate salinity problems are present. These data allow ready identification of sites where treatment or management options are desirable. However, much more information is needed about each site in order to develop a sufficiently detailed understanding of them if it is desired to select sites where an engineering based solution is the necessary option.

Progressively better understanding of sites has developed as Catchment Management Authorities and agencies have developed and implemented catchment wide land and water management plans. Tools and processes have also been developed to prioritise sub-catchments to allow decisions on funding and treatment to be made. In the Goulburn Broken catchment for example, all sub-catchments were ranked in order of salinity severity, the objective being to help guide investment decisions by the CMA and funding bodies (Cheng, SKM, 1999).

It is also recognised now that as salinity is now just one of many themes in catchment management investment plans, treating salt affected areas also requires consideration against other land and water management needs. Prioritisation based on salinity severity alone can therefore be improved if additional benefits of treatment actions, such as enhanced water quality, biodiversity and soil erosion control, can be included in considerations of investment choice.

A number of assessment methods have been evolving as CMAs have sought to prioritise programs under their control. Based on the use of spatial data, such tools as ICSRP have been developed (CLPR 2001). Its main purpose has been to develop an objective, transparent, repeatable and automated process to delineate areas for targeting of government investment in salinity management. Subsequent enhancement of this method produced a newer version called GSHARP (Geospatial salinity hazard and asset risk prediction) that has been used in the Corangamite catchment (Heislers and Brewin, 2004). The evolution in this case has been to improve the ability to include assets at risk.

Further work again in the North Central CMA has focussed on how to incorporate into the priorities ranking the concept of assets at risk from salinity. This approach, called ASSALT (Clifton and Heislers, 2004) operates in three main steps:

- Development of an integrated asset exposure index that reflects the likelihood of a particular asset being exposed to salinity and/or shallow watertables, its vulnerability to that exposure and the relative value of the exposed asset.
- Assessment of where in the landscape that intervention to protect assets from salinity is likely to be effective, and
- Assessment of the priorities for investment, given potentially competing interventions.

In most catchments, work to date has amassed a large but variable amount of data on salinity affected locations. This has been largely to serve planning needs (ie. for Regional Catchment Strategy development). The existing information therefore provides a starting point for this project by identifying the known high risk and asset impacting salinity sites that are most favourable for an engineering based solution.

4.2.2 Use of Groundwater Flow Systems

Prior to each CMA developing Regional Catchment Investment Plans (RCIPs), the National Dryland Salinity Program developed a systematic process of groundwater and dryland salinity mapping. Called the Groundwater Flow Systems Framework (Coram et al 2000, Walker et al 2003), this tool provided the information and methodology for each CMA to greatly improve understanding of salinity processes and occurrence. The maps and summarised technical data for the range of groundwater flow systems within each catchment provide a valuable starting point for considering where an engineering or technical salinity management option might be feasible.

4.2.3 Expert Judgement

In attempting to define the suitability of a site for an IMT solution, use of qualitative data and subjective judgements have proved unavoidable. Across the range of potential factors that need to be taken into consideration, many are not quantitative measures (eg. the value of an environmental asset) or exhibit high variability within the mapped units (eg. groundwater salinity or aquifer characteristics). The conclusion from this was that any system developed would have to rely on expert judgement for many criteria. As a result, a significant amount of subjectivity would arise.

Two strategies were used to reduce subjectivity. The first was to seek agreement from a number of stakeholders and experts familiar with the locations and technical issues to lend weight to the decision made for each parameter. The second was to sum the resulting answers so as to minimise reliance on individual responses.

It also became apparent that the nature of the criteria being considered and the objective of the exercise tended to favour trying to filter sites out by making a 'yes' or 'no' judgement about each criteria. To do this, the overall question **'Are the characteristics of the location favourable, or not favourable to an engineering option?'** could be considered as the defining question.

An alternative approach of trying to score each criterion (say from 1 to 10) requires more judgement on the part of the assessor. It may also generate significantly more debate among stakeholders as to why a particular value is chosen and could detract from the overall objective. How the values derived are subsequently summed and what, or if, any weighting factor should be applied to reflect their relative importance would also add further complication.

It was therefore decided by the project team that the site selection process should operate as a filter (or sieve) system using a 'yes' or 'no' response to the selected criteria. The chosen method provides a list of sites that have a differing number of the key characteristics that are either favourable or unfavourable for an engineering option. Those sites with more criteria marked favourably would then be considered the best prospects for more detailed assessment through the stage 2 process (see Figure 1).

4.3 Site Selection Criteria

The following section describes how sites can be compared with respect to their suitability for an engineering based salinity and water quality improvement solution. The key criteria for comparison fall into the following three categories:

- Asset evaluation
- Groundwater collection feasibility
- Groundwater usage options

Figure 2. Logic diagram showing the three underpinning categories and main criteria used in the development of the filter assessment method.

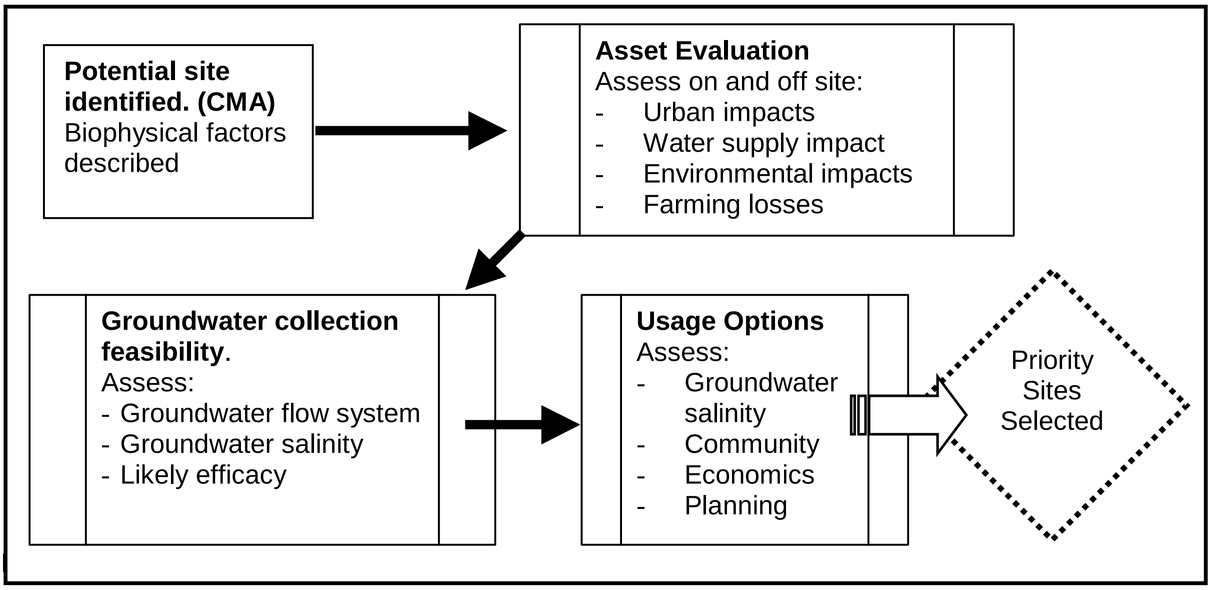


Figure 2 indicates that assets should be considered first on the basis that an underlying justification for addressing a salinity problem must be found before proceeding further. The groundwater collection feasibility aspects are also a vitally important factor in the feasibility of an engineering option. Considering them second in the sequence is really only a matter of practicality, as both are essential. An engineering based option would be untenable if either of these two aspects were unfavourable.

In contrast, groundwater usage options need to be considered only if it is worthwhile diverting the water to protect assets and if the groundwater conditions can support a practical usage option. There is also considerable flexibility to tailor the re-use options to fit the circumstances that apply at the site. However, it is also possible that at some sites, a viable re-use or disposal option cannot be found, thus preventing development of an IMT solution.

Criteria have been identified under each of these categories, with a description of their importance in determining whether a site has good or poor prospects for an engineering based option. For example, under groundwater collection feasibility, the criteria that determine or influence the overall ability to extract groundwater and cause discharge zone reduction are listed. The assessment of each site then involves assessing the data for each site and concluding whether the conditions are favourable or not favourable. The consideration of the three criteria categories for each site then results in a list of sites where conditions are more favourable than others.

4.3.1 Asset Evaluation

A key premise upon which this study was based is that there are dryland salinity and water quality problem areas where the impact is sufficiently high that significant capital expenditure to limit the impacts in a short timeframe can be justified. An example of this might be where saline discharge has a large impact on a town water supply and significant effort to intercept and effectively use the problem groundwater may be justified in order to protect the water supply.

The range of potential asset classes worthy of protection might be:

- ❑ Water Supply - either town supplies in the immediate vicinity or end of valley target obligations.
- ❑ Built assets - urban areas, infrastructure in high watertable areas, high value land etc.
- ❑ Environmental features - wetlands, reserves, river systems at risk of saline impacts.
- ❑ Farm productivity - lost production from affected areas

In considering the potential factors that make an innovative solution necessary to protect assets, some measure of the economic impacts has to be made. In assessing the relative importance of each potential site, it is necessary to consider the size and significance of the assets and the scale of the impact. In the example of a water supply system, the size of the dependant population centre, the salt load and alternate water supply or treatment costs help give some indication of the significance of the impact. Clifton and Heislers (2004) discussed issues of salinity and asset risk assessment in the development of the ASSALT salinity priority setting process. One measure of this was derived as the product of susceptibility to salinity and the probability of the event occurring.

Ownership is another aspect to consider in assessing assets at risk. This includes determining what proportion of individual or public assets are being impacted on. If treating a salinity problem requires public funding, (that will result in predominantly private benefit), then the public investment has to be carefully targeted to ensure capture of the catchment scale and community wellbeing aspects as well.

The downstream salt load impacts and possible credits received through salt capture are another form of asset that should be taken into account at each site. For sites in Victoria and NSW draining to the Murray River, capture of salt load has a defined value through the Salt Disposal Entitlements scheme. A higher salt load site would have greater justification with respect to impact on downstream assets.

Table 3 lists the main asset classes considered to be important in helping to decide whether an engineering solution is favourable or not.

Table 3. Asset class and rationale.

ASSET CLASS	SUB-CLASS	RATIONALE
Built assets	Urban infrastructure	Discharge in town areas generally considered high impact on high value assets
	Transport infrastructure	Transport infrastructure, particularly roads, generally considered to be a high value asset
Water Supply	Downstream population	Assumes that the larger the downstream population, the higher the impacts and the better the benefit / cost ratio
	Irrigation water supply	Irrigation supply asset - impacts are generally less significant than urban supply asset impacts
	In the Murray Darling Basin?	The costs on salt load entering the Murray River are known in terms of EC impacts at Morgan.
Environmental	Size	In general, the larger the feature, the greater its value and the higher the need for protection.
	Condition / value	The health of the feature may be a significant factor, eg. a RAMSAR wetland clearly influenced by a salt problem has a high protection justification
	Sensitivity	A river, lake or wetland having low tolerance to salinity would rank higher than a seasonal salt lake for example.
Farm Productivity	Farm productivity	The area and farming type lost to salinity, productivity impacts

A more detailed assessment of the economic impacts of salinity problem areas and the justification for investment in a control option would subsequently form part of the detailed business case analysis. For this site selection filter, the process initially only needs to distinguish sites that have significant high value features at risk.

Heislers and Brewin (2003) undertook work for the Glenelg Hopkins CMA and discussed the treatment of assets with respect to salinity prioritisation methods. A key conclusion was that asset valuation is a contentious issue, as assets tend to be accorded different value by different stakeholders. Heislers and Brewin (2003) also decided to avoid detailed comparison of asset values, and only included a partial weighting of asset values (for example a highway compared to an unsealed road). With respect to water resource assets, limited detail of water asset mapping meant that assessing saline site impacts on downstream extractable water supplies was also inherently difficult. It was also highlighted that 'the prioritisation process could ultimately accept any imposed relative asset value matrix'.

4.3.2 Groundwater Collection Feasibility

McAuley and Brinkley (2003), tabulated engineering options with respect to groundwater flow systems, based on their work carried out for the NDSP (SKM, 2001). The approach was developed on the basis that a groundwater diversion system capable of exerting control over the discharging groundwater could be matched to the geological and hydrogeological conditions of the range of dryland salinity conceptual models generated in the GFS study (Coram et al, 2000). That groundwater can be intercepted in some substantial way is fundamental to the success of any engineering based option.

The range of criteria and sub-criteria used to assess the extraction potential and their rationale is listed in Table 4. These criteria form the basis for development of the questions used in the filter tool. Where insufficient information existed to address the question, the site was assumed to be unsuitable with respect to that criterion.

Table 4. Groundwater extraction feasibility criteria (after SKM, 2001).

CRITERIA	SUB-CRITERIA	RATIONALE
Geology and Groundwater Flow System	What is the nature of the GFS present at the site / area of interest?	Small systems - good prospects in some circumstances Medium scale - moderate prospects of feasible control Large scale - sometimes good prospects, depending upon responsiveness and size of aquifers, depths, discharge feature configuration and connection.
	Geology type - what is the material at the site?	Ability to find pumping sites with sufficient transmissivity of materials to enable effective water extraction. Scored on transmissivity.
	Flow times / responsiveness - aquifer characteristics	Discharge area response time is mostly related to scale and hydraulic connectivity of the groundwater flow system. A short response time is more likely to be favourable.
	Single or multiple aquifers (ie simple or complex system)	Simple, single aquifer systems are generally more favourable than multiple aquifers.
Local Relief	Elevations across site - site geomorphology and type of salinity occurrence	Slopes and elevations influence: ❑ Gravity drainage options, ❑ area of influence of pumping ❑ discharge site size, ❑ machinery access, ❑ irrigation options, ❑ salt store mobility.
Geophysics	Technology to find best sites	Can geophysics improve the odds of finding sites, eg ground based magnetics to find faults/lineaments etc. in favourable terrain?
Salt Load Export	Groundwater salinity and volume - estimate load from site	Groundwater salinity and volume give an estimate of load. Higher load = higher impact downstream, therefore higher score

4.3.3 Usage Options

The ability to productively use any collected groundwater or to safely store the salt load is an important consideration. Key criteria are:

- Groundwater salinity – the ability of the site to accept groundwater for irrigation, in terms of the biophysical and farm system, treatment and re-use, blending needs, crop tolerance and soil suitability, desalination treatment.
- Water use economics - Water re-use benefits and costs, farming system economics, water storage or disposal costs.
- Community - Community awareness, willingness to take actions.
- Planning - Regulatory issues, eg. Groundwater licensing, off site impacts

Table 5. Usage options criteria and rationale

CRITERIA	SUB-CRITERIA	RATIONALE
Groundwater salinity	Groundwater Salinity	Key aspect is potential groundwater use. Low and medium salinity has higher potential for use.
	Soil suitability	Are there soil types in the locality that are unsuited to irrigation with saline water? (or unsuited for storage structures)
Water use Economics	Water use	Given the salinity and volumes of water estimated, is a value adding use likely, eg potable, horticulture, cropping, aquaculture, trees?
	Management costs	Identify salt management, monitoring and development costs of any re-use system proposed.
Community	Support and willingness	Is the community sufficiently aware and motivated to support or develop a suitable system?
Planning	Regulations and Approvals	Are planning issues and difficulties likely to arise? For example, drainage constraints, salt disposal, new irrigation controls that will obstruct development.

Groundwater salinity seems to be the most important factor influencing usage options at sites. If groundwater is of low salinity, the prospects for safe and acceptable usage being found are significantly higher than for more saline groundwaters.

However, complicating factors could be :

- The volume of groundwater that needs to be pumped to provide control. A low volume of high salinity water may be easier to deal with than a large volume of moderate salinity water.
- Location. Proximity to natural salt lakes could make saline water disposal potentially favourable.
- Chemistry. A high iron content, pH or arsenic content could restrict usage options.
- Improving desalination technology at lower cost could change the options matrix.
- Whether there is sufficient data to make a groundwater usage decision for a site.
- Whether the risks involved with higher salinity usage options can be tolerated.

4.4 Site Filter Tool Developed

The above criteria (in tables 3 to 5) were developed into a series of questions addressing the logic of the site selection process described above and represented in Figure 2. By answering these questions systematically, each site can be **favourably or unfavourably assessed for each** criterion. By working through the questions for the sites under consideration, the accumulated results begin to differentiate sites in terms of the number of favourable and unfavourable responses given. This then reveals those sites where an engineering based solution is both more feasible and more desirable.

In the development of the filter questions, it became apparent that some questions provide useful background information about a site, while other questions are more critical because they have a strong influence on the potential viability of a site. To reflect this, the filter tool site selection process has distinguished **critical and non-critical** questions, in order to give greater weight to what are considered to be the more significant questions. For these critical questions, an explanation' in the spreadsheet includes a **threshold** description to assist users to define when a 'yes' or 'no' condition should be entered. Where the question is deemed critical, a brief explanation about the reasoning behind the decision can also be included in the spreadsheet to add additional qualitative support where sites have similar scores.

Overall, if the answer to a filter question is 'yes', then the relevant characteristic of that site is **favourable towards a detailed consideration of an engineering based solution**.

The spreadsheet filter tool starts with a series of general site information questions that help build a picture of the location. While this step was not envisaged in development of the logic diagram, it was found to be necessary when the filter tool was applied to the NCCMA priority salinity locations. Without basic site information, the process to consider whether it would be suitable or not cannot be commenced. For example, without mapped salinity extent or bore data, it is impossible to address subsequent questions.

The questions under the general site information section, have been included in table 6, below. Questions relating to Assets and Groundwater Extraction are listed in tables 7 and 8 respectively.

Table 6. Site Information Questions

Question	Explanation	Critical or not critical	Reason
Is the site mapped to show the catchment context, GFS, discharge locations?	Can target area/priority site be easily shown in catchment context, may be already mapped (maps from CMA visits) and show assets, topography, discharge zones. Threshold: Clearly without adequate data, judgement cannot be made. If limited data, answer 'no'	Yes	This is critical because without basic information, a site cannot be adequately assessed.
Are photos of site(s) available?	May help in deciding if an engineering solution would work by assisting to conceptualise salinity problems at the site.	No	
Is a conceptual model of the groundwater system / discharge available?	Is a hydrogeological conceptual model available. Availability will depend upon prior study history, but if available, it will have condensed much understanding about a site. If available, the implication is that the site has some significant advantage over an un-modelled site in terms of making a decision. Threshold: If a sound understanding of the groundwater - salinity processes operating is not available, answer is 'no'.	Yes	Has been found to be critical because without a sound understanding of the processes operating, options cannot be envisaged and a case for a feasibility study cannot be confidently developed.
Is the area of saline discharge mapped?	The total area of mapped discharge (not including stream lines) is often known. This Helps establish the severity and scale of the problem.	No	
Is the location currently monitored?	Not critical. Useful to know with respect to information about the site and whether an engineering option (if developed) can be monitored for efficacy	No	
Is there an estimate of annual salt load leaving the sub-catchment/ sites?	Annual salt load estimate. May be based on stream monitoring stations but may not be specific to sub-catchment or area of interest. Especially in the Murray Darling Basin, the salt load is critical in deciding whether the costs of stopping the load leaving can be economically justified. Threshold: If no estimate is available, answer 'no'	Yes	Critical because without at least order of magnitude quantification of salt load, downstream impact cannot be considered. This is critical in assessing economic aspects later.
Is there Groundwater Salinity data for the site?	Groundwater salinities required are in-situ values (not concentration values eg. at discharge site). Important with respect to re-use potential or disposal options. Threshold: If no groundwater salinity data, answer 'no'	Yes	Critical because the groundwater salinity will play an important part in potential re-use / disposal options.

Table 7. Assets Questions

Question	Explanation	Critical or not critical	Reason
Is the site in an Urban Water Supply Catchment?	As far as possible from available map data, make a judgement whether the site is impacting on potable water supplies downstream. Knowing whether town water supplies downstream of the site experience elevated salinity levels is useful information.	No	Individual DLS occurrences unlikely to have significant enough impact on their own to make this a critical factor.
Does the site have a significant end of valley impact?	Does the sub-catchment / site have impact on Murray River salt loads? CMAs have to account for salt loads at end of valley (EOV). Investment in prevention is more likely if the contribution to the EOV total is large. Threshold: If less than 5000 tonnes per year or 5% of EOV total, answer 'no'	Yes	Critical because a strong justification is likely to arise for sites that have recognised EOV impact.
Does the site impact on high value agricultural land use?	High value land use other than broad scale grazing, eg vineyards, horticulture, high amenity value. Because of the extensively distributed nature of most dryland salinity, measures to minimise these impacts can have greater adverse impacts on catchment yield. High value use suggests good reason to invest in protection. Could be critical where the operation is clearly threatened by salinity. Landholder also more likely to want to invest in protection measures.	No	Critical where the operation is clearly threatened by salinity. Landholder also more likely to want to invest in protection measures.
Is there significant salinity impact on infrastructure?	Main consideration is whether saline discharge is impacting on significant built assets, especially urban areas. Threshold: If discharge is mapped within town boundaries, answer yes. Any other built assets not significant enough, therefore 'no'.	Yes	Critical because of the high cost of salinity related damage to urban infrastructure.
Is the site impacting on an irrigation supply?	Where is the site with respect to irrigation supplies eg weirs, reservoirs? If significant downstream irrigation off-takes, answer yes.	No	
Is the majority of salt load generated from the site occurring as base flow to streams?	Groundwater discharge direct to streams. If yes, the majority of salt load is from groundwater discharge, which may be intercepted. If no, the majority of salt load is probably generated as a diffuse load (eg. wash-off) and will generally be much more difficult to capture and divert.	No	
Is there an environmental asset downstream or adjacent that is being impacted upon?	Use mapping data to determine if environmental features are at risk from the salinity occurrence. These could be wetlands, rivers or terrestrial vegetation sites. Threshold: A high or rising watertable under a low salinity environmental site is a high risk that requires action. If so, 'yes'. If judgement is that the impact of the salinity site on any environmental sites is low, answer 'no'	Yes	Critical because a directly affected environ-mental asset of low salinity status (but at risk from salinity increase) requires protection.

Table 8. Groundwater Extraction related Questions.

Question	Explanation	Critical or not critical	Reason
Is there an engineering option compatible with the GFS at the site?	At this initial site filter level, a potential 'engineering' option is always available (based on SKM 2003 - McAuley and Brinkley). In answering this question for the filter process, the fundamental issue to consider is: what is the flow system causing discharge? Then decide whether it is feasible to intercept the groundwater from that system to prevent or reduce discharge at surface. Ignore issues such as cost at this stage. Threshold: Answer will be yes unless the groundwater flow system is poorly defined, there is no conceptual understanding, or extraction would be very limited by low conductivity materials, eg Permian Tillite	Yes	If expert judgement says 'no' to this, then clearly the site should not be considered for a groundwater extraction system. This does not rule out a surface drainage option though.
Is there more than one aquifer / flow system at the site?	Not critical, but the basis for the question is that more than one aquifer will generally reduce the confidence that an interception scheme will produce a predictable outcome	No	
Is the topography favourable for a gravity based engineering option?	Topography is not a constraint to pumping, but is to gravity drainage. Therefore, in a dryland salinity setting, a sloping site is more viable for a low tech, low capital interception type surface or subsurface drainage approach. Conversely, a flat location will require pumping.	No	Not considered a critical issue because technical solutions can generally be found (even though they may be found later not to be economically viable)
Is there well-defined hydraulic connection between the driving groundwater system and the discharge zone?	If hydraulic connection is poor between the target aquifer and the discharge sites, it will be harder to produce an effective result from groundwater interception. What is the conceptual model of the groundwater system and the likely volumes flowing in it to the discharge area? Threshold: If the assessing hydrogeologist has limited data and low confidence in envisaging a workable interception system, answer is 'No'. e.g. diffuse regional discharge through thick, low permeability overburdens would be a 'no'.	Yes	Critical because if the connection is poor or unknown, an effective groundwater pumping scheme is unlikely.
Is there likely to be a potential safe disposal/re-use site in proximity?	Based on groundwater salinity, topography and natural salinity features, is a 'safe' way of utilising or disposing of the collected groundwater likely to be feasible, eg. to evaporation basin, salt tolerant woodlot, salt bush / wheatgrass re-use area, vineyard conjunctive use, river disposal? Threshold: It would be unlikely that a site has no technical option available, so in most cases, answer would be 'yes'. Cost, regulation or local acceptance may rule it out later.	Yes	Critical because without a viable use or disposal plan for the saline water, any option is unlikely to proceed.
Is there likely to be a suitable pumping or drainage interval?	Is the geology present likely to provide a 'practical' drainage layer, ie. one that can be tapped and drained? In fractured rock terrain, bores may be viable if fracturing is sufficient. In poorly fractured terrain, bores are less likely to be viable. Horizontal drains may be suitable in colluvium materials up-slope of discharge areas. Threshold: In most cases a 'yes' would be expected, unless the hydrogeology was known to be of low conductivity and unconducive to extraction of sufficient groundwater from the right location to exert the desired control.	Yes	Critical because a practical extraction system is essential.
Is the location outside a GMA or WSPA area?	Not critical, but if a site is in a WSPA, groundwater extraction may need to address pumping constraints applying to groundwater. (It might be found where a local GFS fed break of slope salinity problem overlies a regional resource aquifer).	No	

Tables 6, 7 and 8 have been implemented in a spreadsheet, with explanations at each step to assist users to respond consistently. The classification of questions into "critical" and "non-critical" provides some guidance on the relative importance of each question. The classification has been based on the project team's experience and knowledge, using a number of subjective criteria. These included:

- Whether a negative response to the question would preclude an engineering based option;
- Whether the question was merely useful supporting information; and
- The likelihood that the circumstance the question related to would actually occur in practice.

Review by a stakeholder reference group of the decisions made would be a useful step to improve confidence that the ranking of suitable sites is reasonable.

A copy of the 'Site Filter' spreadsheet can be obtained from the Victorian Resources Online website (http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/vrohome). Instructions for using the tool are incorporated into the spreadsheet.

4.5 Issues of Scale.

The initial filter tool was developed using the NCCMA priority sites to test the concept (see Section 3.2.1 and Appendix 2, Figure A1). These priority sites are sub-catchments of between 10,000 and 70,000 hectares in size. However, the salt affected land mapped in each sub-catchment is only a few percent of their total area. These mapped salt affected areas contribute significantly to the overall salinity risk status of each sub-catchment.

In considering suitable engineering based options for a sub-catchment, the diffuse nature of dryland salinity discharge and the different scales at which it can be managed are critical issues. Will a single, large scheme be practical? Would a large number of separate, small schemes targeted at each known discharge system be more effective? Is an integrated system of control points at every discharge location possible?

The filter process can help resolve this issue by treating each potential scheme and scale separately. It is plausible that the filter process could be applied to identify most suitable sub-catchments and then reapplied within these to identify the most suitable sites within the most suitable sub-catchments.

In theory at least, the same process could be used again to focus on the next scale down. The main limitation would be the availability of sufficient detailed information within sub-catchments to enable judgements on the filter tool criteria to be made.

5 Catchment Assessments

5.1 North Central CMA

The starting point for identifying potential IMT sites in the North Central catchment was to take previously identified salinity affected areas and develop responses to the filter questions, based on readily available information and an assessment of the groundwater flow systems for each area. Key information on priority NCCMA catchments and the process of selection was obtained from several sources. (Karena 2003, Karena 2004, Clifton and Heislers 2004). Information about specific dryland salinity areas was obtained from readily available knowledge held by the project team in Bendigo.

The filter spreadsheet was applied to ten targeted salinity areas in the NCCMA (see appendix 2, figure A1). Table 9 provides a summary of the filter question responses for the 10 sub-catchments and highlights clear differences between sub-catchments in the number of 'yes' responses to the filter questions.

Table 9. Summary of results for North Central CMA priority salinity sub-catchments

Sub-catchment	Critical questions (Number of positive responses out of 11)	Non Critical questions (Number of positive responses out of 13)
Bet Bet Creek	10	10
Bulabul	8	11
Natte Yallock	8	9
Timor West	7	12
Pental Hills	7	9
Redbank	7	9
Carapooee	6	10
Reedy - Paradise	5	6
Glenloth	5	5
Upper Avon - Richardson	5	4

The three catchments of Bet Bet Creek, Bulabul and Natte Yallock had the highest number of positive responses to critical questions. Looking in detail at this result, it is important to consider which questions were not favourably responded to. Where a no response is given, this deficiency may be more significant at some sites than others.

In the case of Bet Bet Creek, the only critical criterion yielding a negative response was whether there is infrastructure of significance impacted by the salinity occurrence. At a few sites, there are likely to be some roads and possibly some fringe areas of Lexton at risk. However, the assessment at this stage is not compromised by this possibility and a more detailed review would be required to confirm or change the filter results on such aspects.

In the Bulabul catchment, there were no assets of significance identified as threatened by salinity. The other key negative responses were in regard to whether there was likely to be a safe re-use or disposal option and whether groundwater systems were suitably responsive to pumping or drainage. Clearly the scale of implementation would have a major influence on groundwater system response, and while local scale systems could be suitable at specific sites, there is doubt that geological conditions would be consistently favourable at a whole of catchment scale.

For the Natte Yallock catchment, there was no estimate of the annual salt load available, though it is thought to be high. There was also no significant infrastructure impact identified, nor whether a suitable pumping or drainage groundwater response would be manifest. Without an estimate of salt load leaving the catchment, the potential impact of engineering options on downstream irrigation and on end of valley salt loads is unknown. As with the Bulabul catchment, there is some doubt about the availability of suitable groundwater response to drainage adjacent to saline areas due to the generally unfavourable hydrogeological conditions across the area.

This assessment of the North Central CMA priority salinity catchment has highlighted that even on relatively large, priority salinity sub-catchments about which we know a great deal, there are insufficient suitable data available to make even preliminary assessments of potential engineering options with confidence.

5.2 Corangamite CMA

The starting point for identifying potential IMT sites in Corangamite CMA was to take identified salinity affected areas and develop responses to the filter questions using readily available information and assessment of the groundwater flow systems for each area. Key information was obtained from several reports on salinity prioritisation work for the catchment (Dahlhaus 2003, Dahlhaus et al 2002, Heislers and Brewin 2004, Clark 2004). The ICSRP summed salinity hazard for sub-catchments map (from Heislers and Brewin, 2004) is shown in Appendix 2, figure A2.

Approximate priority areas were identified for the catchment by Dahlhaus (2003) and from discussions with the CMA (Tim Corlett) in the form of approximate circles drawn around priority salinity areas on maps. To describe the key characteristics for these areas for data entry onto the filter spreadsheet the key information needed was:

- the nature of the groundwater system responsible for the salinity problem at each location, and
- the salinity manifested at each site.

This information was available in a range of forms (Dahlhaus et al 2002, Heislers and Brewin 2004, Clark 2004). Populating the filter spreadsheet with responses to the questions required a significant effort to gather and collate sufficient suitable data. The vaguely defined priority areas compounded this difficulty, and as a result, the focus was placed on those parts of the catchment of known saline discharge to the surface. This resulted in two of the original interim salinity management target areas identified by Dahlhaus (2003) not being assessed in the filter spreadsheet because the salinity discharge in these two areas is not shown on the salinity discharge mapping layer.

The results of the application of the filter to priority sites in Corangamite is shown in Table 10.

Table 10. Summary of results for some Corangamite CMA Salinity Target Areas

SITE	Critical questions (Number of positive responses out of 11)	Non Critical questions (Number of positive responses out of 13)
Lismore	8	7
Upper Woady - Pittong	7	10
Moriac	6	9
Beeac	6	6
Leslie Manor	6	3
Upper Woady - Corindhap	5	9
Meredith-Bamgarie	5	8
Winchelsea	5	6
Deans-Barongarook	4	6
Barwon Downs	3	7

The three locations with the highest number of positive responses to critical and non-critical questions were the Lismore, Upper Woady-Pittong, and Moriac locations. Reviewing where each of these three received a negative responses highlights key obstacles to developing an IMT solution in these areas.

In the Lismore location, the failures on critical questions were in relation to there being no salt load data and an end of valley impact that is probably very low. The location has several different, yet interacting groundwater flow systems. The current understanding of the groundwater and salinity processes is presently poor and insufficient to draw conclusions on groundwater control feasibility.

In the Upper Woady-Pittong location, the main failures were in relation to assets at risk. The salt loads released to streams have an unquantified downstream impact, so although the impact on the Barwon River via the diversion scheme from Lake Corangamite may benefit through a reduction in salinity, this has not been quantified. The other critical failure was in groundwater extraction feasibility. In deeply weathered granitic terrain such as the Upper Woady-Pittong location, the presence of suitable pumping aquifers is considered unlikely.

The third ranked location fails on five critical questions, but has a higher proportion of non critical questions favourably returned. As with the Lismore site, there is no salt load data and no significant end of valley impact documented. There are also no known infrastructure or environmental assets at risk. The groundwater - salinity conceptual understanding has also not been strongly defined for this location, where the roles of each GFS and their interaction may be complex.

A conclusion that can be drawn from this filtering exercise in the Corangamite CMA region is that despite using a systematic approach to ensure that all questions were addressed using consistent guidelines, decisions were rarely clear cut.

In addressing the questions relating to assets, the approach taken was to consider whether there are critical assets in the region that could conceivably be protected or restored by an engineering based option. Apart from the difficulty of ascribing value to the range of assets involved and the subjectivity of the risk assessment, the Corangamite CMA region is a naturally high salinity landscape with much uncertainty in distinguishing primary and secondary salinity. Given that assets at risk is a key driver for engineering based options, this makes it difficult to confidently identify locations where works might be needed or justified.

The issue of scale is again very significant. Although a single occurrence of saline discharge could feasibly be treated with an engineering solution at a catchment scale, treating a large number of small and isolated sites could be extremely difficult to implement. As shown by the salinity discharge mapping (as seen in Heislers & Brewin, 2004), there are hundreds of known discharge sites in the region which could potentially need to be assessed and treated individually.

5.3 Glenelg-Hopkins CMA

As with the North Central and Corangamite CMAs, the initial approach in the Glenelg-Hopkins CMA was to identify salinity priority areas. Heislers and Brewin (2003) conducted a salinity prioritisation process in the Glenelg-Hopkins CMA that overlaid susceptible asset classes on salinity discharge mapping to highlight sub-catchments having the greatest need for intervention actions. The resulting priority rating table identified over 60 (of 143) sub-catchments as having the top 2 of six available priority ratings. A copy of this priority ranking for the catchment is shown in Appendix 2.

In attempting to apply the IMT filter approach in the Glenelg-Hopkins CMA, the available data were not sufficient to enable assessment of even the 28 highest ranked sub-catchments at the sub-catchment scale. Assessment in the Glenelg-Hopkins CMA region was feasible only at levels of greater spatial aggregation. A different approach was therefore trialled, based on groundwater flow system (GFS) units.

This is a different approach to that taken in the North Central and Corangamite CMA areas, where the focus was on locations. Working through the data available in Dahlhaus et al (2002a), it was possible to make judgements on the questions addressed in the filter spreadsheet and derive a ranking table for the 13 GFS types selected. The results are presented in Table 11.

Table 11. Summary of results for Glenelg Hopkins CMA Salinity Affected Groundwater Flow System types.

Groundwater Flow System	Critical questions (Number of positive responses out of 11)	Non Critical questions (Number of positive responses out of 13)
Volcanic Plains Basalt	9	9
West Dundas Tablelands	9	9
Pliocene sands	7	8
Fractured Palaeozoic rocks	7	8
Volcanic Plains (later phase)	7	8
Fractured granitic rock	7	7
Eastern Dundas Tablelands	7	6
Woorndoo Complex	7	5
Grampians Colluvial (LFS)	6	8
Deeply weathered granite	6	7
Sub-surface deep leads	5	2
Quaternary alluvium and coastal deposits	3	6
Weathered Palaeozoic rocks	3	4

The most favourable GFS types were the Volcanic Plains Basalt and West Dundas Tablelands. For the Volcanic Plains Basalt, the two critical questions unfavourably answered were with respect to an estimate of salt load and whether the site had a significant end of valley impact. Given the extensive area of this GFS type, this is not unexpected.

The West Dundas Tablelands also appear favourable under this assessment. Key critical question failures included estimates of salt load and the significance of impacts on infrastructure.

Using the GFS categories in the filter spreadsheet was a valuable exercise for exploring the suitability and flexibility of the developed concepts and method. The overall results are reasonable from a hydrogeological point of view. However, it highlights some limitations of the process. For example, the assets at risk section was developed for use with specific locations and their probable downstream impact. For extensive areas such as the Volcanic Plains Basalt groundwater flow system, the question cannot be adequately answered.

This is once again reflects issues associated with scale. For example, assessment of a specific sub-catchment where the majority of salinity occurs within this priority GFS type may enable identification of specific downstream impacts on assets. At this scale, it is quite conceivable that there could be a number of known salinity problem sites within a region that are all underlain by that GFS. The filter spreadsheet could be used to help decide which location has the best prospects for investigation and development of a solution.

Overall, it proved difficult to meaningfully answer the filter questions at the GFS scale. On a hydrogeological basis at this scale, it made sense that some GFS types would be more amenable to groundwater extraction than others. However, the more spatially specific questions relating to assets and measured salt loads could not be handled adequately by the filter process at this scale. The filter method would have more value if used to separate out significant salinity occurrences within a GFS type, provided sufficient suitable data exist for the assessment. On this basis, appraisal of the West Dundas Tablelands, looking in more detail at known and relatively well-studied salinity occurrences, could help identify feasible engineering based options.

5.4 Selecting 3 sites for more detailed appraisal.

An objective of this project was that it would identify three sites that would have clear opportunity for adoption of engineering solutions that could then be progressed to the development of business cases for implementation. At the commencement of this study, this objective seemed reasonable. However, having worked carefully through the logic of the issues and developed a site selection process, the sheer complexity of the task has become apparent.

The Bet Bet Creek catchment in the North Central CMA, the Lismore area in the Corangamite CMA and the Volcanic Plains Basalt and West Dundas Tablelands GFS in the Glenelg-Hopkins CMA scored highest in each CMA, using the filter process developed. However, the project was not able to identify specific sites, development proposals, nor local support at specific locations to warrant further investment in the development of business cases. In this respect, the project has failed to meet its original objective.

Nevertheless, the project has made a contribution to our knowledge of this topic. Foremost is a clearer understanding of the probability of viable engineering based solutions for dryland salinity in Victoria. Scenarios where an IMT solution may be favourable are provided in the conclusions section of this report.

7 Conclusions

The concept of applying IMT based solutions to dryland salinity problems holds significant attraction for communities and natural resource managers. This is because of the desire to effect a more rapid reduction in salinity related losses than land use change or agronomy based programs can achieve. The success of engineering solutions in irrigation regions also provides further optimism that these options can be applied in dryland areas.

However, SKM (2001) and the assessment of Victorian examples presented here (see Table 1.) indicate that there are few, if any unqualified successes for engineering solutions in dryland areas. Most of the engineering solutions of significant scale lie in irrigation areas where groundwater extraction is generally more favourable, the economic gains are more obvious and engineered infrastructure is already a common part of the operating environment.

Many of the documented dryland case studies are taken from the extensive salinised landscapes of the Western Australian wheat belt. Even there, significant uncertainty remains amongst the farming and scientific communities in regard to the economic and environmental viability of adopting engineering solutions (Pannell 2001).

This lack of clear evidence for the successful application of engineering solutions in dryland areas suggests that whilst their application is not technically impossible, there are significant issues to be addressed.

This project planned to test whether innovative engineering based solutions were feasible in the Victorian context. The first step was to develop a systematic approach for identifying and ranking sites most suited to IMT solutions. A systematic process to assess and compare a set of key factors for known salinity problem areas has been developed. However, while the process developed seems sound, the outcomes have not been as clear as initially hoped for. The reasons for this conclusion are explained below.

7.1 The inherent complexity of dryland IMT solutions

The complexity involved in the consideration of IMT solutions in dryland salinity impacted areas makes building a sound 'business case' for their development a significant challenge. The main uncertainties include:

- The practicalities of groundwater extraction and whether there is sufficient hydrogeological understanding of a site. Though a technical solution may be feasible, the ultimate constraint may be the very high cost of investigating a site, designing a workable solution, implementing it and then operating and maintaining it for a long period of time.
- Suitable disposal or reuse options. In most instances, this will have to occur on-site, given the need to prevent downstream salt load or in-stream water quality impacts. Once again the limitation may not be a technical one, but rather one of economic efficiency.
- Uncertainty about future salinity, which is the result of ongoing dynamic processes. . The current dry climatic phase we have been experiencing has lowered watertables throughout the state and reduced salinity risk and occurrence. The uncertainty that climate change may make salinity risk diminish in the future makes significant dryland salinity investment decisions more difficult. Under both scenarios of changed climatic conditions and widespread agronomic changes impacting on recharge and discharge zones, the need for an engineering option to bring forward a solution in a reasonable time is now less certain.
- Inadequate suitable data at the spatial resolutions required for site assessment. Although it was initially envisaged that a systematic, objective process for selecting the most favourable sites could be developed, it has been unavoidable in practice that a very large degree of subjectivity has dominated the process. This has been inevitable given the dependence on judgements being made about poorly defined and hidden natural systems. The high costs of obtaining hydrogeological data at a suitable resolution for decision making is a common constraint. Removing subjectivity in the site selection process would require very significant investment in more detailed data acquisition across large areas.

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7.2 The importance of high value assets

Sound reasons for an IMT solution are more likely to occur if there is a local, well-defined public asset requiring protection. Rather than focussing on the poorly defined threat of dryland salinity (in all its forms), protection of a recognised asset can provide a focus to enable better targeted effort. The advantages of the asset protection focus and justification include:

- An economic risk profile can be generated for an asset that can help define the starting point for how much money might be justifiably spent developing an engineering solution.
- A well defined asset presents a realistic and attainable target for an engineering solution and for defining its performance criteria.

Pannell (2001) has argued that investment in salinity mitigation would be most efficient if strategically targeted at the protection of specific assets and further suggested the importance of developing improved methods for making more productive use of saline land and water, given that disposal downstream would probably be limited in many dryland landscapes.

7.3 The Role of Scale

Ultimately, any technical option needs to place works on the ground in specific locations. However the scale of dryland salinity and the widely dispersed nature of discharge sites very quickly renders assessment of treatment options at individual sites infeasible. Sufficient data at the scales required for assessment are not available in most cases. This is compounded by the range of scales at which an engineering option might need to be implemented, from localised intervention at small sites to very large, whole of catchment works.

7.4 Favourable Scenarios

The project has been successful in clarifying the circumstances where an engineering based solution is more likely to be viable. Successful engineering solutions must satisfy the following criteria:

- Protect a well defined asset of high value that is under direct and unequivocal threat from salinity processes or water quality impacts. In these situations the downstream benefits of reducing saline base flow in streams can provide strong justification for public investment.
- Use engineering systems that intercept water effectively and efficiently.
- Be able to productively and sustainably use the intercepted water.
- At the farm scale, involve simple, small scale salinity problems where a basic collector system (such as tile drains, mole drains, surface interception drain) and pump with an on-site re-use system can be developed to manage the water within the property boundaries. These solutions can have greater benefit where landholders can integrate them with other beneficial catchment works (for example biodiversity improvement and shelter belt establishment) to achieve multiple outcomes.

8 Recommendations

The following recommendations arise from the project:

- This study has highlighted the very low probability that widespread adoption of engineering based solutions for dryland salinity will be justifiable in Victoria.
- At the farm scale the most likely circumstance where a system could be feasible is that of a small site with simple and favourable hydrogeology. Such a site would have to be amenable to an efficient collection system and an agronomic system that can sustainably contain salt or nutrient on site. Implementation of such systems should aim to achieve multiple outcomes such as biodiversity enhancement.
- The only circumstance where an engineering based solution has potential is where a highly valued asset is at substantial direct risk of salinity damage that cannot be more efficiently resolved by other means.
- The existence of potentially viable sites for implementation of engineering options for dryland salinity and water quality management is not precluded by the inability of this project to identify them, which has largely been the result of inadequate suitable and extensive data sets.
- That Stage 2 of this study as originally proposed not proceed.

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Websites

Environment Victoria

http://www.envict.org.au/inform.php?menu=7&submenu=220&item=668

Link to a selection of key pieces of current legislation which impacts on Victoria's rivers and their ecosystem health.

Murray Darling Basin Commission

http://www.mdbc.gov.au/naturalresources/natural.htm

Link to natural resource management, basin salinity management strategy, salt load offset schemes etc.

Victorian Legislation

http://www.dms.dpc.vic.gov.au/

Links to: Environmental Protection Act 1970

Victorian Water Act (1989)

Planning and Environment Act (1997)

Victorian Resources Online

http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/vrohome

Links to: .pdf version of this report

Spreadsheet based filter tool developed by this study

Filter tool results for NorthCentral, Corangamite and Glenelg-Hopkins CMA's

Appendix 1. Project Proposal

1 **Program/Project Title:** **Innovative Salinity and Nutrient Management Technologies for Victorian NAP Catchments**

Program/Project Description:

Project Statement

This project will assess the technical, economic and social feasibility of implementing a range of innovative salinity, nutrient and sediment management technologies in the NAP dryland catchments of Victoria. Some of the proposed technologies have been proven and implemented both in Australia and overseas in irrigation settings. Their potential application in dryland settings appears promising, but is currently not known.

Treatments dealing with the symptoms of dryland salinity, such as the revegetation of recharge areas or the establishment of radically new farming systems, will typically have lag times measured in decades before their effects are significant at a landscape scale. At the same time, the creation of a water market and the social/political imperative to invest in regional Victoria are facilitating the widespread development of new irrigated agricultural enterprises on “greenfield” sites higher in catchments. Catchment managers and policy developers urgently need good information on the technical, economic and social feasibility of new techniques for salinity and nutrient management in these areas in order to frame better catchment management strategies and policy instruments. Approaches of this nature will be essential if significant improvements in the projected downstream impacts of dryland salinity and nutrient loads are to be managed in the relatively short term (10 to 100 years).

This project will firstly review existing information relevant to the application of innovative salinity, nutrient and sediment management techniques, and manage a consultative process for selecting three case study sites. Using the three selected sites, the project will examine ways that salinity, nutrient or sediment generating priority sites can be managed by innovative, hybrid engineering/agronomic technologies until more desirable, whole-of-catchment hydrologic balances are achieved. It will examine in detail the biophysical, economic and social feasibility of these technologies and the business case for implementation at each site.

Project Objective

The primary project objective is to develop and impart a greater science-based knowledge of the potential applications (type and location) of engineering/agronomic salinity and nutrient management techniques, in order to better inform, target and stimulate future catchment management investment and policy development. This is completely in accord with the main goal of the NAP, which is to motivate and enable regional communities to use coordinated and targeted action to (a) prevent, stabilise and reverse trends in salinity, particularly dryland salinity, and (b) improve water quality and secure reliable allocations for humans, industry and the environment.

Project Activities

The project objective will be accomplished in a staged approach by:

- Establishment of a steering group composed of stakeholder representatives (drawn from NAP, CMAs, CAW, EPA, Water Authorities). The project steering group will ratify the project structure, approach and quality assurance processes and milestones.
- An information review process involving a literature review, technical workshop and expert consultation. The literature review will include review of engineering interception works and innovative techniques that have been, or could be, implemented for environmental benefit with respect to salinity and nutrient impacts in dryland areas of Victoria’s NAP catchments. It will also include comprehensive review of relevant legislation, policies and guidelines. A technical workshop will be run to discuss in detail the range of relevant innovative technologies and their practical applicability in the context of different types of groundwater flow systems, catchments and salinity/nutrient settings. Key catchment managers and policy developers will be invited to this workshop. Added insight on technologies and their potential application will be gained from a targeted program of expert consultation. The information gained from the review process will be carefully assessed to obtain that which is most useful and likely to add most value to the project and NAP outcomes.
- Facilitated selection of three case study sites within Victorian NAP catchments. Site selection will be based on existing NAP catchment priorities with respect to threats and assets (mostly determined in NAP Regional Foundation Programs) and consultation with the project steering group and the CMAs. It will also be guided by the understanding gained on the manageability of the Groundwater Flow Systems (GFS) defined in the MDBC Catchment Characterisation Project. The sites, together, will enable coverage of a range of identified technologies, the specifics of which will be discussed and decided upon with the relevant CMAs and project experts.

- Comprehensive, integrated assessments of groundwater systems, surface hydrology, terrestrial and aquatic ecosystems, soils, geology, geophysics and climate at each of the three case study sites. The information gained will form the basis of a characterisation of each site in order to design the most appropriate innovative management interventions. With respect to groundwater systems, it is intended to utilise the modelling tools FLOWTUBE and MODFLOW to improve conceptual understanding and prediction of system behaviour, responsiveness to engineering intervention and the feasibility of achieving protection of the target asset(s) in a reasonable timeframe.
- Development of detailed specifications for systems implementation. The most suitable agronomic, engineering and soil management technologies will be specified in detail for each case study site. The aquaculture component of systems will be specified with the assistance of the Aquaculture Program at MAFRI (DPI), which is actively researching the commercial application of inland saline aquaculture in Victoria. Regional and local stakeholders will be consulted to establish the compatibility of preferred management systems with existing programs, priorities and values, and any implications with respect to existing legislation, regulations or policies.
- Analyses of on-site and off-site impacts of innovative management systems will include both biophysical and socioeconomic aspects.
  - The project will assess the effectiveness of these systems with respect to protection of assets and productive use of resources. It will estimate the changes in salt and nutrient fluxes resulting from implementation of proposed systems, and the effects of these systems on terrestrial and aquatic environments. A baseline assessment of ecosystem health on and adjacent to the study sites will serve as a reference against which projected local environmental impacts (positive or negative) can be assessed.
  - Projected establishment and operation costs and benefits will be analysed and appropriate cost share arrangements developed. The attitude and capacity of stakeholders with respect to proposed systems will be surveyed and assessed, as will the relevant institutional, legislative and regulatory aspects of proposed systems.
- Preparation of final report, incorporating results of the above activities, and presentation to stakeholders. The findings may form the basis for implementation of innovative management systems.

Project Focus

The project will investigate and develop knowledge on the potential for innovative solutions based on engineering/agronomy/aquaculture. Management techniques to assure the sustainability of these systems, including waste recycling techniques and the use of organic waste stocks and organic soil ameliorants, will be critically assessed. The project will also examine the feasibility of these and similar systems as interim 10 to 100-year solutions, while improved hydrologic balance by vegetative means is achieved in our catchments. Important bases for this examination will include the NDSP "Options for the Productive Use of Salinity" (OPUS) database and the LWRRDC study entitled, "Assessment of the Efficacy of Engineering Options for the Management of Dryland Salinity" (LWRRDC Final Research Report, December 2001).

Examples of technologies that will be investigated include:

- Saline groundwater interception schemes that rehabilitate surrounding farmland (e.g. the existing Pyramid Salt site at Pyramid Hill and planned site at Pyramid Creek).
- Hybrid engineering / bio-drainage systems such as Serial Biological Concentration (SBC) and the CSIRO FILTER system to productively manage saline and nutrient rich drainage effluent water;
- The use of soil ameliorants to stabilise soil structure under intermittent saline water use;
- The potential use of a range of groundwater interception technologies, both in lower and upper landscape settings;
- The integration of saline aquaculture(mariculture) into interception systems to provide economic returns from currently unproductive resources.

Saline groundwater interception schemes are engineering solutions that may be implemented at a range of scales. In large scale systems, groundwater is pumped to the surface and held in evaporation basins where it may be used for salt production. These systems are known to rehabilitate surrounding farmland and have the potential for aquaculture integration.

Serial Biological Concentration (SBC) is a technology that uses pastures, crops or trees to concentrate salt and nutrients in water while reducing overall volume. Vegetation is irrigated (from groundwater or other sources) and drainage effluent (smaller volume, higher salinity) is collected in a sub-surface tile drainage system for further use on subsequent crops.

Filtration and Irrigated Cropping for Land Treatment and Effluent Reuse (FILTER) has been developed by CSIRO, Griffith. It combines cropping with filtration through the soil to a sub-surface drainage system to strip nutrients from nutrient rich effluent. The technology could be incorporated with SBC where nutrient rich, saline effluent requires disposal.

Saline agronomy and forestry are essential components in any groundwater reuse system. Crop/pasture and tree species suited to the available water quality, soil types, climatic conditions and management systems will be identified and assessed. The database developed by the OPUS project will serve as baseline information. This work will link with the CRC for Plant Based Solutions to Dryland Salinity.

Organic soil ameliorants can play an important role in the salt/soil structure interaction. The project will include an extensive literature review dealing with beneficial uses of naturally derived organic amendments in saline-sodic soils. Organic waste stocks (ie compost, sewage sludge, agri-industry waste, etc) and other potential organic soil ameliorants (sources of humic substance such as peat, brown coal, etc) will be identified and their potential role in the process of saline soil amelioration will be documented.

There is potential for groundwater interception and reuse systems to provide solutions to break-of-slope discharge management. Reuse of intercepted groundwater up-slope can mitigate saline seeps downslope and result in improved stream water quality. This system would require complementary recharge planting. The engineering component of the system would provide control at least until the recharge planting water consumption has fully developed. Such a system has rarely, if ever, been applied in full and the concept will be further explored under this project.

Saline aquaculture could improve the financial feasibility of drainage effluent management systems. By integrating aquatic species into water management chains, an economic return can be generated from otherwise unproductive resources. In addition, some forms of aquaculture (bivalve molluscs, plankton, zooplankton and herbivorous fish) result in nutrient removal. This project will review aquaculture species and systems that have potential to be integrated into saline interception schemes, and will provide an assessment of market demand and opportunities.

Project Outcomes
The project will develop tools to facilitate optimal implementation of innovative management technologies. Project outcomes will include the generation of knowledge for catchment managers and policy developers on the potential and scope for the application of innovative salinity and nutrient management technologies in the Victorian NAP catchments. Opportunities for the implementation of these technologies will have been identified by the project through stakeholder endorsed selection, design and evaluation processes. The approaches used will be packaged in forms that regional stakeholders in Australia can use and adapt for specific settings into the future.

2

Specify Program Logic and how the project meets the Regional Delivery, Stakeholder and Multiple Benefits objectives of the NAP:

- *Include a description of the underlying Program Logic that supports your submission*

Program logic – Part 1: Selection of sites

Reading from left to right, the program logic tables indicate the resources and activities that will be required to deliver the project outputs, the target group for each output, the expected outcomes and the indicators of success for each output.

Inputs	Activities	Outputs		Outcomes			Success indicators
		Deliverables	**Target group**	**Short term**	**Mid term**	**Long term**	
Data on and knowledge of hydrogeology and salinity processes; assets; land uses; etc at subcatchment scale.	Establishment of project steering committee	Potential IMTs review Relevant legislation, regulation and institutional constraints review	CMAs, local governments, natural resource managers	The scope of IMTs to be considered by the project will have been endorsed by catchment stakeholders	Opportunities for implementation of IMTs will have been identified in NAP catchments		Endorsement of the selected sites by the project steering committee and regional stakeholders
	Review and workshop of potential IMTs						
Strong stakeholder decision- and policy-maker representation on the project steering committee Hydrogeology, agronomy, soils, engineering and socioeconomics expertise	Development of selection methods	Documented site selection methodology endorsed by stakeholders		An endorsed methodology for selection of potential IMT sites will have been developed, implemented and documented.			
	Consultations with stakeholders						

* IMT – innovative management technology

Program logic – Part 2: Design and evaluation of three selected sites

<table>
<tr><th rowspan="2">Inputs</th><th rowspan="2">Activities</th><th colspan="2">Outputs</th><th colspan="3">Outcomes</th><th rowspan="2">Success indicators</th></tr>
<tr><th>Deliverables</th><th>Target group</th><th>Short term</th><th>Mid term</th><th>Long term</th></tr>
<tr><td rowspan="4">Strong stakeholder decision- and policy-maker representation on the project steering committee

Hydrogeology, agronomy, soils, engineering and socioeconomics expertise</td><td>IMT evaluation method development</td><td rowspan="3">Documented, peer reviewed IMT evaluation methodology endorsed by stakeholders</td><td rowspan="3">Technical specialists</td><td rowspan="3">Key decision- and policy- makers support the methodology for IMT evaluation.</td><td rowspan="9">A methodology for evaluation of potential IMTs will have widespread adoption in NAP catchments

Enhanced regional capacity through significantly improved knowledge of the potential for IMTs.</td><td rowspan="9">IMTs will be being optimally implemented in NAP catchments</td><td rowspan="3">Endorsement of the IMT evaluation approach by the project steering committee and CMAs</td></tr>
<tr><td>Consultations with stakeholders</td></tr>
<tr><td>Preparation and submission of refereed paper</td></tr>
<tr><td>Preparation of user manual</td><td>Packaged evaluation methodology for use by stakeholders</td><td>CMAs, local governments, natural resource managers</td><td>The IMT evaluation methodology is readily usable and transferrable</td><td>Adoption of the IMT evaluation approach by the target group</td></tr>
<tr><td>Field survey and interpretation expertise</td><td>Detailed biophysical surveys of 3 sites</td><td rowspan="5">Reports that detail design and business case of potential IMTs at 3 selected sites</td><td rowspan="5">Technical specialists and CMAs, local governments, natural resource managers</td><td rowspan="5">Approach for design and evaluation of IMTs will have been developed and demonstrated.</td><td rowspan="5">IMT potential evaluated at three priority sites.

Use of the packaged design and evaluation methodology by stakeholders.</td></tr>
<tr><td>Relevant legislation, planning controls, policies and guidelines</td><td>Detailed socio-economic review of 3 sites</td></tr>
<tr><td rowspan="3">Hydrogeology, agronomy, soils, engineering and socioeconomics expertise</td><td>Selection, design and evaluation of IMT for 3 sites</td></tr>
<tr><td>Preparation of feasibility reports for 3 sites</td></tr>
<tr><td>Presentation of feasibility reports to CMAs</td></tr>
</table>

♦ *Describe how the submission will address and underpin the regional delivery of NAP objectives of salinity reduction and water quality improvement.*

This project will identify high priority, immediate actions to address salinity, particularly dryland salinity, and deteriorating water quality in NAP catchments in Victoria. The project will identify opportunities for decisive salinity and water quality related action to ensure that our land and water management practices will sustain productive and profitable land and water uses as well as our natural environments.

The project will use an asset based approach to identify high priority sites for the potential application of innovative technologies and will work within the relevant Regional Catchment Strategies and integrated regional plans to motivate and enable regional communities to use coordinated and targeted action to:

- Prevent, stabilise or reverse trends in salinity affecting the sustainability of production, the conservation of biological diversity and the viability of infrastructure,
- Improve water quality for human uses, industry and the environment and
- Enhance our capacity to productively use and manage variable quality water.

♦ *Describe how the submission will enhance the delivery of regional investment plans by the Catchment Management Authorities (CMA's).*

Current activities in NAP catchments in Victoria include the identifying key assets, assessing the condition of catchment resources and developing improved understanding of the processes threatening assets and appropriate responses to them. The potential for innovative agronomic/engineering management techniques to protect key assets and manage the impacts of increased salinity and degraded water quality is currently unknown and represents a critical information gap. This project will provide important information not only on the potential of these approaches at three selected sites, but also more generally. The project will also develop and package rigorous approaches to the design of such systems and to the assessment of them with respect to both biophysical and socioeconomic aspects. These packaged approaches will have wide application for catchment managers in the NAP catchments of Victoria.

♦ *Describe how the proposal will engage stakeholder support and the nature of this support.*

Strong stakeholder support will be critical to the success of the project. We propose that a project steering committee with high level representation from relevant organisations (eg NAP, CMAs, CAW, EPA, water authorities, local government) be established at project inception to guide project implementation. A wider stakeholder group will be invited to contribute to a national workshop that will focus on potential innovative technologies and which will be held during Stage 1 of the project. Extensive consultation with regional stakeholders will be undertaken to ensure the Stage 1 site selection processes and Stage 2 evaluation processes are both appropriate and acceptable to regional stakeholders.

♦ *Clearly define and justify the perceived multiple benefits of the submission and its application across regions.*

Greater knowledge of the technical feasibility, biophysical impacts, economic viability and the social and institutional issues of engineering/agronomy based options for saline and/or nutrient rich effluent management will be important for the development of better catchment water management policy. These technologies have the potential to improve outcomes in dryland salinity, water quality, conservation of biodiversity and infrastructure protection. Potential aquaculture production from saline interception schemes could provide long term employment and an increased skills base in regional communities.

Information generated by this project will be of direct value in the ongoing development and implementation of catchment management plans. Aspects of the project, such as the potential for use of saline groundwater for aquaculture, will provide information for the development of future regional development strategies. The information is likely to be applicable across a number of regions. The development of an inland aquaculture industry, focusing on integrated salt and nutrient management systems, could provide an economic underpinning of salinity management strategies and would fit well with NAP guidelines.

Significantly, information generated from this project will contribute to a knowledge base required for the development of potential market mechanisms for salt and nutrient management services by landholders.

3

A Project Operational Summary;

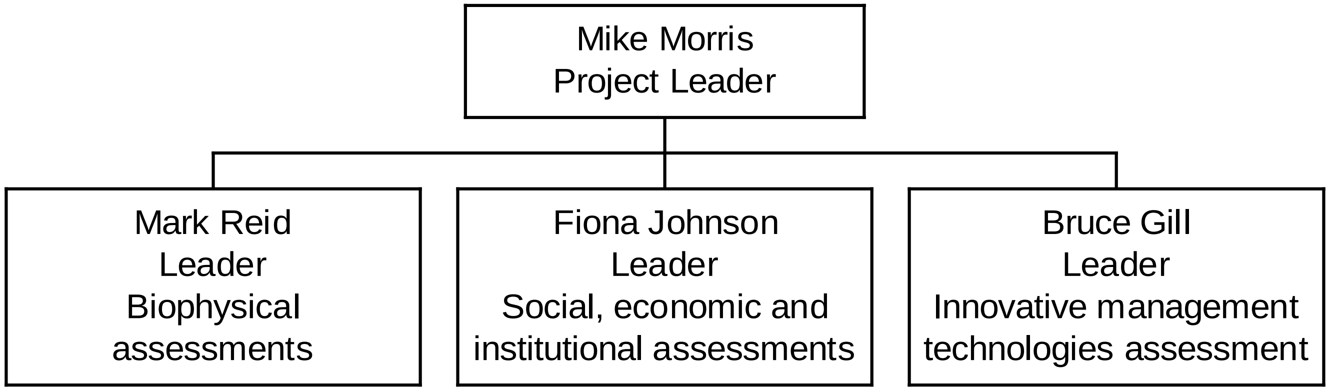
- *Describe clearly project tasks and milestones and link these to financial funding needs set out under B below (you should consider the following points when preparing tasks and milestones: 1. Objectives, 2. Inputs, 3. Approach, 4. Outputs, 5. Resources)*

Objectives	Inputs	Approach	Outputs	Resources
Site selection approach and selected sites endorsed by stakeholders.	• Stakeholder, decision- and policy-maker representation on the project steering committee. • Hydrogeology, agronomy, soils, engineering and socio-economic expertise. • Catchment biophysical condition information.	• Establishment of project steering committee • Review and workshop of potential innovative technologies and relevant institutional issues • Development of selection methods • Consultations with stakeholders	• Potential IMTs review • Relevant legislation, regulation and institutional constraints review • Documented site selection methodology endorsed by stakeholders • Study sites selected and endorsed	
Evaluation methodology endorsed by stakeholders.	• Hydrogeology, agronomy, soils, engineering and socio-economics expertise • Data on the range of potential innovative technologies • Existing data • Stakeholder involvement	• Consultation with stakeholders • Assessment of the biophysical, socioeconomic and institutional conditions at each study site • Selection of potential technologies most suited to each site • Assess triple bottom line aspects of potential options	• Detailed biophysical surveys of each site • Detailed socio-economic review of IMT options for the 3 sites • Business case for the development of each site • Submission of refereed paper	
Evaluation methodology usable by stakeholders throughout Australia	• Results of selection approach and site evaluation methodology. • Relevant legislation, planning controls, policies and guidelines	• Combine results of site assessments, develop scenarios that define IMT's for a range of circumstances • Use practical understanding gained from site assessments and stakeholder review to develop real world IMT feasibility.	• Approach for evaluation of IMTs developed and demonstrated • A packaged evaluation methodology that is readily useable and transferable	
Opportunities for implementation of IMTs will have been identified in NAP catchments	• Documentation of study procedures and project results. • Discussions with stakeholders	• Compile the results and conclusions of the study. • Presentation of study results to stakeholders • Determine best dissemination of study outcomes	• Reports that detail the results of the study for each site. • Wide dissemination of study outcomes • Presentation of feasibility reports to CMAs	

- *Set out a clear Program Management plan for your project. Include Project management structure and a 1 page CV for each Key Personnel.*

The organisational chart below shows the proposed project management structure. Mike Morris will have overall leadership of the project and will be responsible for development and implementation of the project communication strategy and for overall delivery of the project. Mark Reid will lead and be accountable for the delivery of the biophysical assessment components of the project. Similarly, Fiona Johnson will lead the socioeconomic, regulation and institutional constraints assessments component, while Bruce Gill will have responsibility for innovative management technology assessments.

Project Management Structure



CVs for these key staff are attached to this application.

The project proposes to engage specialists and consultants outside the core project team, where their specialist skills will add significant value. For example, preliminary discussions have been had with Phil Dyson and Associates, who in recent years, has had technical direction of the NDSP Salinity Tools Project and close involvement with the MDBC Catchment Characterisation Project and the OPUS project. We propose that governance for the appointment of contractors or consultants to the project would be through the project steering committee.

- *Describe the way forward as to how your project will be implemented and/or adopted for use by stakeholders.*

A key outcome of the project will be to enhance current knowledge of the potential of innovative management technologies. The project will provide a rigorous assessment of the potential for innovative management techniques on three selected sites in Victorian NAP catchments and will package the assessment methodology for more general use, enabling stakeholders to better assess options for salt affected areas within any catchment. A key factor in the success of the project will be excellent communication processes both during project execution and in the dissemination of project results.

- *Include a section on risk assessment and how risk is to be managed against each of the key project outcomes*

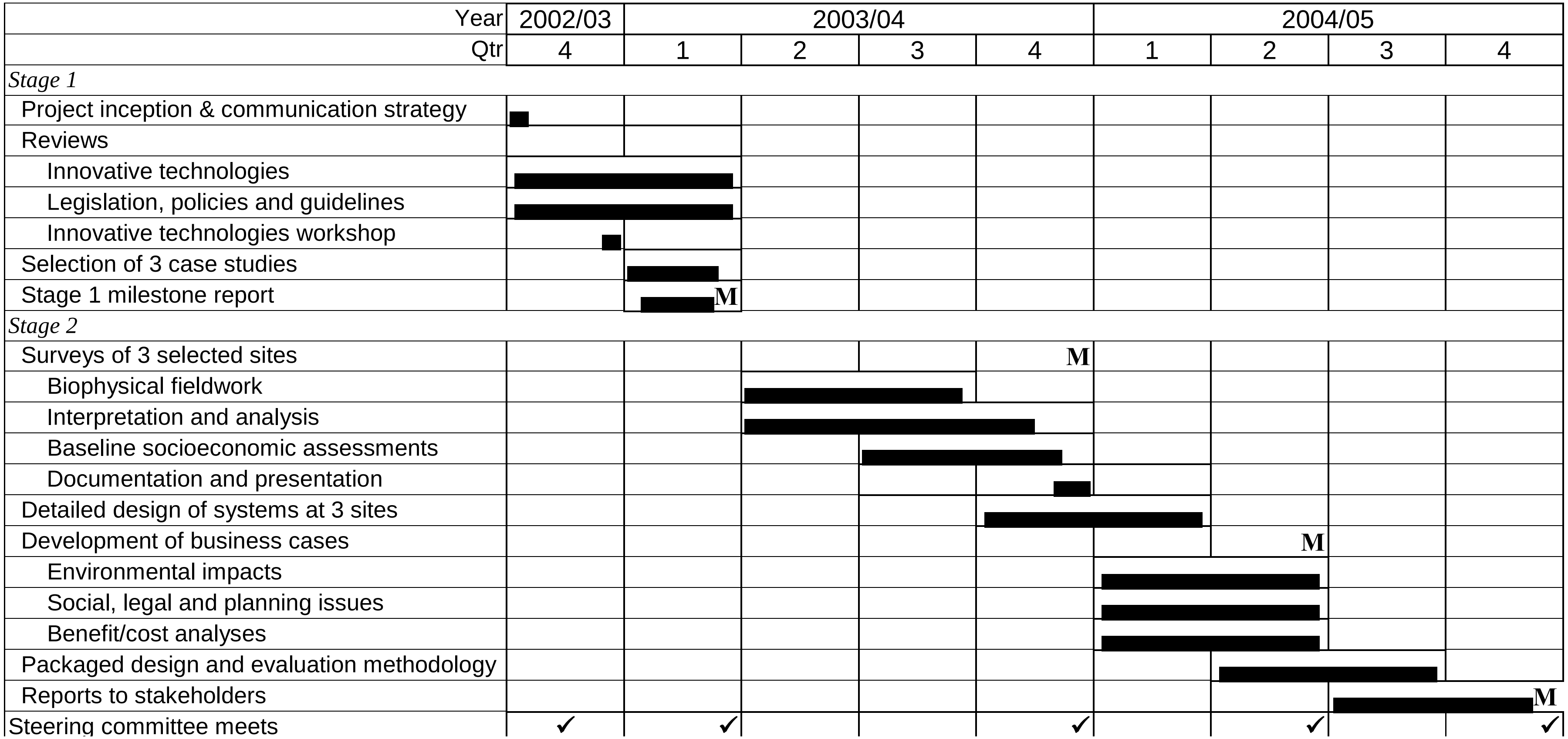
Key Project Outcome	Description of Risk	Likelihood	Consequence	Management Approach
Review of current IMTs and identification of potential implementation sites	• Available technologies are not well documented or field tested. • The range of potential implementation sites is too small. • The potential sites are impractical or unsuitable for engineering and groundwater re-use solutions.	Low	Project will not proceed further	Project is staged so that the consequence of failure in Stage 1 limits subsequent commitment to expenditure.
Prioritisation of potential sites and selection of three trial sites	• Stakeholder support for selected study sites not forthcoming	Low	Delay in selecting study sites; Delay to project	Ongoing involvement of stakeholders in project steering committee and regular communications.
Three sites biophysical studies, including field investigations	• Limited detail in existing site data. • Limited landholder support or even obstruction to proposed site study sites	Moderate	Increased field investigations. Reduced reliability in selection of IMTs	Selection of sites with good base data Involvement of stakeholders throughout site selection and assessment period.
Management system selection and design	• Specialists may not be available when required	Low	Delay to project completion	Maximise forewarning time of project input requirements.
Imparting and extending the knowledge of the project outcomes	• Key audience groups miss out on study findings	Low	Optimal implementation of IMTs knowledge will not be broadly disseminated.	Communications strategy developed at project inception Availability of project reports and outcomes on suitable web site (eg NDSP site).

***B* Project Costing and Timelines**: *(Indicate the total level per annum of human and financial resources required (financial to distinguish capital, operating, administration cost).*

- *Describe the projected timelines required to undertake and implement your submission and indicate any staging involved through to completion.*

The Gantt chart below provides an outline of the proposed project timelines. Stage 1 of the project will have 6 months duration, during which reviews of potential innovative technologies and of relevant legislation, policies and guidelines will be completed. A national innovative technologies workshop will be held during this review period. Stage 1 will conclude with the selection of 3 case study sites and presentation of a milestone report. A decision whether to proceed to Stage 2 can be made at this point.

Stage 2 of the project will involve data acquisition and detailed analyses of the 3 selected sites. A milestone at June 2004 will include completion of the acquisition, analysis and interpretation of data, and ratification of the innovative technology approach at each of the 3 sites by the project steering committee. The business case for each site will be completed by a milestone at December 2004, with completion and release of a packaged evaluation methodology and final report by June 2005.



Appendix 2 - Catchment Salinity Priority Maps

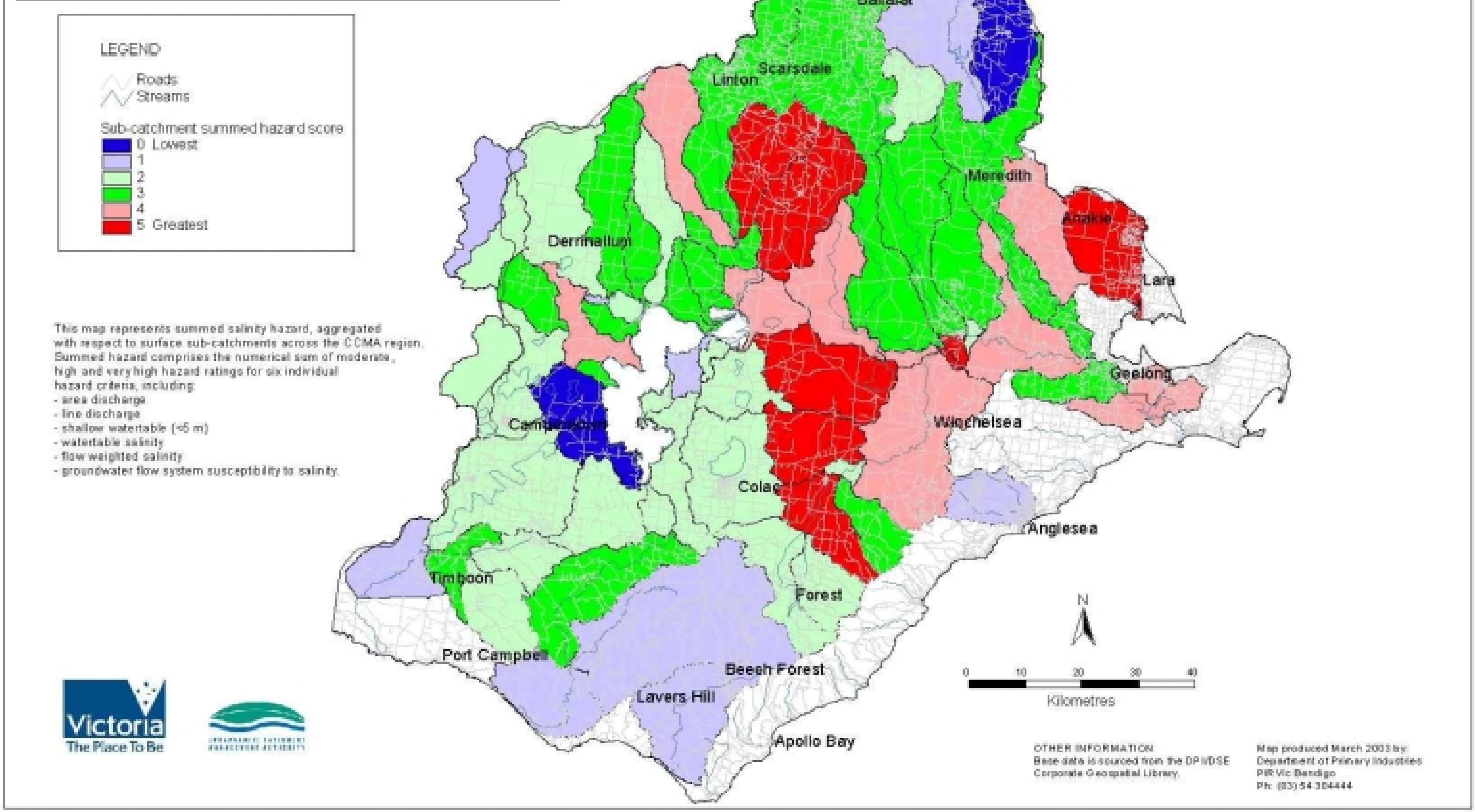
Figure A1 - North- Central CMA

Figure A2 - Corangamite CMA

Figure A3 - Glenelg - Hopkins CMA

Figure A1. North Central CMA. 10 Priority catchments
(taken from Karena, J. 2003)

Figure A2. Corangamite ICSRP Summed Salinity Hazard.
(from Heislers and Brewin, 2004)



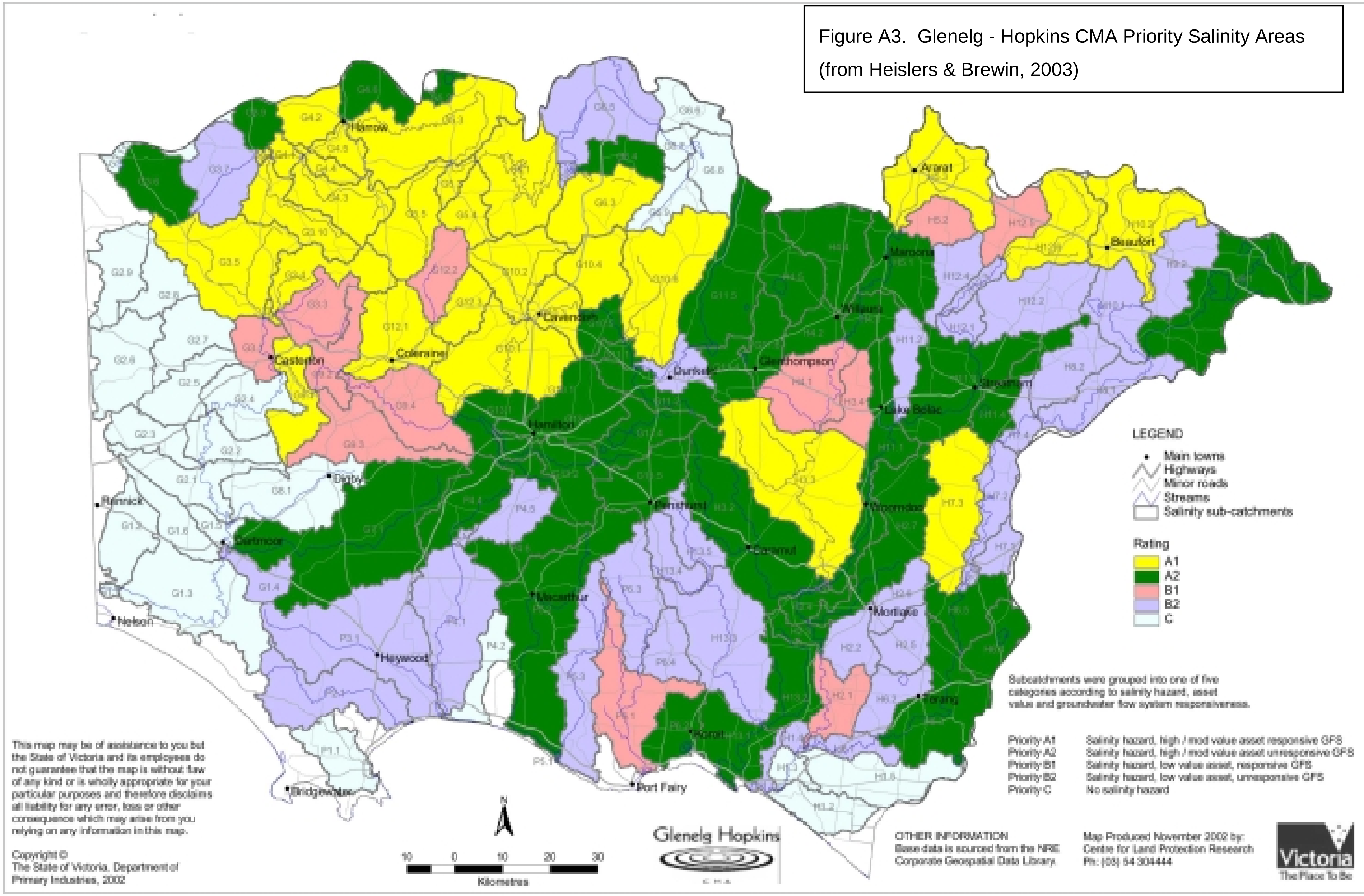


Figure A3. Glenelg - Hopkins CMA Priority Salinity Areas (from Heislers & Brewin, 2003)