



# Wimmera Regional Salinity Action Plan

2005 - 2010



Wimmera  
Catchment Management  
Authority

*Waterways for Life.*

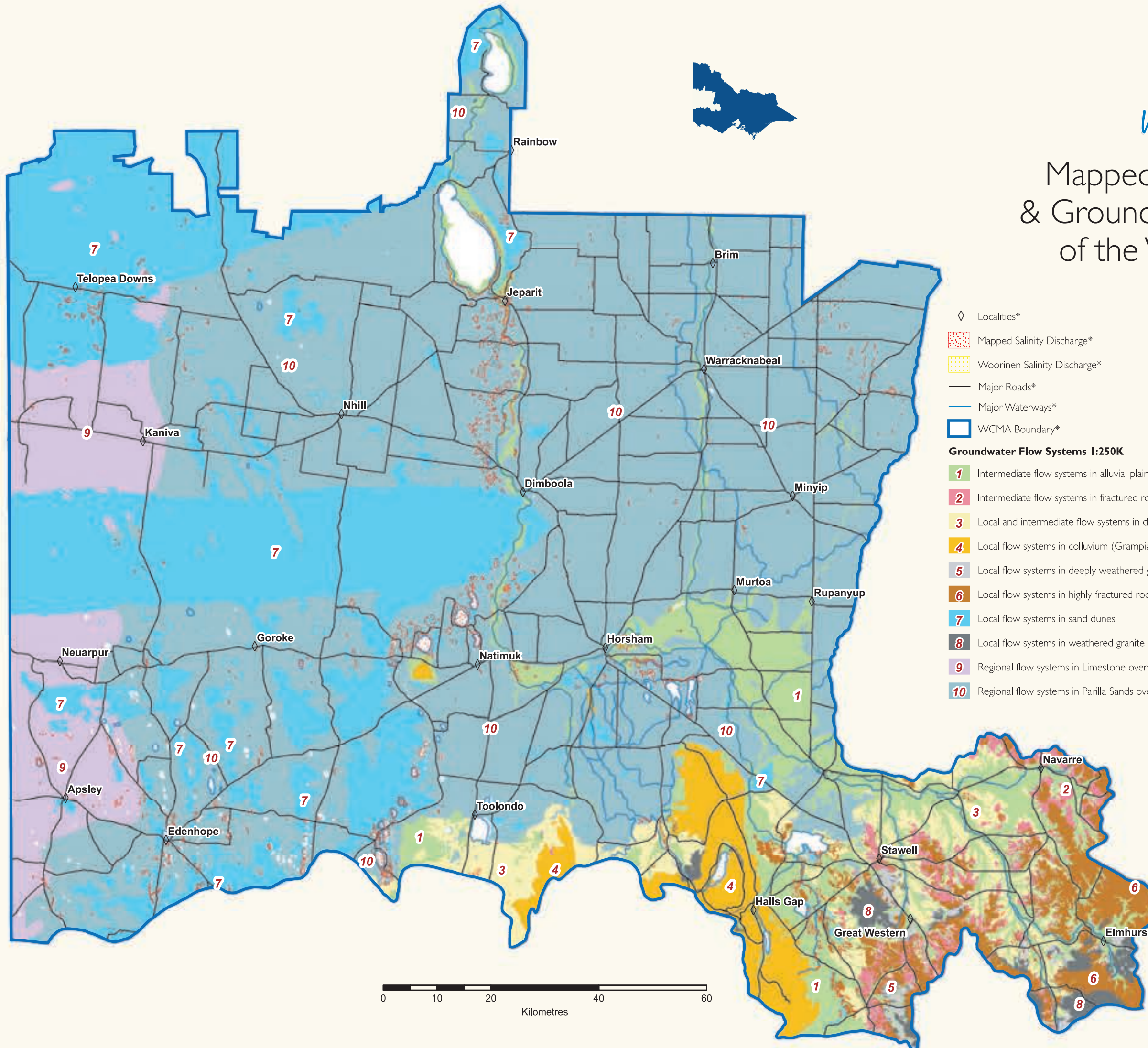


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# Mapped Salinity Discharge & Groundwater Flow Systems of the Wimmera Region



\* This data was obtained from the Department of Natural Resource and Environment's (NRE) Corporate Library Database.

Projection: Map Grid of Australia (Zone 54)  
Datum: GDA 1994

This map produced in February 2005  
by Wimmera CMA.

Wimmera CMA does not warrant that  
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Juanne Bourke  
Chair  
Wimmera CMA  
26 Darlot St  
**HORSHAM VIC 3400**

Q2 Ref: CS31/0015

Dear Ms Bourke,

**Endorsement of Wimmera Regional Salinity Action Plan**

It is with pleasure that I advise that the Government supports and endorses the Wimmera Regional Salinity Action Plan.

The process undertaken by Wimmera Catchment Management Authority and regional stakeholders in the development of the plan is to be commended. The Wimmera plan has demonstrated leadership in developing the use of groundwater flow systems to understand the processes of salinisation and for designing appropriate management actions.

I would like to commend the efforts of the Wimmera community in the development of this plan and I am sure this will be a positive step forward in the management of salinity in the region. I look forward to seeing the plan move into the implementation phase.

Yours sincerely

**JOHN TILVER MP  
Minister for Environment**



# WIMMERA REGIONAL SALINITY ACTION PLAN 2005

## Acknowledgments

This project has been funded by the National Action Plan for Salinity and Water Quality. This document was written by Brendan Madden of The Virtual Consulting Group and Phil Dyson of Phil Dyson and Associates with input from Wimmera Catchment Management Authority (CMA). The Wimmera CMA Project Manager was Mr Bernie Dunn, Land and Biodiversity Program Manager. Wimmera CMA is grateful for the assistance of the project steering committee in the development of the document. This group included representatives from:

- Department of Primary Industries
- Grampians Wimmera Mallee Water Authority
- Wimmera CMA Board
- Wimmera CMA Land Issues Functional Committee
- Sinclair Knight Merz

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## FOREWORD

In 2002 a steering group was formed to oversee the development of a Wimmera Regional Salinity Action Plan. This group consisted of representatives from Wimmera CMA, Land Issues Functional Committee, Department of Primary Industries, Department of Sustainability and Environment and Grampians Wimmera Mallee Water Authority.

The challenge in developing this salinity action plan for the Wimmera was to bring together the learnings and knowledge generated through three existing plans, combine this with the latest information and provide clear direction for investment in salinity management over the next five years.

Wimmera CMA engaged a team of consultants in September 2002 and they and the Project Steering Committee have since worked closely to develop this plan. The process has included:

- A review of all relevant background documentation.
- Field trip with the steering committee to examine existing initiatives and explore groundwater flow systems (GFSs) and processes in the catchment.
- Develop profiles of each of the GFSs.
- A series of workshops with key stakeholders and relevant staff to examine issues relating to Implementation, Research and Development and Monitoring.
- Prepare a draft plan for community consultation.
- Present draft plan to and discussion with Wimmera CMA Board and Land Issues Functional Committee.
- A rapid appraisal of the draft plan by the DSE state-wide salinity planning team.

The draft plan was available for public comment and consultation for a three-month period. There were seven targeted briefing and discussion sessions across the region as part of the consultation process.

The plan was reviewed in light of comments received by the Project Steering Committee.

The plan was then forwarded to DSE and the State Minister for Environment.

This plan will provide the framework to guide investment in salinity management in the Wimmera over the next five years. I commend this plan to you and encourage you to get involved in its implementation as we all have a role to play.



**Barry Hall**  
**Wimmera CMA Board Member**

# TABLE OF CONTENTS

## PART ONE - SALINITY IN THE WIMMERA REGION

<b>1.1</b>	<b>INTRODUCTION</b>
<b>1.1.1</b>	<b>Wimmera River Catchment</b>
<b>1.1.2</b>	<b>Millicent Coast Basin</b>
<b>1.1.3</b>	<b>Land Use</b>
<b>1.1.4</b>	<b>Population</b>
<b>1.2</b>	<b>SALINITY MANAGEMENT IN THE WIMMERA REGION</b>
<b>1.2.1</b>	<b>Wimmera Regional Catchment Strategy</b>
<b>1.2.2</b>	<b>Wimmera Catchment Salinity Management Plan</b>
1.2.2.1	Past Achievements
1.2.2.2	Key Challenges for the Future
<b>1.2.3</b>	<b>Wimmera Catchment Irrigation Area Salinity Management Strategy</b>
1.2.3.1	Overview
1.2.3.2	The Strategy
1.2.3.3	Review Recommendations
<b>1.2.4</b>	<b>West Wimmera Salinity Management Plan - Draft</b>
<b>1.2.5</b>	<b>Development of a Wimmera Region Salinity Action Plan</b>
<b>1.3</b>	<b>SOCIAL ISSUES AND SALINITY MANAGEMENT</b>
<b>1.3.1</b>	<b>Social Drivers and Natural Resource Management</b>
1.3.1.1	Issues/Values
1.3.1.2	Knowledge
1.3.1.3	Uptake of Programs and Current Recommended Practices
<b>1.3.2</b>	<b>Implications</b>
<b>1.4</b>	<b>SALINITY THREATS TO THE WIMMERA REGION</b>
<b>1.4.1</b>	<b>Agricultural Land</b>
1.4.1.1	Current Situation
1.4.1.2	Future Projections
<b>1.4.2</b>	<b>Infrastructure</b>
1.4.2.1	Road, Rail and Transmission Lines
<b>1.4.3</b>	<b>Wimmera River</b>
1.4.3.1	Water Quality
1.4.3.2	Salt Loads
<b>1.4.4</b>	<b>Wimmera Mallee Pipeline Project</b>
<b>1.4.5</b>	<b>Flora and Fauna</b>
<b>1.4.6</b>	<b>Wetlands of the Region</b>
<b>1.4.7</b>	<b>Ecological Vegetation Classes</b>
<b>1.4.8</b>	<b>Impacts of Salinity Management Options upon Flora and Fauna</b>
<b>1.4.9</b>	<b>Impacts Outside the Wimmera Region</b>
<b>1.5</b>	<b>THE FUTURE WITHOUT A PLAN</b>
<b>1.5.1</b>	<b>Environmental Losses</b>
<b>1.5.2</b>	<b>Lost Agricultural Production</b>
<b>1.5.3</b>	<b>Infrastructure Losses</b>

## PART TWO - GROUNDWATER FLOW SYSTEMS IN THE WIMMERA REGION

<b>2.1</b>	<b>GROUNDWATER FLOW SYSTEMS</b>
<b>2.1.1</b>	<b>Introduction</b>
<b>2.1.2</b>	<b>Scales of GFS</b>
2.1.2.1	Salinity Management Triage
<b>2.1.3</b>	<b>Salinity Management Options</b>
<b>2.2</b>	<b>REGIONAL FLOW SYSTEMS IN THE PARILLA SANDS</b>
<b>2.2.1</b>	<b>Overview</b>
<b>2.2.2</b>	<b>Salinity Processes</b>
<b>2.2.3</b>	<b>Impacts Outside the Wimmera Region</b>
<b>2.2.4</b>	<b>Asset Threats</b>
<b>2.2.5</b>	<b>Management Options</b>
2.2.5.1	Biological
2.2.5.2	Engineering
2.2.5.3	Living with Salinity

<b>2.2.6</b>	<b>Management Recommendations</b>
2.2.6.1	Implementation Opportunities
2.2.6.2	Research and Development Recommendations
<b>2.2.7</b>	<b>Irrigation in the Wimmera</b>
2.2.7.1	Overview
2.2.7.2	Irrigation Salinity Management
2.2.7.3	Management Recommendations
<b>2.3</b>	<b>REGIONAL FLOW SYSTEMS IN LIMESTONE</b>
<b>2.3.1</b>	<b>Overview</b>
<b>2.3.2</b>	<b>Salinity Processes</b>
<b>2.3.3</b>	<b>Asset Threats</b>
<b>2.3.4</b>	<b>Management Options</b>
<b>2.3.5</b>	<b>West Wimmera Bore Decommissioning</b>
<b>2.3.6</b>	<b>Management Recommendations</b>
<b>2.4</b>	<b>LOCAL FLOW SYSTEMS IN WOORINEN FORMATION</b>
<b>2.4.1</b>	<b>Overview</b>
<b>2.4.2</b>	<b>Salinity Process</b>
<b>2.4.3</b>	<b>Asset Threats</b>
<b>2.4.4</b>	<b>Management Options</b>
2.4.4.1	Biological
2.4.4.2	Engineering
2.4.4.3	Living With Salinity
<b>2.4.5</b>	<b>Management Recommendations</b>
2.4.5.1	Implementation Opportunities
2.4.5.2	Research and Development Recommendations
<b>2.5</b>	<b>LOCAL FLOW SYSTEMS IN SAND DUNES (LOWAN FORMATION)</b>
<b>2.5.1</b>	<b>Overview</b>
<b>2.5.2</b>	<b>Salinity Processes</b>
<b>2.5.3</b>	<b>Asset Threats</b>
<b>2.5.4</b>	<b>Management Options</b>
2.5.4.1	Biological
2.5.4.2	Engineering
2.5.4.3	Living With Salinity
<b>2.5.5</b>	<b>Management Recommendations</b>
2.5.5.1	Implementation Opportunities
2.5.5.1.1	<i>Northern Section</i>
2.5.5.1.2	<i>Southern Section</i>
2.5.5.2	Research and Development Recommendations
<b>2.6</b>	<b>LOCAL FLOW SYSTEMS IN WEATHERED GRANITES (HIGH RELIEF)</b>
<b>2.6.1</b>	<b>Overview</b>
<b>2.6.2</b>	<b>Salinity Processes</b>
<b>2.6.3</b>	<b>Asset Threats</b>
<b>2.6.4</b>	<b>Management Options</b>
2.6.4.1	Biological
2.6.4.2	Engineering
2.6.4.3	Living With Salinity
<b>2.6.5</b>	<b>Management Recommendations</b>
2.6.5.1	Implementation Opportunities
2.6.5.2	Research and Development Recommendations
<b>2.7</b>	<b>LOCAL FLOW SYSTEMS IN DEEPLY WEATHERED GRANITE (LOW RELIEF)</b>
<b>2.7.1</b>	<b>Overview</b>
<b>2.7.2</b>	<b>Salinity Processes</b>
<b>2.7.3</b>	<b>Asset Threats</b>
<b>2.7.4</b>	<b>Management Options</b>
2.7.4.1	Biological
2.7.4.2	Engineering
2.7.4.3	Living with Salinity

## TABLE OF CONTENTS

<b>2.7.5</b>	<b>Management Recommendations</b>
2.7.5.1	Implementation Opportunities
2.7.5.2	Research and Development Recommendations
<b>2.8</b>	<b>LOCAL FLOW SYSTEMS IN HIGHLY FRACTURED ROCKS</b>
<b>2.8.1</b>	<b>Overview</b>
<b>2.8.2</b>	<b>Salinity Processes</b>
<b>2.8.3</b>	<b>Asset Threats</b>
<b>2.8.4</b>	<b>Management Options</b>
2.8.4.1	Biological
2.8.4.2	Engineering
2.8.4.3	Living With Salinity
<b>2.8.5</b>	<b>Management Recommendations</b>
2.8.5.1	Implementation Opportunities
2.8.5.2	Research and Development Recommendations
<b>2.9</b>	<b>INTERMEDIATE GROUNDWATER FLOW SYSTEMS IN FRACTURED ROCKS</b>
<b>2.9.1</b>	<b>Overview</b>
<b>2.9.2</b>	<b>Salinity Processes</b>
<b>2.9.3</b>	<b>Asset Threats</b>
<b>2.9.4</b>	<b>Management Options</b>
2.9.4.1	Biological
2.9.4.2	Engineering
2.9.4.3	Living With Salinity
<b>2.9.5</b>	<b>Management Recommendations</b>
2.9.5.1	Implementation Opportunities
<b>2.10</b>	<b>LOCAL AND INTERMEDIATE SYSTEMS IN DEEPLY WEATHERED FRACTURED ROCKS</b>
<b>2.10.1</b>	<b>Overview</b>
<b>2.10.2</b>	<b>Salinity Processes</b>
<b>2.10.3</b>	<b>Asset Threats</b>
<b>2.10.4</b>	<b>Management Options</b>
2.10.4.1	Biological
2.10.4.2	Engineering
2.10.4.3	Living With Salinity
<b>2.10.5</b>	<b>Management Recommendations</b>
2.10.5.1	Implementation Opportunities
2.10.5.2	Research and Development Recommendations
<b>2.11</b>	<b>INTERMEDIATE FLOW SYSTEMS IN ALLUVIAL PLAINS</b>
<b>2.11.1</b>	<b>Overview</b>
<b>2.11.2</b>	<b>Salinity Processes</b>
<b>2.11.3</b>	<b>Asset Threats</b>
<b>2.11.4</b>	<b>Management Options</b>
2.11.4.1	Biological
2.11.4.2	Engineering
2.11.4.3	Living With Salinity
<b>2.11.5</b>	<b>Management Recommendations</b>
2.11.5.1	Research and Development Recommendations
<b>2.12</b>	<b>LOCAL FLOW SYSTEMS IN COLLUVIUM (GRAMPIANS SANDSTONE)</b>
<b>2.12.1</b>	<b>Overview</b>
<b>2.12.2</b>	<b>Salinity Processes</b>
<b>2.12.3</b>	<b>Asset Threats</b>
<b>2.12.4</b>	<b>Management Options</b>
2.12.4.1	Biological
2.12.4.2	Engineering
2.12.4.3	Living With Salinity
<b>2.12.5</b>	<b>Management Recommendations</b>
2.12.5.1	Research and Development Recommendations

## **PART THREE: THE FIVE YEAR ACTION PLAN**

### **3.1 VISION**

#### **3.1.1 Introduction**

#### **3.1.2 Streams of the Wimmera River Basin**

#### **3.1.3 Terminal Lakes**

#### **3.1.4 Wetlands and Streams of the Millicent Coast Basin**

#### **3.1.5 Agricultural Land**

#### **3.1.6 Remnant Vegetation**

#### **3.1.7 Groundwater**

### **3.2 INVESTMENT CLASSIFICATION OF GROUNDWATER FLOW SYSTEMS**

#### **3.2.1 Investment Classification Framework**

3.2.1.1 Groundwater Flow System Characteristics

3.2.1.2 Investment Classifications

### **3.3 HOW IS IT ALL GOING TO HAPPEN?**

#### **3.3.1 Management Arrangements**

3.3.1.1 Current Arrangements

3.3.1.2 Future Management Model

#### **3.3.2 Implementation Strategy**

3.3.2.1 Implementation Principals

3.3.2.2 Proposed Implementation Initiatives and Resources

#### **3.3.3 Incentive Rates**

#### **3.3.4 Additional Incentives Required for Salinity Management**

3.3.4.1 Perennial Plant Establishment

#### **3.3.5 Research and Development Needs**

3.3.5.1 GFS Knowledge Gaps and Research and Development Needs

3.3.5.2 Priority Research and Development Needs

3.3.5.3 Landcare Processes at Catchment/Groundwater Flow System Level

3.3.5.3.1 *Mount William Creek Catchment*

3.3.5.3.2 *Local Flow Systems in Low Relief Granites (deeply weathered)*

3.3.5.3.3 *Local Flow Systems in Deeply Weathered Fractured Sedimentary Rock*

3.3.5.3.4 *Sub-regional Flow Systems in Upland Alluvium*

#### **3.3.6 Catchment Salt and Water Balances**

#### **3.3.7 Biological Manipulation of Water Balance of Catchments**

3.3.7.1 Lucerne and Other Introduced Perennial Plants

3.3.7.2 Native Grasses

3.3.7.3 Engineering Options to Protect Assets

3.3.7.4 Productive Use

#### **3.3.8 Monitoring and Evaluation**

3.3.8.1 Monitoring Principals

3.3.8.2 Evaluation Principals

3.3.8.3 Bore Monitoring Network

3.3.8.3.1 *Lower Wimmera*

3.3.8.3.2 *Upper Wimmera*

3.3.8.3.3 *Millicent Coast Basin*

3.3.8.4 Monitoring Within Groundwater Flow Systems

3.3.8.5 Surface Water Monitoring

3.3.8.5.1 *Continuous Flow and Salinity Recorders*

3.3.8.5.2 *Capacity to Inform Salinity Mitigation*

3.3.8.5.3 *Millicent Coast*

### **3.4 SALINITY ACTION PLAN TARGETS**

#### **3.4.1 Public Investment Requirements**

### **3.5 COST-BENEFIT ANALYSIS**

#### **3.5.1 Quantifiable Costs**

#### **3.5.2 Quantifiable Benefits**

#### **3.5.3 Quantifiable Cost-Benefit Analysis**



# TABLE OF CONTENTS

## REFERENCES

Wimmera Salinity Research, Investigations and Monitoring Bibliography  
Glossary of Terms

## FIGURES

Figure 1	The Wimmera Catchment Management Region
Figure 2	The Wimmera RCS Structure and Linkages to State and Basin Initiatives
Figure 3	Annual Salt Load and Distribution in the Wimmera Catchment
Figure 4	Groundwater Flow Systems of Australia
Figure 5	Groundwater Flow System of the Murray Darling Basin
Figure 6	Cross-section of the Regional Flow System in Parilla Sands
Figure 7	Cross-section of the Regional Flow System in Parilla Sands in Edenhope Area
Figure 8	Windmill Trial of Groundwater Pumping of the Regional Flow System in Parilla Sands
Figure 9	Cross-section of the Murray Group Limestone in West Wimmera
Figure 10	Representation of Corroded and Successfully Decommissioned Bores
Figure 11	Cross-section of a Local Flow System in the Woorinen Formation
Figure 12	Cross-section of a Local Flow System in Sand Dunes (Lowan Formation)
Figure 13	A Clay Borrow Pit Showing the Lowan Sand over the Weathered Surface of the Parilla
Figure 14	A Local Saline Discharge Site in the Lowan Formation Groundwater Flow System
Figure 15	Cross-section of a Local Flow System Weathered Granite (High Relief)
Figure 16	A Solar Pump Installed in High Relief Granite Terrain at Langi Ghiran
Figure 17	Cross-section of a Local Flow System in Deeply Weathered Granite (Low Relief)
Figure 18	Cross-section of a Local Flow System in Fractured Rock
Figure 19	Cross-section of an Intermediate Flow System in Fractured Rocks
Figure 20	Cross-section of a Local Flow System in Deeply Weathered Fractured Rock
Figure 21	Cross-section of an Intermediate Flow System in Alluvial Plains
Figure 22	Cross-section of a Local Flow System in Colluvium

## TABLES

Table 1	Land Use in the Wimmera Region
Table 2	Population of Local Government Area in the Wimmera Region
Table 3	Area of Land Affected by Salinity in the Wimmera
Table 4	Infrastructure Affected by Salinity in the Wimmera
Table 5	Current and Predicted Stream Salinity Levels
Table 6	Mass of Salt Generated/Imported in the Wimmera Catchment
Table 7	Destiny of Salt Loads in the Wimmera Catchment
Table 8	Expected Water Savings from the Northern Mallee and Wimmera Mallee Pipelines
Table 9	Estimated Cost of Agricultural Production Lost as a Result of Salinity in the Wimmera
Table 10	Annual Non-agricultural Costs of Dryland Salinity in the Wimmera
Table 11	Snapshot of the Regional Flow System in Parilla Sands
Table 12	Management Recommendations to Minimise the Impacts of Salinity on the Regional Flow System in Parilla Sands
Table 13	Management Rec. to Minimise the Impacts of Salinity on the Regional Flow System in Parilla Sands in Edenhope Area
Table 14	Management Recommendations to 471 High-priority Bores
Table 15	Rec. Management Options to Achieve a 50% Reduction in Recharge for the Woorinen Groundwater Flow System
Table 16	Snapshot of the Local Flow Systems in Sand Dunes (Lowan Formation)
Table 17	Management Recommendations to Achieve a 50% Reduction in Recharge for Local Flow Systems in Sand Dunes
Table 18	Snapshot of the Local Flow Systems in Weathered Granite (High Relief)
Table 19	Management Recommendations for Local Flow Systems in Weathered Granite (High Relief)
Table 20	Snapshot of the Local Flow Systems in Deeply Weathered Granites (Low Relief)
Table 21	Management Recommendations for Local Flow Systems in Deeply Weathered Granites (Low Relief)
Table 22	Snapshot of the Local Fractured Rock Groundwater Flow Systems
Table 23	Management Recommendations for Local Fractured Rock Groundwater Flow System
Table 24	Snapshot of the Intermediate Fractured Rock Groundwater Flow Systems
Table 25	Management Recommendations for Intermediate Groundwater Flow System in Fractured Rocks
Table 26	Snapshot of the Local and Intermediate Flow Systems in Deeply Weathered Fractured Rocks
Table 27	Management Rec. for Local and Intermediate Groundwater Flow Systems in Deeply Weathered Fractured Rocks
Table 28	Snapshot of the Intermediate Groundwater Flow System in Alluvial Plains
Table 29	Management Recommendations for Intermediate Groundwater Flow System in Alluvial Plains
Table 30	Snapshot of the Local Flow Systems in Colluvium (Grampians Sandstone)

Table 31	Management Recommendations for Local Flow Systems in Colluvium Groundwater Flow Systems
Table 32	Investment Classification of Wimmera Region Groundwater Flow Systems
Table 33	Assessment of the Characteristics and Priority Levels of Groundwater Flow Systems in the Wimmera
Table 34	Indicative Technical Support Resources Required to Undertake Proposed Implementation Activities
Table 35	Indicative Five Year Grant/Works Budget Required to Undertake Proposed Implementation Activities
Table 36	Proposed Implementation Initiatives for each Groundwater Flow System
Table 37	Regional Catchment Strategy Incentive Rates (July 2004)
Table 38	Assessment of Groundwater Flow System Knowledge Gaps, R & D Needs and Potential Research Partners
Table 39	Region-wide Research and Development Needs
Table 40	Groundwater Monitoring - Wimmera Region
Table 41	Bore Location by Aquifer and Groundwater Flow System - Wimmera Region
Table 42	Extra Monitoring Infrastructure Required
Table 43	NRM and Works Targets for the Implementation of the Wimmera Regional Salinity Action Plan
Table 44	Indicative Annual Public Investment Required to Implement Proposed Five-year Program of Activities
Table 45	Quantifiable Benefits and Costs of Implementing the Wimmera Regional Salinity Action Plan

## ABBREVIATIONS

BOS	Break Of Slope
BRS	Bureau of Rural Sciences
CMA	Catchment Management Authority
COAG	Council of Australian Governments
CRC	Cooperative Research Centre
CRC LEME	Cooperative Research Centre for Landscape Environments and Mineral Exploration
CRC PBMDs	Cooperative Research Centre for Plant-based Management of Dryland Salinity
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DPI	Department of Primary Industries
DSE	Department of Sustainability and Environment
EC	Electrical Conductivity
EMS	Environmental Management System
EVC	Ecological Vegetation Class
GFS	Groundwater Flow System
GFSs	Groundwater Flow Systems
GRDC	Grains Research and Development Corporation
ha	Hectare
km	Kilometre
MDBC	Murray Darling Basin Commission
ML	Megalitre
mm	Millimetres
NAP	National Action Plan for Salinity and Water Quality
NDSP	National Dryland Salinity Program
NLP	National Landcare Program
NHT	Natural Heritage Trust
NLWRA	National Land and Water Resources Audit
NRM	Natural Resource Management
%	Percent
R&D	Research and Development
RIRDC	Rural Industries Research and Development Corporation
SKM	Sinclair Knight Merz
WFP	Whole Farm Plan
mS/cm	Milli Siemens per centimetre
PMP	Property Management Plan

I.1 INTRODUCTION

The Wimmera Region covers about 2,350,000 ha of central western Victoria including the Wimmera River Catchment and part of the Millicent Coast Basin adjacent to the South Australian border (Figure 1).

I.1.1 WIMMERA RIVER CATCHMENT

The Wimmera River Catchment forms the south-west part of the Murray Darling Basin. It is a landlocked catchment with the Wimmera River and tributaries draining from the Mt Cole/Pyrenees Ranges in the south east and the Grampians in the south to the terminal lakes of Hindmarsh and Albacutya and the Wyperfeld floodplains in the north. The Wimmera River is the largest inland waterway in Victoria and the section downstream from Polkemmet Bridge is listed under the Victorian Heritage Rivers Act 1992. The majority of flows in the Wimmera system are harvested for town and stock and domestic use.

I.1.2 MILLICENT COAST BASIN

The Victorian portion of the Millicent Coast Basin comprises an area of about 1.4 million hectares and contains over 3000 wetlands, accounting for about 25% of Victoria's individual wetlands. Wetland types include freshwater meadows, shallow and deep freshwater marshes, permanent open freshwater wetlands and semi-permanent saline and permanent saline wetlands.

I.1.3 LAND USE

Since settlement in the 1850s, 85% of the region has been cleared for agricultural production, with only 1% of native vegetation on private land and the remaining 14% native vegetation in National, State or Regional Parks, State Forests and public reserves. Agriculture is the main land use in the region with approximately 2200 farms generating \$560 million of production during the 1996/97 season.<sup>1</sup>

TABLE 1: LAND USE IN THE WIMMERA REGION. <sup>2</sup>	
Land Use	% of Region
Dryland Cropping	50
Sheep Wool	26
Sheep Meat	17
Beef	4
Other	3
Total	100%

The region's agriculture is dominated by broadacre land uses. Dryland cropping is the major agricultural enterprise in the region, accounting for 50% of all agricultural land use, while dryland pasture for sheep wool and meat production accounts for a further 43%. A diverse range of activities including beef, viticulture, dairying and horticulture accounts for a small proportion of land use in the region.

<sup>1</sup> ABS 1997

I.1.4 POPULATION

The region has a population of over 50,000 people. About 70% of the population lives in urban centres of Horsham, Stawell, Nhill, Dimboola and Warracknabeal while the remaining 30% reside on farms or in the smaller regional communities (TBA Planners 1998).

TABLE 2: POPULATION OF LOCAL GOVERNMENT AREA IN THE WIMMERA	
Shire	Population (2001)
Hindmarsh	6,523
Yarriambiack	8,262
Northern Grampians	13,110
West Wimmera	4,860
Horsham Rural City	18,584
Total <sup>3</sup>	51,339

Note: The Wimmera CMA Region also includes parts of Ararat and Pyrenees municipalities

I.2 SALINITY MANAGEMENT IN THE WIMMERA REGION

I.2.1 WIMMERA REGIONAL CATCHMENT STRATEGY

Salinity is addressed as part of the Wimmera Regional Catchment Strategy (RCS); the overarching strategy for the region that provides direction for natural resource management (NRM) in the Wimmera from 2003 until 2008. The RCS brings together the actions of various other plans such as the Wimmera Regional Salinity Action Plan and prioritises them; forming a prospectus for investment from the Victorian and Commonwealth Governments to protect the Wimmera's assets. Figure 2 outlines the links between the Wimmera RCS and local, regional, state and Murray Darling Basin plans. The RCS also links the Wimmera Regional Salinity Action Plan and provides framework to deal with issues that impair landholder capacity to implement recommended actions such as problem wildlife. Over the past 10 years there has been three separate plans dealing with salinity management in the Wimmera Region.

- The Wimmera Catchment Salinity Management Plan developed in 1992 and implemented from 1992 to 2002.
- The Wimmera Catchment Irrigation Area Salinity Management Strategy, 1995.
- Draft West Wimmera Salinity Management Strategy released in 2001.

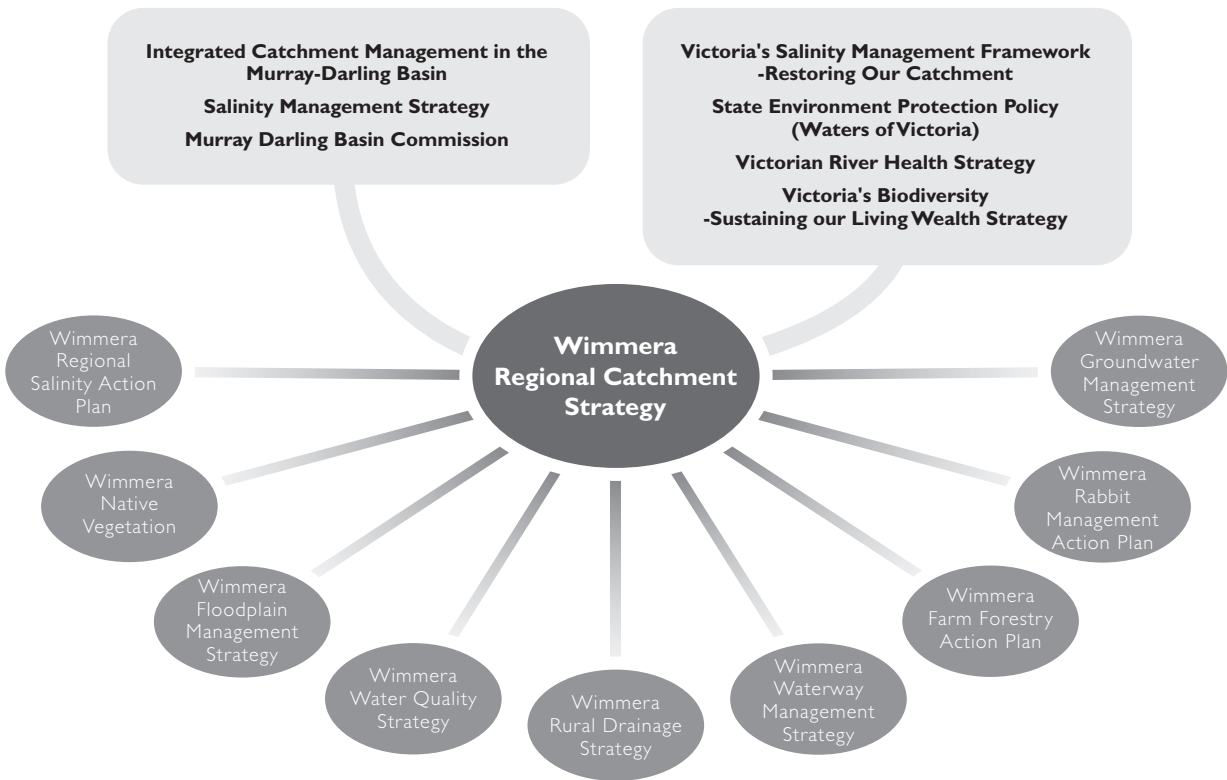
<sup>2</sup> Developed from data collected from the "Understanding the social drivers of catchment management in the Wimmera region" study.  
<sup>3</sup> Excluding the parts of the Ararat Rural City and Pyrenees Shire which are in the Wimmera region



FIGURE 1: THE WIMMERA CATCHMENT MANAGEMENT REGION



FIGURE 2:THE WIMMERA RCS STRUCTURE AND LINKAGES TO STATE AND BASIN INITIATIVES



1.2.2 WIMMERA CATCHMENT SALINITY MANAGEMENT PLAN

The Wimmera Catchment Salinity Management Plan (excluding the West Wimmera area) was initially released for public discussion in November 1992. The Victorian Government provided its response to the plan in May 1994. The main objective of the plan as endorsed by the Government was:

- To improve water quality and protect the agricultural, environmental and social values of the catchment by:
  - Increasing community awareness and understanding of the salinity control measures;
  - Implementing improved land and water management practices; and
  - Reclaiming salt affected areas.

The plan was developed by a Wimmera Catchment Co-ordinating Group with help from state agencies. Implementation was overseen by a Salinity Implementation Group until 1997. The plan was then managed on behalf of the Wimmera community by Wimmera CMA. The CMA provided overall co-ordination of salinity management in the catchment, set the strategic direction and supported the Land Issues Functional Committee (FC). The Land Issues FC monitored project implementation and approved new projects against priorities of the plan. The Catchment and Agricultural Services (CAS) division of the Department of Natural Resources and Environment (NRE) was the major provider of technical and extension services to support implementation of the plan. Research, investigations, monitoring and reporting services were provided by the Centre for Land Protection Research, NRE Bendigo and Sinclair Knight Merz through a Government Services Contract administered by Grampians Wimmera Mallee Water Authority.

1.2.2.1 Past Achievements

A review of the implementation of the Wimmera Catchment Salinity Management Plan in 2001 highlighted a number of significant achievements including:

- Early recognition of the importance of the impact of salinity on water quality and biodiversity issues;
- Significant improvement in community awareness of salinity issues and the impact on water quality as a result of extension and communication activities including school programs and Waterwatch;
- Development of a good regional knowledge base on the current extent of salinity and the processes affecting salinity in various parts of the catchment. Much of this has been achieved through the catchment's research and development (R&D) program including a Paired Catchment Study, Groundwater Trends Report, Groundwater Pumping Trials and Rhymney Hill revegetation project;
- Implementation and promotion of a range of revegetation activities including the establishment of 52,891 ha of perennial plants (124% of the 2000 target), 5000 ha of trees (89% of the 2000 target) and 5439 ha of lucerne (56% of the 2000 target);
- Adoption of improved crop management across 234,000 ha (130% of the 2000 target); and
- Development of 294 whole farm plans (WFP) (78% of the 2000 target).

### 1.2.2.2 Key Challenges for the Future

The review also highlighted a number of challenges to be addressed in developing a future salinity management plan for the region.

These include:

#### a) Awareness

While community awareness of salinity has improved dramatically during implementation of the plan, the community is not fully aware of the new knowledge of GFSs and the impact they have on major environmental, infrastructure and agricultural assets. Communication activities will need to focus on relating GFSs to their impact on assets.

#### b) Knowledge

- There is limited confidence in estimates of the area of land at risk to salinity in the future. Clarification of the potential risk using new digital elevation modelling techniques in conjunction with existing 1:25 000 discharge mapping and groundwater trends is a priority.
- Understanding the hydrological and hydrogeological processes in the catchment has improved rapidly; however, further modelling is required to investigate groundwater responses to various management options. The suite of management options for various parts of the catchment will need to be extended and refined on the basis of such modelling.
- Further investigations of groundwater pumping and other engineering options will be necessary to allow for specific interventions to protect some key assets.
- While there is good technical knowledge of many of the individual management options, there is limited understanding of how these options best fit within farming systems. Farm-systems research and modelling will be required to develop solutions that are practical at a farm level.
- Current Wimmera farming systems based on annual crops and pastures do not utilise available rainfall, especially large episodic recharge events.

#### c) Attitude

The review highlighted that the lack of information available on the drivers of community attitude limits the ability to tailor implementation programs. To address this issue, Wimmera CMA commissioned Charles Sturt University in 2001 to undertake a comprehensive social research project to develop a better understanding of attitudes, perceptions and the drivers for change.

#### d) Skills and Information

- It is increasingly difficult to encourage farmers to participate in WFP courses. Design of a new methodology, including linkages to quality assurance programs and other potential incentives, and improved marketing will be required to improve farmer participation in the future. A review of WFP in the region is currently underway and will provide future recommendations for the use of this particular tool/mechanism.
- Implementation of management options in the future will require skills in analysing farming systems and business planning to maximise economic outcomes.
- There is limited information available on the potential of

productive uses of saline resources in the catchment, which is limiting the community's capacity to adopt such options.

- There is limited understanding of the environmental and biodiversity assets and the processes which are threatening these assets.
- Without reliable quantification of the value of the environmental assets at risk it will continue to be difficult to justify significant investment in salinity management. A review of previous approaches to environmental valuation and development of a suitable approach for the Wimmera Catchment is required.

#### e) Resources

- Where implementation of salinity management options provides significant environmental services to the community, payments should be made available to farmers to encourage adoption of such options. This will require a clear understanding of the services the community wants.
- Although the present system of monitoring is adequate in many areas, it does not allow for adequate reporting of the extent of changes in salinity status over time. Nor does it attempt to target works and measure the impact of these works against natural resource indicator targets.

## 1.2.3 WIMMERA CATCHMENT IRRIGATION AREA SALINITY MANAGEMENT STRATEGY

### 1.2.3.1 Overview

Grampians Wimmera Mallee Water Authority supplies irrigation water to 250 irrigators who irrigate approximately 3000 ha of land in three main districts:

- Quantong - west of Horsham and north of the Wimmera River
- Riverside/Drung/Haven - south east of Horsham and south of the Wimmera River
- Murtoa/Coromby - around Murtoa

These areas are located over the regional Parilla GFS.

### 1.2.3.2 The Strategy

The objective of the Wimmera Irrigation Area Salinity Management Strategy was to "provide directions for the sustainable use of land and water resources, and the protection of the agricultural, environmental, and social values of the Wimmera Irrigation Area". It specifically aimed to:

- Improve the understanding of the physical features and processes occurring in the irrigation area and establishing base information for future initiatives;
- Improve skills of land and water managers; and
- Improve physical layout and operation of the irrigation areas.



### 1.2.3.3 Review Recommendations

While the review of Wimmera Catchment Irrigation Area Salinity Management Strategy noted significant achievements of the strategy it concluded that:

*It is unlikely that any major changes to the salinity status of the Wimmera irrigation area, either positive or negative, are going to occur without major changes in land use and irrigation management.*

To help the change in land use and irrigation management, the review recommended four main future directions:

- Regional development - promote a Land Capability study, encouraging transfer of water out of the Wimmera River trench and, adopting high-value crops and new technology.
- Monitoring and Investigation - further monitoring and investigations under normal seasonal conditions and allocations to determine current land use, impact on groundwater systems and groundwater levels.
- Drainage - encourage the use of re-use systems.
- Ongoing help including revegetation works, channel seepage works, salinity mapping and assistance to landholders.

### 1.2.4 WEST WIMMERA SALINITY MANAGEMENT PLAN - DRAFT

In June 2001 a draft West Wimmera Salinity Management Strategy was prepared under the guidance of a working group comprising landholder representatives from across the West Wimmera and agency representatives from that region.

Three priority areas were identified within West Wimmera; Mosquito Creek Catchment, Edenhope district and Telopea Downs district. The strategy identified nine programs to deal with salinity issues and included research, monitoring, environmental, forestry, pastures, cropping, saline resources, water management and implementation.

The draft strategy recognised the need to better understand salinity processes and trends; for the community and landholders to be fully informed about salinity; and the many resource, social and economic challenges of dealing with salinity in a large, sparsely-populated area.

### 1.2.5 DEVELOPMENT OF A WIMMERA REGION SALINITY ACTION PLAN

In 2002 a steering group was formed to oversee development of a Wimmera Region Salinity Action Plan. This group consisted of representatives from:

- Wimmera CMA
- Land Issues FC
- DPI
- DSE
- Grampians Wimmera Mallee Water
- Victorian Institute for Dryland Agriculture

The Project Steering Committee engaged a team of consultants in September 2002 and have since worked closely with them to develop this plan.

The challenge was to bring together the learnings and knowledge generated through the three existing plans and combine this with the latest information from relevant state and federal initiatives to form a salinity action plan for the Wimmera. The process has included:

- A review of all relevant background documentation.
- Field trip with the steering committee to examine existing initiatives and explore GFSs and processes in the catchment.
- Develop profiles of each GFS.
- A series of workshops with key stakeholders and relevant staff to examine issues relating to:
  - Implementation
  - R&D
  - Monitoring.
- Prepared a draft plan for community consultation including:
  - Presentation to and discussion with CMA Board and the Land Issues FC
  - Presentation to and appraisal by DSE state-wide salinity planning team
  - A series of seven targeted briefing and discussion sessions across the region attended by about 150 people
  - Formal submissions/responses from key Landcare groups and interested individuals.

The steering committee, with help from the consultants, collated and assessed feedback from the briefing submissions, formal submissions and DSE appraisal. The draft plan was modified and expanded accordingly to deal with the issues raised during the public consultation phase.

This plan represents the culmination of the process.

## 1.3 SOCIAL ISSUES AND SALINITY MANAGEMENT

### 1.3.1 SOCIAL DRIVERS AND NATURAL RESOURCE MANAGEMENT

During 2002 Charles Sturt University undertook a social research study to gain a better understanding of the social drivers of catchment management in the Wimmera Region. As well as providing insights to the social drivers, the study provides a baseline of social indicators for the catchment. It is envisaged that a repeat study will be undertaken in 2007 to measure changes in these indicators.

The study report highlights many issues of relevance to salinity management including:

#### 1.3.1.1 Issues/Values

- Four of the top five priority issues relate to social rather than NRM aspects
- Dryland Salinity was only rated as important by 15% of respondents
- Major NRM issues relate to reduced river and stream flows, weeds and pest animals, and recreational impacts
- Most landholders expressed a desire to hand on their property in "better condition"

### 1.3.1.2 Knowledge

- Low awareness of the returns from farm forestry
- Low knowledge of the extent of original native vegetation cover
- Low knowledge of the extent and management of dryland salinity. However, landholders showed good awareness of salt-affected areas on their property
- Higher knowledge was significantly linked to the adoption of current recommended practices for conservation

### 1.3.1.3 Uptake of Programs and Current Recommended Practices

- High adoption of:
  - Pest plant and animal control works
  - Watering stock off stream
  - Conservation tillage
  - Planting trees and shrubs
- High concern about the effectiveness of many current recommended practices, particularly relating to habitat conservation, even among those that had trialed the recommended practice
- Low confidence in scientists' knowledge of how to manage dryland salinity
- Factors linked to adopting current recommended practices include:
  - Landcare and Topcrop membership
  - Involvement in government-funded works
  - Involvement in property planning
  - Knowledge of current recommended practices and their implementation
  - Landholder identified saline areas
- No linkage between profitability and uptake of current recommended practices
- Half the respondents would be interested in taking on extra revegetation works under the increased cost sharing arrangements proposed (\$1000 per ha plus an annual payment)

### 1.3.2 IMPLICATIONS

There are many implications of the findings of the social drivers study and the Project Steering Committee has considered these in developing the implementation phase of this action plan. Throughout the implementation of this plan, these issues will need to be continually addressed and given due consideration.

The key issues considered in developing this plan include:

1. Salinity will struggle to gain attention as an issue in its own right. The future focus of a salinity plan needs to link salinity to a broader regional socio-economic picture. As a result, all future salinity management initiatives will need to be developed and implemented while considering their interaction with the socio-economic structure of the region. Some of these considerations will be:
  - What threat does salinity pose to the priority social issues identified in the study?
  - What are the social opportunities from implementing salinity management options, employment and new industries?
  - How can salinity management be linked more closely with regional development?
2. In an NRM context the major concern in relation to salinity will be its impact on river and stream flows and the associated impact on recreational values.
3. The desire of landholders to leave their property in "better condition" provides a major opportunity. There is a need to better understand landholders' definition of "better condition" and potentially influence this desire to include broader off-site NRM impacts of land use.
4. Farm forestry and the potential returns need to be better understood and promoted if commercial/semi-commercial revegetation options are to be promoted effectively.
5. Landcare, Topcrop and government programs have a strong impact on adoption of current recommended practices; can these mechanisms of delivery be strengthened to appeal to a broader cross-section of landholders?
6. Property Planning is strongly linked to adopting current recommended practices; can property planning therefore play a role in promoting salinity management in the future?
7. There is a need to further increase knowledge of NRM issues and management options. Community education is likely to continue to provide a good return on investment

### 1.4 SALINITY THREATS TO THE WIMMERA REGION

The Wimmera RCS identified the following nine key groups of assets in the Wimmera Region:

1. Wetlands and streams of the Wimmera River Basin
2. Terminal lakes of the Wimmera River Basin
3. Wetlands and streams of the Millicent Coast Basin
4. Groundwater
5. Remnant Vegetation
6. Agricultural Land
7. Parks and Reserves
8. State Forests
9. Heritage Sites

Assets one to six are considered to be at most risk from the threat of salinity along with the region's major utility infrastructure including road, rail transmission lines and urban water supplies.

While biodiversity is not recognised as being at risk, implicit in each of these asset groups are the biodiversity values supported within each of the assets.

## 1.4.1 AGRICULTURAL LAND

### 1.4.1.1 Current Situation

National Land and Water Resources Audit (NLWRA) data indicates that 96,400 ha of the region currently has water tables within two metres of the surface and that even at lower estimates, 56,000 ha of the region is at high risk of salinity. Current discharge maps for the region show almost 22,000 ha, or just over 1% of the region, as visibly affected to some degree by salinity. This includes almost 6000 ha of severely impacted land.

### 1.4.1.2 Future Projections

At the lower limit of trend estimate, NLWRA data indicates a stabilisation of the area of land with watertables within two metres of the surface and possibly a slight fall by 2050. At the upper limit of trend values the area with high watertables would increase to 160,000 ha, which represents 8% of the agricultural land in the catchment. More detail on the area of land affected by salinity is in Table 3.

## 1.4.2 INFRASTRUCTURE

### 1.4.2.1 Road, Rail and Transmission Lines

NLWRA data indicates that almost 650 km of roads in the region are currently within areas with watertables at less than two metres. As shown in Table 4, under the low trend estimates the length of roads at risk will remain at similar levels until 2020, however, at the high trend estimates more than 900 km of roads will be at risk.

**TABLE 4: INFRASTRUCTURE AFFECTED BY SALINITY IN THE WIMMERA**

Infrastructure Item (km)	1998	2020 Estimates	
		lower	upper
Road			
Highway sealed	19.9	18.3	32.6
Major road sealed	65.9	68.4	102.2
Major road unsealed	153.8	157.9	220.3
Other road sealed	101.4	102.0	152.6
Other road unsealed	170.5	169.4	219.1
Vehicular track	130.0	128.4	204.6
Railway	13.4	14.0	16.9
Transmission Line	4.1	3.6	19.3

Source: NLWRA 2001; Sinclair Knight Merz 2001

**TABLE 3: AREA OF LAND AFFECTED BY SALINITY IN THE WIMMERA**  
**Groundwater Flow System**

	Area Affected by Salinity (ha)			
	Low	Moderate	High	Total
Intermediate flow systems in alluvial plains	2,951	1,281	263	4,495
Intermediate flow systems in fractured rocks (sedimentary and metamorphic)	128	49	0	177
Local and intermediate flow systems in deeply weathered fractured rocks (sedimentary and metamorphic)	45	131	4	179
Local flow systems in colluvium (Grampians Sandstone)	6	0	0	6
Local flow systems in deeply weathered granite (low relief)	25	10	0	35
Local flow systems in highly fractured rocks (sedimentary and metamorphic)	5	0	0	15
Local flow systems in sand dunes (Lowan Formation)	1,816	280	1,204	3,301
Local flow systems in weathered granite (high relief)	8	0	0	8
Regional flow systems in limestone overlain by local flow systems in Woorinen sediments	349	0	4	353
Regional flow systems in Parilla Sands overlain by local flow systems in Woorinen sediments	6,109	807	2,508	9,423
Groundwater Flow Systems - No Data	1,948	208	1,563	3,719
<b>Total</b>	<b>13,399</b>	<b>2,765</b>	<b>5,547</b>	<b>21,711</b>

Source: Generated from Wimmera CMA GIS data sets.



### 1.4.3 WIMMERA RIVER

#### 1.4.3.1 Water Quality

The quality of surface water in the Wimmera's rivers and streams is generally rated as fair to poor: Current flow-weighted average stream salinity levels range between 488 and 680 mS/cm and are expected to marginally worsen as shown in Table 5.

**TABLE 5: CURRENT AND PREDICTED STREAM SALINITY LEVELS**

Gauging Station	Salinity (mS/cm)		
	2000	2020	2050
Wimmera R at Horsham	488	488	490
Wimmera R at Lochiel	680	682	687
Wimmera R upstream of Lake Hindmarsh	680	684	691

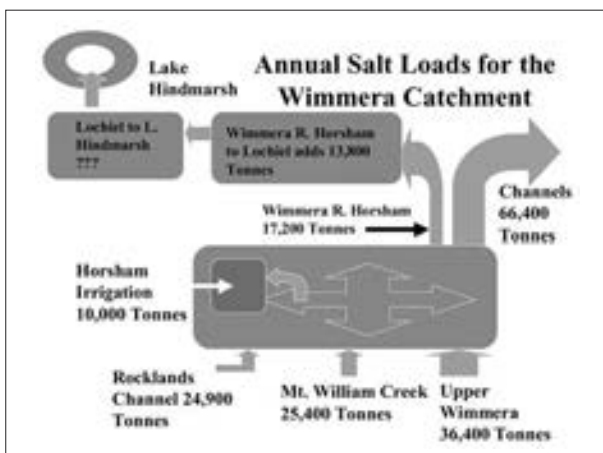
Source: NLWRA 2001; Sinclair Knight Merz 2001

Flow-weighted salinity is a good indication of the average salinity per megalitre (ML) of flow. But in the context of water quality, actual salinity levels can provide a better indication of the potential impacts on key assets such as flora, fauna and agricultural use. Mean daily salinities in Wimmera River in 2002 (SKM 2003) ranged from 1425 electrical conductivity (EC) at Horsham to 16,189 at Tarranyurk. There are also deep pools in the Wimmera River between Horsham and Lake Hindmarsh that contain water between 40,000 EC and 50,000 EC and are devoid of oxygen.

#### 1.4.3.2 Salt Loads

Hooke (1991) computed salt loads for most of the gauging stations in the Wimmera using data from the preceding 10 years. This was presented in a complex tree diagram illustrating salt loads computed at gauging stations, together with salt loads computed from a mass balance between stations (see Figure 3).

**FIGURE 3: ANNUAL SALT LOADS AND DISTRIBUTION IN THE WIMMERA CATCHMENT (developed from Hooke, 1991).**



This information is particularly useful because it illustrates the relative contribution of different parts of the catchment. At its broadest level, the Hooke computations show the relative contributions of salt from and to the Wimmera Region as shown in Table 6 and Table 7. The total amount of salt generated within the Wimmera-Rocklands system according to Hooke estimates is about 110,000 tonnes per annum. It is worth noting that the Hooke calculations are based on a relatively wet period of years during the 1980s. As salt loads are somewhat proportional to flows we would expect the loads during the 1990s, a relatively drier period in comparison to the 1980s, to be considerably less.

It should also be noted that the Hooke data is based on older continuous flow monthly salinity data. It is now recognised that salt loads calculated from this information may be up to 50% lower than actual values. While there is some doubt about the absolute values, the relative distribution across the catchment should remain the same.

**TABLE 6: MASS OF SALT GENERATED/IMPORTED IN THE WIMMERA CATCHMENT (NOT ACCOUNTING FOR THAT ENTERING BELOW LOCHIEL)**

Catchment/Stream	Salt Load
Upper Wimmera Catchment	36,400
Mt. William Creek Catchment	25,400
Rocklands channel	24,900
Wimmera River below confluence with Mt. William Creek to Lochiel	24,200
<b>Total salt generated</b>	<b>110,900</b>

Source: NLWRA 2001; Sinclair Knight Merz 2001

The fate of salt in the surface drainage system is also apparent from the Hooke computations. They indicate 76% (76,500 tonnes) of annual saltloads are removed via the channel system in the form of irrigation and stock and domestic supplies both within and distant to the immediate Wimmera Region. About 31,000 tonnes of salt remains in the river and passes below Lochiel each year.

**TABLE 7: DESTINY OF SALT LOADS IN THE WIMMERA CATCHMENT**

Stream	Salt mass (Tonnes)
Exported via main central and Charlton Channels	23,000
Exported via Rocklands (Lubeck) channel	9,000
Exported via Taylor's Lake outfall channel	28,000
Exported to Horsham Irrigation Region	10,000
Minor channels and seepage losses	4,900
Yarriambiack Creek	1,600
Total salt exported to channels and Yarriambiack Creek	76,500
Lower Wimmera River at Lochiel	31,000
<b>Total annual salt flow (minus salt below Lochiel)</b>	<b>184,000</b>

Source: Hooks, 1991, Revised Dyson 2003.

A small proportion of these salt loads is derived directly from airborne salt in rainfall. With average annual rainfall, 30 to 50 kg per ha per year of airborne salt is deposited in the region. Some of this is washed off in run-off and ends up in the stream while the large majority will accumulate in the soil, underlying regolith and the groundwater:

1.4.4 WIMMERA MALLEE PIPELINE PROJECT

The Wimmera Mallee Pipeline Project aims to pipe the existing, highly-inefficient channel system that supplies 120,000 ML of water to 5500 primary producers and 29,000 urban water customers in 36,000 towns across the region. At present, about 103,000 ML of that water is lost in delivering 17,000 ML for end use.

The project has four key aims:

- 1. To save water currently lost through evaporation and seepage.
- 2. To use water saved through a piped system to maximise community benefits. These benefits include social, economic and environmental.
- 3. To provide better quality water for intended uses.
- 4. To provide a secure and reliable water supply.

Successful implementation of the project will result in significant quantities of water becoming available for environmental flows in the Wimmera River. The completion of both the Northern Mallee and Wimmera Mallee pipelines is expected to generate water savings of 148,000 ML per annum (see Table 8).

TABLE 8: EXPECTED WATER SAVINGS FROM THE NORTHERN MALLEE AND WIMMERA MALLEE PIPELINES

	Environmental Flows	Other Uses	Total Savings
NMP	35,000	20,000	55,000
WMP	83,000	10,000	93,000
Total	118,000	30,000	148,000

Source: Wimmera Mallee Pipeline Project - Interim Business Case

It is expected that 118,000 ML will be made available for environmental flows in the Glenelg and Wimmera catchments. With the implementation of the Wimmera Mallee Pipeline Project, much of the salt currently exported through the channel system will be retained within the Wimmera Catchment. This will have implications for the use of environmental flows and ultimately the salt load reaching Lake Hindmarsh.

These environmental flows have the potential to significantly impact on water quality in the river. On one hand they have the potential to dilute salt concentrations and potentially reduce the impact of groundwater intrusions from the regional Parilla system. However, the flows will bring with them extra salt loads from the GFS in the upper catchments which are currently diverted into the channel system.

Management of any future environmental flows also raises major R&D questions in terms of the best combination of size of flows, timing of flows and the source of water for the flows. Implementation of the pipeline project will also reduce the recharge resulting from channel seepage/leakage. Current estimates suggest that the current channel network contributes about 5-6% of the total Wimmera catchment recharge.

1.4.5 FLORA AND FAUNA

NLWRA data estimates that 9% of the region's threatened flora species and 11% of its threatened fauna species are in areas with shallow watertables. Under current trends this is not expected to change significantly by 2020.

It is estimated that in the worst case scenario, 16 species of flora and 10 species of fauna could have more than 50% of their records in areas of shallow watertables by 2050. These species include the Eastern Curlew, Freckled Duck, Freshwater Catfish, Golden Perch, Magpie Goose and Unspeckled Hardyhead.

1.4.6 WETLANDS OF THE REGION

The Millicent Coast Basin within the Wimmera Region contains over 3000 wetlands; about 25% of Victoria's wetlands. The wetlands in this area are valued for their ecological significance, heritage, amenity, tourist and recreational value<sup>7</sup>. Most are located in the south-western area and occur in chains that form the natural surface water drainage system of the area, instead of a more defined river system. These wetland chains generally start near the Glenelg River catchment in the south and flow north-west towards Little Desert National Park.

These wetlands have significant environmental values and provide key habitat for flora and fauna.

Due to the location of wetlands in the landscape and the relatively flat landscape, the watertable does not need to rise far to put them at risk from salinity. Consequently they are often the first environmental feature to be affected. Wetlands may be best referred to as "windows to the watertable". Many wetlands in the Douglas Depression were naturally saline at pre-European settlement, but there are now many in the Edenhope area that have become more saline as a result of changed land management practices since European settlement. An example of an affected wetland is Brickies Swamp, south of Edenhope.

1.4.7 ECOLOGICAL VEGETATION CLASSES

Ecological Vegetation Classes (EVC) is a system of classifying plant communities. These communities usually consist of a group of species that regularly occur together; and may be defined on the basis of floristics, life-forms, reproductive strategies, climate, landscape position, soil type and hydrology. An assessment is then made about the conservation status of EVC to determine management priorities and activities. The extent of EVC for each conservation status in each GFS in the Wimmera can be seen in Table 8B.

1.4.8 IMPACTS OF SALINITY MANAGEMENT OPTIONS UPON FLORA AND FAUNA

Some current salinity management options such as phalaris and tall wheat grass have the potential to be invasive to adjoining land. Grant incentives are only to be used in accordance with the Wimmera CMA incentive grant guidelines. Any new salinity control biological option must be evaluated for its invasiveness potential and appropriate action taken based on that evaluation.

<sup>7</sup> WCMA, 2003. Wimmera Regional Catchment Strategy. Wimmera Catchment Management Authority, Horsham.

#### 1.4.9 IMPACTS OUTSIDE THE WIMMERA REGION

The regional Parilla Sands GFS also extends into the Victorian Mallee (Macumber 1992). Groundwater and associated salt loads from the Wimmera flow in a north and north-west direction into the Mallee and ultimately discharge directly into Mallee salt lakes and the Murray River.

Comparison of recharge volumes and head drops for the Wimmera and Mallee regions indicates that the Wimmera may be a driving force behind groundwater flow from the Mallee dryland areas. Although groundwater processes are slow, reducing recharge in the Wimmera eventually has the potential to reduce discharge to areas outside the catchment.

#### 1.5 THE FUTURE WITHOUT A PLAN

The consequences of taking no action to manage salinity in the Wimmera are dire. Based on the asset threats identified, the losses will include:

- (i) Major environmental degradation and loss of flora and fauna species as a result of:
  - Increasing salt loads in the Wimmera River
  - Rising watertables below significant wetlands
  - Loss of habitat in discharge areas
  - Increased salt loads reaching Lake Hindmarsh;
- (ii) An increase in the already-significant lost value of agricultural production; and
- (iii) Significant public and private infrastructure damage.

#### 1.5.1 ENVIRONMENTAL LOSSES

The many environmental assets of the region are largely unquantifiable in dollar terms. But these assets are the major reason to justify the need for action to manage salinity in the region. The threats to these assets include:

- (i) A continuation and probable increase in the already high salt loads in the Wimmera River system, leading to:
  - Increased river salinities
  - Loss of instream and riparian biodiversity
  - Inability to sustain viable populations of native flora and fauna
  - Damage to the Heritage-listed section of the river;
- (ii) Increased salt flows into Lake Hindmarsh and as a result:
  - Loss of biodiversity and a decline in native flora and fauna
  - Inability to sustain fish populations
  - Decline in recreational fishing
  - Death of vegetation surrounding the lake
  - Reduction in tourism to this area;
- (iii) A decline in the function, health, uniqueness, diversity, and ability of the region's wetlands to support a diverse range of flora and fauna; and
- (iv) Loss of the significant environmental, cultural and economic value of these wetlands to the community and loss of the opportunity to develop and support initiatives such as:
  - An ecotourism industry based on wetland systems and wilderness values
  - An educational centre
  - A range of specialised industries including yabbies and water-based recreational pursuits.

**TABLE 8B: ECOLOGICAL VEGETATION CLASSES BY GROUNDWATER FLOW SYSTEM**

Groundwater Flow System title	ENDANGERED		VULNERABLE		DEPLETED		LEAST CONCERN	
	Extant Ha	Pre-European Ha	Extant Ha	Pre-European Ha	Extant Ha	Pre-European Ha	Extant Ha	Pre-European Ha
Intermediate flow systems in alluvial plains	13,028	144,718	12,222	29,821	3,716	11,782	6,542	11,979
Intermediate flow systems in fractured rocks (sedimentary and metamorphic)	1,579	33,194	1,104	4,978	4,821	22,613	1,287	4,812
Local and intermediate flow systems in deeply weathered fractured rocks (sedimentary and metamorphic)	3,789	48,617	2,171	5,936	710	2,391	5,223	7,217
Local flow systems in colluvium (Grampians Sandstone)	397	1,101	2,912	3,530	2,296	2,303	56,268	60,189
Local flow systems in deeply weathered granite (low relief)	354	4,788	156	2,452	718	2,196	195	363
Local flow systems in highly fractured rocks (sedimentary and metamorphic)	159	3,538	232	1,368	15,960	28,586	1,083	5,359
Local flow systems in sand dunes (Lowan Formation)	6,282	37,006	22,725	67,212	18,245	32,949	206,677	360,423
Local flow systems in weathered granite (high relief)	456	3,442	2,296	4,854	3,490	4,359	2,460	2,716
Regional flow systems in limestone overlain by local flow systems in Woorinen sediments	4,693	133,008	1,835	14,402	286	894	583	2,991
Regional flow systems in Parilla Sands overlain by local flow systems in Woorinen sediments	47,450	1,064,294	19,517	96,451	3,305	17,128	6,096	12,151
<b>Total</b>	<b>78,186</b>	<b>1,473,706</b>	<b>65,169</b>	<b>231,003</b>	<b>53,548</b>	<b>125,201</b>	<b>286,415</b>	<b>468,201</b>

## 1.5.2 LOST AGRICULTURAL PRODUCTION

The current cost of lost agricultural production is estimated to be \$2.3 million per annum, calculated as the basis of gross margin forgone. This is an average of \$94 lost per ha of salt-affected land. With a conservative estimate of a steady 1% per annum rise in the area of salt-affected land in the region, this cost would increase to \$2.8 million by 2020 (see Table 9). These losses represent less than 0.5% of the current gross value of agricultural production from the region.

## 1.5.3 INFRASTRUCTURE LOSSES

The Murray Darling Basin Commission and the National Dryland Salinity Program funded a three-year research project entitled "Determining the full costs of dryland salinity across the Murray Darling Basin" (Wilson 2002). Results of this research is summarised in Table 10.

This project looked at the costs and impacts on:

- Local Government - increased repair and maintenance, water treatment, construction costs, preventative works and shortened lifespan of infrastructure;
- Households and businesses - costs of saline water supplies and high saline watertable damage to buildings; and
- State Government and Utilities - increased repair and maintenance, water treatment, construction costs, preventative works and shortened lifespan of infrastructure, education, research and extension.

**TABLE 10: ANNUAL NON-AGRICULTURAL COSTS OF DRYLAND SALINITY IN THE WIMMERA**

Non-agricultural costs	Costs	Sub-totals
<b>Households and Businesses</b>		
Saline town water supply	4,663,924	
High saline watertable damage	2,676,710	
Total		7,340,634
<b>Local Government</b>		
Repairs and Maintenance	1,032,772	
Construction	59,414	
Reduced Lifespan	2,345,858	
Preventative Works	0	
Total		3,438,044
<b>State Government and Utilities</b>		
Repairs and Maintenance	4,744,755	
Reduced Lifespan	1,892,257	
Other	642,990	
Total		7,280,002
<b>Total Infrastructure Costs</b>		<b>18,058,680</b>

Source: Wilson 2002

**TABLE 9: ESTIMATED COST OF AGRICULTURAL PRODUCTION LOST AS A RESULT OF SALINITY IN THE WIMMERA**

	Severity of Salinity			
	Low	Moderate	High	Total
Current Area Salinity (ha)	7,012	3,903	5,841	24,669
% of Gross Margin Lost	50%	75%	100%	
Current Gross Margin Loss (\$)	443,416	430,829	875,475	2,341,768
2020 Area @ 1% p.a. increase (ha)	8,387	4,669	6,987	29,508
2020 Gross Margin Loss (\$)	530,391	515,336	1,047,197	2,801,099



**Lower Wimmera River and Lake Hindmarsh.**



**Saline discharge, south of Stawell.**



## 2.1 INTRODUCTION

On the basis of similar groundwater systems occurring within similar geological, geomorphic and climatic settings, the NLWRA defined and mapped at a 1:5,000,000 scale the GFSs across Australia (Figure 4). This approach has provided the opportunity to investigate areas in which similar management options could be applied.

**FIGURE 4: GROUNDWATER FLOW SYSTEMS OF AUSTRALIA**



The GFS approach was further refined during 2000-2003 for the Murray Darling Basin with 1:2,000,000 scale maps developed, (figure 5).

**FIGURE 5: GROUNDWATER FLOW SYSTEMS OF THE MURRAY DARLING BASIN**



Similar to other catchments within the Murray Basin, the Wimmera Region comprises a suite of different geological and geomorphic terrains with a diverse range of GFSs (Murray-Darling Basin Commission 2003). Each GFS causes or has the potential to cause dryland salinity. The nature of groundwater movement through each of these systems, and the manner in which each interacts with the surface hydrology, dictates the range of options that might be applied to either mitigate or manage salinity both now and in the future.

### 2.1.1 SCALES OF GFSS

GFSs may be grouped according to the scale of their geological and geomorphic attributes (Coram et al. 2001)

**Regional** GFSs function over very large distances (>50 km), similar in scale to river basins, and are termed "Regional". These GFSs have high storage capacity and permeability and respond very slowly to increased groundwater recharge.

**Intermediate** GFSs occur across a number of sub-catchments (20,000-30,000 ha) and cause groundwater discharge at some point lower in the main catchment. These GFSs function over rather large distances (up to 20-30 km) but less than regional systems. They have moderate storage capacity and permeability and slowly respond to increased recharge (take longer to "fill" than local GFSs).

**Local** GFSs occur within small sub-catchments (<2,000-3,000 ha) and function over smaller distances (5-10 km). These GFSs generally have low water storage capacity and permeability and rapidly respond to increased intake of groundwater.

### 2.1.2 SALINITY MANAGEMENT OPTIONS

#### 2.1.2.1 Salinity Management Triage

In considering possible options to manage salinity there are three possible alternatives:

- 1 Options that seek to reduce the impact of current salinity issues within a "reasonable" timeframe.
- 2 Options that seek to avoid future salinity impacts.
- 3 Options that seek to adapt to saline environs.

Given that GFSs behave differently, it is likely that more than one management option will be required to address salinity. Salinity cannot be "fixed" quickly, but requires a combination of prevention, treatment and improvement of symptoms. In addition, management strategies need to be cost-effective and easy to implement.

Salinity can be addressed through a combination of management options:

- Biological (eg. manage groundwater recharge using native plant revegetation, agro-forestry or high water-use crops);
- Engineering (eg. drains, pumps, water diversion systems); and
- Living with salt (eg. salt-tolerant plants for forestry, stock feed, saline aquaculture, extraction of high grade salt, use of native grasses).

The scale of GFSs is particularly important when planning biological management of groundwater recharge. The larger the GFS, the greater the volume of groundwater and the greater the scale of intervention required. Conversely, revegetation of areas with smaller GFSs may generate the desired reduction in groundwater recharge with less intervention and in less time.

Other characteristics must also be considered since the response of local GFSs to recharge-reduction strategies may vary. For example, where the permeability of an aquifer is very poor, movement of groundwater through the system may be restricted. As a result, watertable levels in the lower parts of the catchment may change over long time-frames.

## 2.2 REGIONAL FLOW SYSTEMS IN THE PARILLA SANDS

### 2.2.1 OVERVIEW

During early Tertiary times, 60 million years ago, extensive subsidence began to occur to the west of the present Dividing Range in south-eastern Australia. A broad shallow depression opened up across a vast region stretching from the eastern sector of South Australia through western and northern Victoria and southern NSW. The depression, now filled with sediment, is known as the Murray Basin.

In the Wimmera Region, early development of the Murray Basin saw sediment derived from erosion of the uplands deposited over the floor of the deepening depression. Later, during the period from 32 to 12 million years ago, the sea entered from the south west through South Australia and extended 400 km inland, drowning ancient river valleys and sediments. During this inundation an extensive layer of limestone precipitated from the shallow sea. The **Murray Group Limestone** now forms an extensive regional aquifer west of the Wimmera River. In the most westerly areas of the Wimmera Region, and in adjacent South Australia, the groundwater found within the aquifer is fresh and is an important resource for irrigation, stock watering and domestic use. Further west in the vicinity of the Murray River in South Australia, groundwater in the aquifer is more saline and causes extensive salinity in some regions, particularly along the trench of the Murray River.

The sea inundated the region a second time about six million years ago, and finally retreated from the basin about two million years ago. During the retreat, vast amounts of fine-grained sand were deposited as north-south trending stranded beach ridges. These sediments, known as the **Parilla Sand**, form the uppermost aquifer of the Murray Basin (see Figure 6). The Parilla Sand may be up to 50 m thick, and is separated from the underlying Murray Group Limestone by a clay layer. The salt concentration of the groundwater in the Parilla Sand aquifer ranges from 5000 mg/L in the south to more than 35,000 mg/L in the north.

The Parilla Sand is quite permeable; groundwater moves freely through it and readily finds its own level in the landscape. Accordingly, the watertable is very flat over large regions, irrespective of local relief.

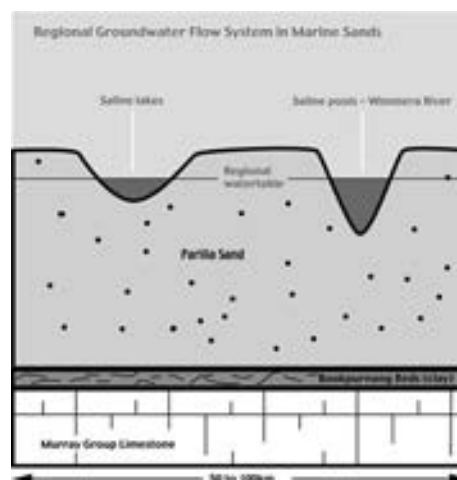
### 2.2.2 SALINITY PROCESSES

Groundwater discharge and salinity occurs where the level of the land lies below or within two metres of the regional watertable. In many places this occurs naturally, such as at Mitre Lake near Mount Arapiles and within the salt lake chains of the Douglas Depression. Where the groundwater surface has risen because of an increase in groundwater recharge due to native vegetation clearing, the area of saline groundwater discharge has increased as more of the lower landscape has been affected. These salt lakes provide a natural evaporation basin; for example the 200 ha Mitre Lake would provide 2000 to 3000 ML/yr groundwater evaporation.

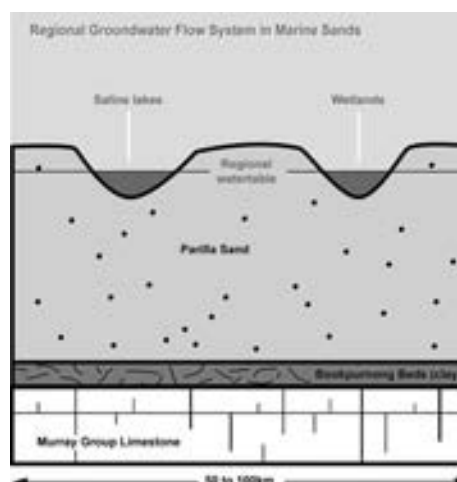
Rivers and streams represent lower points of the landscape. These are often impacted by saline discharge from regional groundwater. They are very prone to salinity, and the discharge

of the saline groundwater from the Parilla Sand into the Wimmera River north of Horsham is a most graphic example of environmental damage caused by this process. The deeper pools of the river, which have traditionally been principal breeding grounds for fish and other freshwater aquatic species, now contain saline, deoxygenated groundwater that threatens the ecological viability of the river.

**FIGURE 6: CROSS-SECTION OF THE REGIONAL FLOW SYSTEM IN PARILLA SANDS**



**FIGURE 7: CROSS-SECTION OF THE REGIONAL FLOW SYSTEM IN PARILLA SANDS IN EDENHOPE AREA**



**Sample bottle on left is highly saline and anoxic water from deep pool at Polkemmet.**

2.2.3 IMPACTS OUTSIDE THE WIMMERA REGION

The regional Parilla Sands GFS also extends into the Victorian Mallee (Macumber 1992). Groundwater and associated salt loads from the Wimmera flow in a north and north-west direction into the Mallee and ultimately discharge directly into the Mallee salt lakes and the Murray River.

Comparison of recharge volumes and head drops for the Wimmera and Mallee regions indicates that the Wimmera Region may be a driving force behind groundwater flow from the Mallee dryland areas. Although groundwater processes are slow, reducing recharge in the Wimmera eventually has the potential to reduce discharge to areas outside the catchment.

2.2.4 ASSET THREATS

The regional Parilla GFS poses a major threat to key Wimmera Catchment assets including:

- Wimmera River - A contribution of 17,000 tonnes of salt to the river between Horsham and Lochiel. The contribution between Lochiel and Hindmarsh is unquantified, but is estimated to be at least another 17,000 tonnes
- Wetlands in the Edenhope area
- Water quality in Lake Wallace and Lake Hindmarsh
- Mosquito Creek - in particular the upper reaches
- Loss of small areas of agricultural land on the Wimmera River floodplain
- Urban salinity issues in and around Jeparit
- Water quality in the Murray Group Limestone

TABLE 11: SNAPSHOT OF THE REGIONAL FLOW SYSTEM IN PARILLA SANDS

Total Area of System (ha)	1,194,395
Percentage of Wimmera Region	51.0%
Area of Mapped Discharge (ha)	9,423
Discharge as % of System	0.8%
Discharge as % of Wimmera Salinity	43.4%
Woody Vegetation	24,006
% of GFS	2.4%

2.2.5 MANAGEMENT OPTIONS

2.2.5.1 Biological Control of Groundwater Recharge

The dynamics of regional groundwater flow within the transmissive Parilla Sand aquifer affords little support for options that involve a reduction in groundwater recharge accruing from biological intervention. This is because:

- (a) The scale of land use change required to affect significant recharge reduction is large in comparison to the areas experiencing the problems;
- (b) In most instances, recharge occurs episodically in response to years when high rainfall occurs; and
- (c) The regional nature of groundwater flow is likely to sustain elevated groundwater pressures and the present groundwater discharge irrespective of any lessening of recharge.

Therefore, the focus should be on R&D into productive perennial plants for these areas to maintain productivity in an increasingly-saline environment.

Over the last 10 years, the Hindmarsh Landcare Network has achieved significant progress in developing options for productive use of saline lands. Farmers in the area have integrated trees and salt bush plantings into their farm management to address saline scolds. Anecdotal evidence suggests they are starting to achieve productivity benefits.

2.2.5.2 Engineering

Where dryland salinity associated with Parilla Sands threatens important assets such as the infrastructure of regional towns or important environmental assets (eg. wetlands), the only option to artificially lower groundwater may be to adopt engineering techniques such as groundwater pumping or surface/subsurface drainage. But care needs to be taken when adopting this strategy to ensure that adequate allowance is made for the disposal of saline water. This may call for construction of evaporation basins.

FIGURE 8: WINDMILL TRIAL OF GROUNDWATER PUMPING OF THE REGIONAL FLOW SYSTEM IN PARILLA SANDS



### 2.2.5.3 Living With Salinity

The range of productive and innovative options for living with salinity is quite diverse for the saline regional groundwater systems of the Murray Basin in Victoria.

A plentiful supply of groundwater with high salinity affords many different options. These include the more conventional agricultural options such as forage production from halophytic vegetation, largely saltbush, through to salt land pastures that include Tall Wheat Grass and Puccinellia.

Equally, a range of other more niche-market options are available, and although many of these remain in their infancy, they are being developed throughout Australia.

Among these less conventional options are:

- Distichlis, a north American halophyte with grain, pasture, turf and fodder species;
- Production of algal products such as beta-carotene and seaweed, and from the more saline groundwater; salt and mineral production; and
- Saline aquaculture industry.

Those interested in pursuing productive options for living with dryland salinity can refer to a study commissioned by the National Dryland Salinity Program. Outcomes of the Options For The Productive Use Of Salinity (OPUS) project can be found on the National Dryland Salinity Website at [www.ndsp.gov.au](http://www.ndsp.gov.au).

### 2.2.6 MANAGEMENT RECOMMENDATIONS

Management recommendations to minimise the impacts of salinity on the regional flow system in Parilla Sands are in Table 12. Recommendations to minimise the impacts of salinity on the regional flow system in Parilla Sands in the Edenhope area are in Table 13.

### 2.2.6.1 Implementation Opportunities

The regional scale of the Parilla GFS and its limited responsiveness to change restricts the implementation options available over the next five years. Initiatives in this GFS will need to focus on the short to medium-term protection of high value assets, identifying longer-term options and developing opportunities based on saline agriculture and groundwater. Future implementation activities should focus on:

- Raising community awareness of the regional nature of the GFS, the inability to “fix the problem” with current knowledge and farming systems and new opportunities that might exist;
- Research and investigation of the management options in the near-river zone including electromagnetic studies;
- Developing an environmental services package for near-river intervention works if appropriate;
- Linkages with the Wimmera Mallee Pipeline Project to ensure appropriate use of environmental flows to minimise the impact of salt loads on river ecosystems;
- Public sector investment in groundwater pumping and saline pool pumping to protect high value assets;
- Demonstrating and promoting new industries based on saline groundwater use;
- Further research and investigation of the recharge and water-quality filtering role of the Wimmera River floodplain and developing management options to potentially provide greater volume of clean water direct to the river; and
- Implementing saline agriculture opportunities on salt-affected lands including the use of salt bush and other salt-tolerant species.

**TABLE 12: MANAGEMENT RECOMMENDATIONS TO MINIMISE THE IMPACTS OF SALINITY ON THE REGIONAL FLOW SYSTEM IN PARILLA SANDS**

Option	Location in the landscape	Adoption required
Groundwater pumping for watertable control	Consistent with location of assets	Intervention consistent with aquifer properties and assets
Saline agriculture	Salt-affected lands	Selective establishment on and around discharge areas
Enterprises based upon saline groundwater	Consistent with groundwater pumping for asset protection	Consistent with realising sufficient groundwater to support saline enterprises

**TABLE 13: MANAGEMENT RECOMMENDATIONS TO MINIMISE THE IMPACTS OF SALINITY ON THE REGIONAL FLOW SYSTEM IN PARILLA SANDS IN EDENHOPE AREA**

Option	Location in the landscape	Adoption required
Surface Water Management	Edenhope Area	Surface water drainage management plan around Edenhope and Lake Wallace



### 2.2.6.2 Research and Development Recommendations

Research and development activities will address the following knowledge gaps:

- Understanding the capacity of engineering intervention to support in-stream salinity and biodiversity aspirations;
- The capacity for in-stream groundwater interception from deep pools;
- Groundwater flow paths into the Wimmera River including an understanding of the impact of the near-river zone and the location of concentrated points of flow into the river;
- The technology required to achieve effective asset protection through groundwater pumping and disposal;
- What might and might not be achieved in establishing niche-market industries based upon production from saline land and water resources; and
- Definition of Woorinen/Lowan/Parilla salinity issues in Edenhope region.

## 2.2.7 IRRIGATION IN THE WIMMERA

### 2.2.7.1 Overview

Grampians Wimmera Mallee Water Authority supplies irrigation water to 250 irrigators who irrigate about 3000 ha of land in three main districts:

- Quantong - west of Horsham and north of the Wimmera River
- Riverside/Drung/Haven - south east of Horsham and south of the Wimmera River
- Murtoa/Coromby - around Murtoa

These areas are located over the regional Parilla GFS.

The water used for irrigation in these areas brings with it about 10,000 tonnes of salt per annum. When irrigation water returns to the system after the current run of dry years, managing this salt will be an important issue.

### 2.2.7.2 Irrigation Salinity Management

While the review of Wimmera Catchment Irrigation Area Salinity Management Strategy noted significant achievements of the strategy it concluded that:

*It is unlikely that any major changes to the salinity status of the Wimmera irrigation area, either positive or negative, are going to occur without major changes in land use and irrigation management.*

To help the change in land use and irrigation management, the review recommended four main future directions:

- 1 Regional development - promote the Land Capability study, encouraging transfer of water out of the Wimmera River trench and adopting high-value crops and new technology.
- 2 Monitoring and Investigation - further monitoring and investigations under normal seasonal conditions and allocations to determine current land use, impact on groundwater systems and groundwater levels.
- 3 Drainage - encourage the use of re-use systems
- 4 Ongoing help including revegetation works, channel seepage works, salinity mapping and assistance to landholders.

Over recent years there has been limited irrigation water available in the system and as such there have been minimal opportunities to progress the recommendations of the review.

### 2.2.7.3 Management Recommendations

The recommendations of the review will be acted upon appropriately when irrigation water returns to the system.



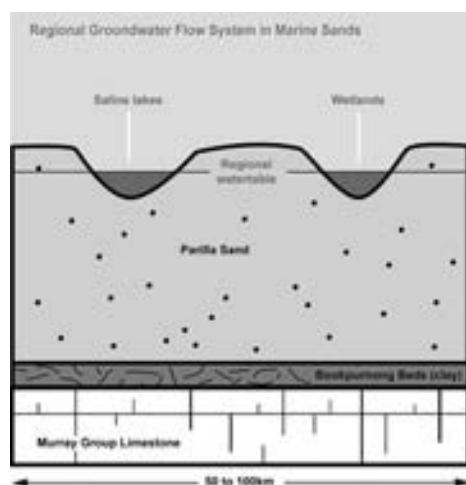
**Mapping and sampling saline pools in the Wimmera River at Polkemmet.**

## 2.3 REGIONAL FLOW SYSTEMS IN LIMESTONE

### 2.3.1 OVERVIEW

The Murray-Group Limestone is a highly transmissive aquifer that lies buried 80 metres beneath the surface of the land throughout most of the Wimmera plains west of the Wimmera River. The aquifer also extends into South Australia. The limestone is about 100 m thick. In the Wimmera's west, it is an extremely important aquifer that provides a fresh groundwater resource (See Figure 9).

**FIGURE 9: CROSS-SECTION OF THE MURRAY GROUP LIMESTONE IN WEST WIMMERA**



In the Wimmera, groundwater within the aquifer generally has a salinity of less than 1000 mg/l. Further north and west in South Australia, the groundwater salinity rapidly rises. Close to the Murray River, it can be greater than 20,000 mg/l. In the east, the Murray Group Limestone is confined to 30 m of clay sediment known as Bookpurnong beds. In West Wimmera, these sediments "pinch out"; leaving Pliocene Parilla/Loxton sands sitting directly over the limestone.

### 2.3.2 SALINITY PROCESSES

Saline groundwater discharge from the Murray Group Limestone causes extensive dryland salinity in South Australia. But this does not occur in Victoria because in the east, groundwater lies well below the surface of the land. Salinity does occur, however, where groundwater is drawn from the limestone and used to irrigate crops and pastures, particularly where this is supported by centre pivot irrigation. Dissolved calcium, magnesium, carbonate and bicarbonate ions sourced from the limestone cause the precipitation of calcium/magnesium carbonate within the irrigated soils during successive wetting and drying. Removing these dissolved ions increases the concentration of dissolved sodium ions relative to other ions, causing clays to become more dispersive and the soil to become less permeable. The loss of soil permeability and leaching capacity ultimately results in the accumulation of salts within the irrigated soils (Gardiner, 2001). If left untreated, the process may destroy soil structure and soil permeability and render the land unsuitable for irrigation within a decade.

### 2.3.3 ASSET THREATS

The two major asset threats to this flow system are the water quality in the limestone aquifer and the agricultural land used for irrigated production

### 2.3.4 MANAGEMENT OPTIONS

Soils impacted by this form of salinity can be chemically ameliorated in different ways.

Firstly, the balance of dissolved calcium and magnesium relative to sodium can be restored through adding gypsum (calcium sulphate).

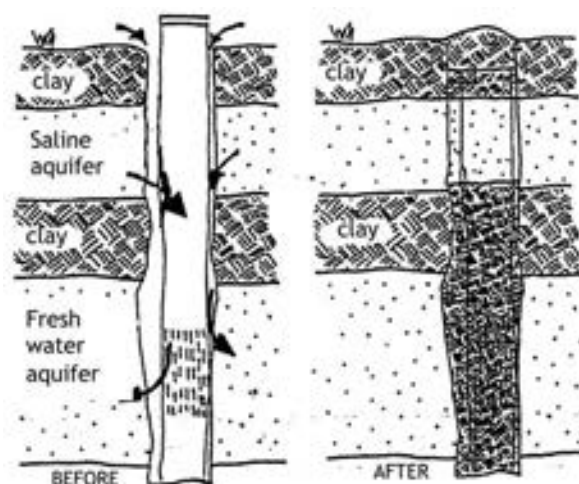
Secondly, the high pH conditions leading to the precipitation of calcium and magnesium salts can be moderated through adding sulphuric acid, elemental sulphur or pyrite.

Both forms of treatment require careful consideration. They should be only be pursued after rigorous soil analyses and consultation with professionals skilled in the chemical management and amelioration of clay soils.

### 2.3.5 WEST WIMMERA BORE DECOMMISSIONING

Good quality water and high yields make the Murray Group Limestone aquifer a vital resource in the West Wimmera Region. In many parts of the region, it is the only reliable source of water. This groundwater resource is threatened by the presence of failed or failing groundwater bores because the limestone aquifer is, in places, overlain by the saline Parilla Sands aquifer. As shown in Figure 10, older bores drilled into the limestone are likely to have deteriorated to the stage where the steel casing has corroded allowing water from the Parilla sand aquifer to enter the bores and pass down into the fresher limestone aquifer, thus contaminating the better-quality groundwater resource. This places the continuing sustainable use of the groundwater at risk.

**FIGURE 10: REPRESENTATION OF CORRODED AND SUCCESSFULLY DECOMMISSIONED BORES**



A failed bore needs to be sealed or “decommissioned” to:

- Prevent contamination of groundwater;
- Conserve yield and groundwater pressure (uncontrolled flow from an artesian bore can deplete the resource and increase the pumping costs of surrounding users);
- Prevent inter-aquifer flow - pristine aquifers can be protected from uncontrolled flow from a more saline aquifer; and
- Eliminate physical hazards (old bores are hazardous to children, animals and machinery).

Any bore that is damaged or beyond repair should be decommissioned. In particular, those bores older than 20 years and not in current use, constructed from steel casing, damaged or corroded, pumping sand, yielding saltier/poorer quality water, flowing uncontrollably, de-watering quickly, silted, collapsed or blocked, replaced by another bore or not needed.

Grampians Wimmera Mallee Water Authority is managing a project to identify all bores in West Wimmera that should be decommissioned. A similar four-year decommissioning project has recently been completed in the Mallee Region. The dual aims of the West Wimmera project are to develop a prioritised list of bores requiring decommissioning and promote public awareness of the issue. A list of registered bores from the State Groundwater Management system, and potentially unregistered wind pump bores using GIS analysis, has been created. This list totals 2835 bores. The list was ranked based on bore material type, bore age and salinity and head difference between the limestone and parilla aquifers. Of these, the highest priority bores, 471 in total, have been ranked as follows in Table 14:

2.3.6 MANAGEMENT RECOMMENDATIONS

The public awareness campaign to help identify bores which may require decommissioning is about to start and will be done through distributing pamphlets via mail drops and advertising in local newspapers. Local drilling contractors are being contacted and GIS analysis is also being employed to help identify unlicensed bores drilled before the Groundwater Act (1969).

2.4 LOCAL FLOW SYSTEMS IN WOORINEN FORMATION

2.4.1 OVERVIEW

The most recent phase of sediment deposits within the Wimmera plains has occurred cyclically over the past 32,000 years (Douglas & Ferguson Ed 1976). During this time, the climate has oscillated between temperate, high-rainfall conditions and periods of great aridity. During the arid times, lakes and other surface water systems dried; leaving elevated watertables, and numerous saline groundwater discharge zones. This highly saline environment destabilised clays, and strong prevailing winds carried them as aeolian sediment westward where they were ultimately deposited as a veneer, or sheet of sediment, comprising low relief dunes or mounds. Further north, beyond the Wimmera, the same episodes of aeolian activity resulted in considerable re-working of coarser grained alluvium and formation of extensive Mallee dunefields.

FIGURE 11: CROSS-SECTION OF A LOCAL FLOW SYSTEM IN THE WOORINEN FORMATION

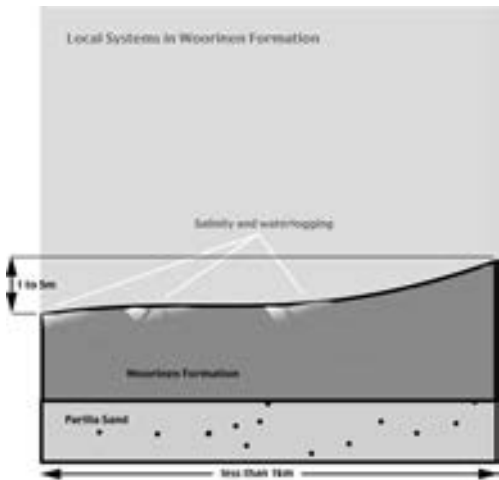


TABLE 14: MANAGEMENT RECOMMENDATIONS TO 471 HIGH-PRIORITY BORES

Priority	Number of Bores	Characteristics
Highest Priority	26	All constructed from corrodible material, average age is 40 years, average salinity difference between MGL and Parilla is 2300 mg/L TDS and average head difference between MGL and Parilla is 5.6 m
Very High Priority	37	All constructed from corrodible material, average age is 42, average salinity difference between MGL and Parilla is 1020 mg/L TDS and average head difference between MGL and Parilla is 4.6 m
High Priority	69	All constructed from corrodible material, average age is 40, average salinity difference between MGL and Parilla is 620 mg/L TDS and average head difference between MGL and Parilla is 6.4 m
Moderately High Priority	339	All constructed from corrodible material, average age is 41, and average head difference between MGL and Parilla is 6.8 m

### 2.4.2 SALINITY PROCESS

The Woorinen Formation comprises very localised shallow perched groundwater systems (Hocking 1999). Evaporation of low salinity groundwater in waterlogged discharge areas causes soil salinity in numerous locations scattered throughout the eastern sector of the Wimmera Plains. This form of salinity is most common in the Warracknabeal area.

### 2.4.3 ASSET THREATS

This salinity poses a threat only to small areas of agricultural land and a minor risk to remnant vegetation in low-lying areas and at the break of slope. In very wet years some overland flow might go to local creeks resulting in a minor contribution to salt loads.

### 2.4.4 MANAGEMENT OPTIONS

#### 2.4.4.1 Biological

##### Pasture and cropland agronomy

The very localised nature of GFSs within the Woorinen Formation lend them to treatments that involve reducing groundwater recharge through biological means. The most effective treatments involve establishing deep-rooted perennial plants, particularly lucerne. Where soil conditions support active growth, this plant with its deep rooted system and moderate salinity tolerance is an excellent choice in dewatering of local GFSs. It affords one of the greatest options for salinity management within cropping terrain, where it is grown in a pasture phase of the rotation, or incorporated through inter-cropping.

Simple manipulation of annual crops alone, whilst providing some opportunities for improved water use and increased production is less likely to deliver the water use requirements that can be gained from perennial plants.

##### Trees and woody vegetation

Using trees in salinity management has potential, but much greater salinity management is likely to be achieved where trees are used in combination with widespread adoption of pastures such as lucerne.

The shallow and perched nature of the local GFS, combined with generally low to moderate salinity groundwater affords an opportunity for trees and woody vegetation to be used in belts or small plantations above zones of saline groundwater discharge. The aim is for vegetation to either use water that has accumulated below the discharge regions or to intercept groundwater migrating down slope.

#### 2.4.4.2 Engineering

The main engineering option to manage salinity within the Woorinen Formation involves avoiding waterlogging through improvements in surface and subsurface drainage. The

imminent piping of the channel system through this area will result in significant changes to surface water movement and groundwater recharge. This alteration of drainage needs to be done with consideration to achieving salinity management benefits.

Groundwater pumping is unlikely to be effective, as the clay soils would not provide sufficient yield.

#### 2.4.4.3 Living With Salinity

Traditional salt-tolerant pastures including Tall Wheat Grass and Puccinellia afford opportunities for production from saline soils in less degraded landscapes, whilst Saltbush and other halophytes provide opportunities on more severely affected soils.

### 2.4.5 MANAGEMENT RECOMMENDATIONS

Table 15 details management options for achieving a 50% reduction in recharge for the Woorinen GFS.

#### 2.4.5.1 Implementation Opportunities

As the Woorinen Formation comprises very localised shallow perched groundwater systems, benefits of improved salinity management will largely occur on site. The key focus of implementation activities related to this GFS will therefore need to provide information and knowledge to support individuals to implement changes within their farming systems.

Key initiatives which could support management change on this GFS include:

- Collating and distributing an information package with latest knowledge of agro-forestry, lucerne and revegetation alternatives for the area.
- Linking into the Wimmera Mallee pipeline farm planning initiative.
- An extension resource with a lucerne focus.
- Establishing demonstration sites covering:
  - High water use crops;
  - Salt-tolerant farm forestry;
  - Agro-forestry (eucalyptus oil, broom bush and wattle seeds);
  - Electric fencing and stock management;
  - Lucerne in crop rotations;
  - Capture and use of surface water for on-farm/biodiversity purposes;
  - Capture and use of subsurface flows while still fresh.

#### 2.4.5.2 Research and Development Recommendations

Potential R&D to investigate the impact of toxic elements in the root zone on production of some alkaline soils.

**TABLE 15 RECOMMENDED MANAGEMENT OPTIONS TO ACHIEVE A 50% REDUCTION IN RECHARGE FOR THE WOORINEN GROUNDWATER FLOW SYSTEM**

Option	Location within catchment	Proportion of the Catchment
Lucerne	Lower to mid slopes	At least 20% of catchment
Agro-forestry - interception	Lower slopes and affected areas	Generally less than 5 %
Improved surface drainage	Lower slopes	Generally less than 5 %



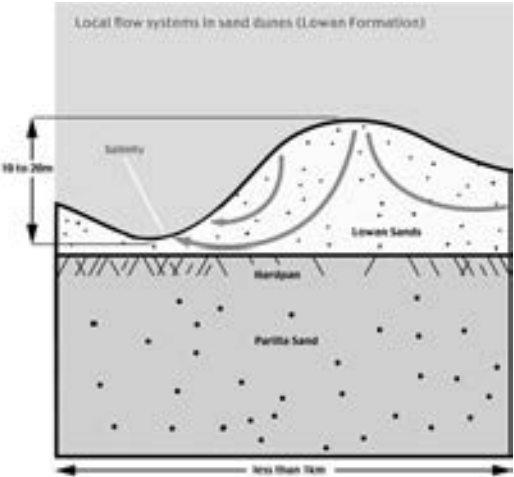
2.5 LOCAL FLOW SYSTEMS IN SAND DUNES (LOWAN FORMATION)

2.5.1 OVERVIEW

The Lowan Formation comprises a series of irregular sand dunes. These have been deposited cyclically over the past two million years in response to wind erosion and deflation of the Parilla Sand.

In the Telopea Downs area, sand dunes of the Lowan Formation were cleared and developed for agriculture in the 1960s. Since clearing, local perched and somewhat fresh groundwater systems have formed within the sand dunes. These now discharge at breaks of slope, and where successive phases of dune building have caused small internal basins. Salinity develops in these basins through evaporation of local groundwater discharge.

FIGURE 12: CROSS-SECTION OF A LOCAL FLOW SYSTEM IN SAND DUNES (LOWAN FORMATION)



Groundwater in the dunes is perched over the weathered surface of the Parilla Sand, known geologically as the Karoonda Surface. The weathered material comprises layers of ironstone, silt and clay.

TABLE 16: SNAPSHOT OF THE LOCAL FLOW SYSTEMS IN SAND DUNES (LOWAN FORMATION)

Total Area of System (ha)	498,877
Percentage of Wimmera Region	21.3%
Area of Mapped Discharge (ha)	3,301
Discharge as % of System	0.7%
Discharge as % of Wimmera salinity	15.2%
Woody Vegetation	223,806
% of GFS	44.9%

2.5.2 SALINITY PROCESSES

Recharge to these very local dune systems occurs through two processes. Firstly, after significant rainfall, water infiltrates very sandy soils on slopes of the dunes and percolates to the groundwater. Lack of water-holding capacity of the sandy soils allows this process to occur somewhat readily. Secondly, again after significant rainfall, run-off occurs and water accumulates in the lower landscape, percolating to the underlying groundwater. A tendency of sandy soils to be non-wetting supports this process.

2.5.3 ASSET THREATS

This salinity results in loss of productive agricultural land and predominantly occurs on-farm. In the northern section this GFS makes no contribution to stream saltloads. In the southern section, the GFS poses some threats to Mosquito Creek, Lake Wallace and wetlands.

FIGURE 13: A CLAY BORROW PIT SHOWING THE LOWAN SAND OVER THE WEATHERED SURFACE OF THE PARILLA



FIGURE 14: A LOCAL SALINE DISCHARGE SITE IN THE LOWAN FORMATION GROUNDWATER FLOW SYSTEM



## 2.5.4 MANAGEMENT OPTIONS

### 2.5.4.1 Biological

#### Perennial plants

These small, perched, local flow systems are readily managed through biological means where perennial vegetation can be established. The main limiting factor is poor water-holding capacity of the soils. Where this can be overcome, establishing deep-rooted pastures such as lucerne provides an excellent option for salinity management with potential for both recharge mitigation, and to use groundwater in evapo-transpiration.

#### Trees and agro-forestry

A more permanent solution may involve establishing "interceptor" belts immediately above salt-affected areas. This would involve a lesser requirement for intensive management that might suit needs of absentee land owners. It is possible that suitable tree/shrub species with capacity to act as phreatophytes, could harvest groundwater through vegetative use leaving less water available to discharge in the lower landscape.

### 2.5.4.2 Engineering

The most appealing engineering option involves harvesting clay from the weathered surface of the Parilla Sand and incorporating it within surface soils on the dunes. This improves water-holding capacity and water entry to soils, and provides vegetation with greater opportunity to use rainfall. It, in turn, affords less opportunity for deep drainage and groundwater recharge.

### 2.5.4.3 Living With Salinity

Living with salt options are probably of a lesser requirement in these localised groundwater systems as they are very amenable to recharge management treatments. A range of salt-tolerant grasses are available, however, that could be established on saline lands.

## 2.5.5 MANAGEMENT RECOMMENDATIONS

**TABLE 17: MANAGEMENT RECOMMENDATIONS TO ACHIEVE A 50% REDUCTION IN RECHARGE FOR LOCAL FLOW SYSTEMS IN SAND DUNES**

Option	Location within catchment	Proportion of catchment
Lucerne	Lower to mid slopes	At least 50% of catchment
Agro-forestry - interception	Lower slopes and affected areas	Generally less than 10%
Clay spreading	General throughout catchment	At least 50%

### 2.5.5.1 Implementation Opportunities

The processes operating in the Lowan Formation GFS are very local with few off-site impacts from any resulting salinity. There is limited justification to provide financial incentives on the basis of community benefit.

### 2.5.5.1.1 Northern Section

Many landholders in northern areas of the Lowan Formation GFS particularly around Telopea Downs have trialed and adopted clay spreading. Telopea Downs Agricultural and Landcare Group prepared the information package "Best Management Practices for Non-wetting Sands" to assist farmers considering adoption of clay spreading.

Future implementation should:

- Provide information and technical support for those considering clay spreading
- Support equipment-sharing arrangements
- Identify potential for low interest loans
- Demonstrate low rainfall forestry options (sugar gums, eucalyptus oils) and/or Tagasaste as low maintenance, extensive management options which could appeal to absentee landholders.

### 2.5.5.1.2 Southern Section

Clay spreading is still a relatively new option in southern sections of the Lowan Formation GFS below the Little Desert. As such potential exists to establish and monitor of a series of demonstration sites to test;

- Productivity benefits
- Impact on recharge rates
- Different clay application rates

Commercial forestry (blue gum and pine plantations) currently extend into this area but are not often located in the best areas for salinity management. Developing linkages with plantation companies and providing information has the potential to facilitate better outcomes.

Some off-site (public) impacts of salinity are found in the southern area and depending on demonstration site outcomes, cost-sharing assistance for clay spreading and other management options could be considered.

### 2.5.5.2 Research and Development Recommendations

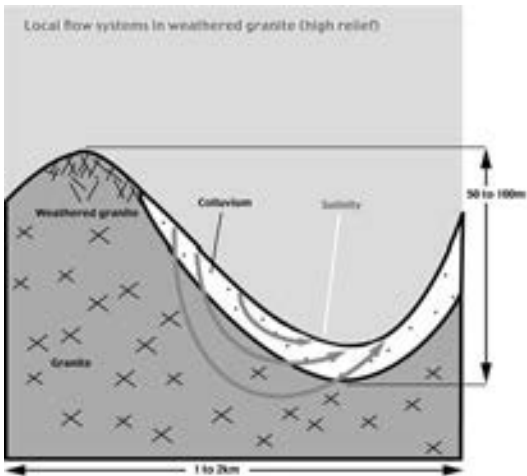
Investigate clay spreading and associated farming system changes on recharge in the southern section of the Lowan sands.

2.6 LOCAL FLOW SYSTEMS IN WEATHERED GRANITES (HIGH RELIEF)

2.6.1 OVERVIEW

Local GFSs affect salinity within granitic terrain. In higher relief granites the landscape is usually not deeply decayed, and groundwater migrates from slopes of the catchments toward valley floors through aquifers comprising either the abundant colluvium (sediment) usually found on slopes, or underlying weathered and occasionally fractured rock.

FIGURE 15: CROSS-SECTION OF A LOCAL FLOW SYSTEM WEATHERED GRANITE (HIGH RELIEF)



2.6.2 SALINITY PROCESSES

Shallow perched groundwater within the colluvium/weathered rock migrates down-slope where it either discharges at the break of slope, or feeds a somewhat poorly-defined thin basal aquifer that extends beneath the adjacent valleys. In the latter situation groundwater pressures build up under the alluvium and dryland salinity occurs in response to artesian conditions that develop in the valley floor. Recharge occurs primarily through the colluvium, although to a lesser extent it may also occur through shallow soils and rock fractures on the upper slopes.

TABLE 18: SNAPSHOT OF THE LOCAL FLOW SYSTEMS IN WEATHERED GRANITE (HIGH RELIEF)

Total Area of System (ha)	16,798
Percentage of Wimmera Region	0.7%
Area of Mapped Discharge (ha)	8
Discharge as % of System	0.0%
Discharge as % of Wimmera salinity	0.0%
Woody Vegetation	9,79
% of GFS	58.3%

2.6.3 ASSET THREATS

Relatively less salt is present in these types of landscapes so this GFS is not a major contributor to Wimmera River saltloads. It does pose a threat to some smaller local creeks and tributaries. Discharge at the break of slope poses a threat to small areas of agricultural land.

2.6.4 MANAGEMENT OPTIONS

2.6.4.1 Biological

Steep hydraulic gradients and moderate permeability in the coarse-grained colluvium/weathered rock afford opportunities for biological control of recharge. These conditions mean the aquifers are highly responsive to changes in water balance at the land surface. Perennial pastures afford opportunities for increased water use, where the annual rainfall is <600 mm. Establishing and managing introduced perennial plants is often difficult because of adverse soil conditions, in particular, poor fertility and excessive soil acidity. Existing native pastures may afford greater control given that they are more tolerant of such conditions. Native pastures capacity to mitigate recharge in granitic terrain, however, remains largely unknown. Shallow perched groundwater in the colluvium/weathered rock presents unique opportunities to manage salinity through biological means. Tree belts planted over the exposed colluvium afford a level of recharge control to the aquifer and when planted at lower extremities of the colluvium provide a means of groundwater interception before recharging the deeper valley sediments. Trees should be planted in belts over the colluvium along the primary break of slope of the granitic ranges, preferably in plantations at least 50 metres wide. Optimum conditions for groundwater interception occur when tree belts are located where the hydraulic gradient reduces and the colluvium begins to thin. Groundwater in this position usually has low salinity and approaches within two metres of the land surface. Where the rainfall is high (>600 mm) in regions experiencing this form of dryland salinity, it is unlikely that perennial pastures will have a significant role in salinity mitigation. Below this level they may be part of a significant salinity mitigation strategy, however low soil fertility and soil acidity issues must be addressed.

2.6.4.2 Engineering

Groundwater pumping from the colluvium/weathered rock affords a level of salinity management where it is technically feasible. It may also be useful in augmenting farm water supplies, and securing environmental flow to local streams. Pumping trials have been successful in dewatering high relief granitic terrain at Langi Ghiran in the upper Wimmera catchment. (Solar pumping was used in the initial trial but was unable to deliver sufficient water and has been replaced with mains power.)

FIGURE 16: A SOLAR PUMP INSTALLED IN HIGH RELIEF GRANITE TERRAIN AT LANGI GHIRAN EAST



2.6.4.3 Living With Salinity

Living with salt in these local flow systems involves traditional saline seepage management. Affected areas are mostly quite small. They occur in response to discharge of low to moderate salinity groundwater in regions where rainfall is relatively high on a seasonal basis. Affected soils are quite wet in winter and quite dry (almost arid) in summer. Treatment involves fencing out affected areas and establishing salt-tolerant grasses such as Tall Wheat Grass, Puccinellia, Strawberry clover etc.

2.6.5 MANAGEMENT RECOMMENDATIONS

2.6.5.1 Implementation Opportunities

Implementation initiatives for this GFS will need to focus on groundwater interception and pumping options. Landholders will need significant technical support in identifying, locating and installing these options. Key components of an implementation strategy will include:

- Further trialing and validating groundwater pumping in different locations and with different methods including siphon pumping.
- Developing options and recommendations for water use including environmental flows, productive use and disposal of lower quality water:
- Providing technical support and incentives for groundwater pumping at rates set in the RCS for off-stream watering with additional incentives where water is provided for environmental flows.
- Providing environmental services payments and technical support to promote farm forestry opportunities for interception belts.
- WFP to context break of slope plantations in with the rest of the farm layout
- Promoting perennial plants on arable areas.

2.6.5.2 Research and Development Recommendations

- Investigate effectiveness of low volume groundwater pumping in salinity mitigation
- Investigate effectiveness of interception plantations on managing salinity
- Investigate impact of plantations and groundwater pumping on baseflow
- Most effective location of break of slope plantations/interceptor belts
- Understand linkage between this GFS and the upland colluvium

TABLE 19: MANAGEMENT RECOMMENDATIONS FOR LOCAL FLOW SYSTEMS IN WEATHERED GRANITE (HIGH RELIEF)

Option	Position in the landscape	Proportion of Landscape	Recharge reduction
Perennial plants	Arable lands on south and east aspects	At least 45%	15%
Improved management Native Pastures	Other aspects	At least 45%	15%
Groundwater interception belts	Break of slope above saline land	5 - 10 %	50%
Groundwater pumping	Mid slopes within colluvium	1 pump equivalent to approx 20ha of recharge control	10% per pump



2.7 LOCAL FLOW SYSTEMS IN DEEPLY WEATHERED GRANITE (LOW RELIEF)

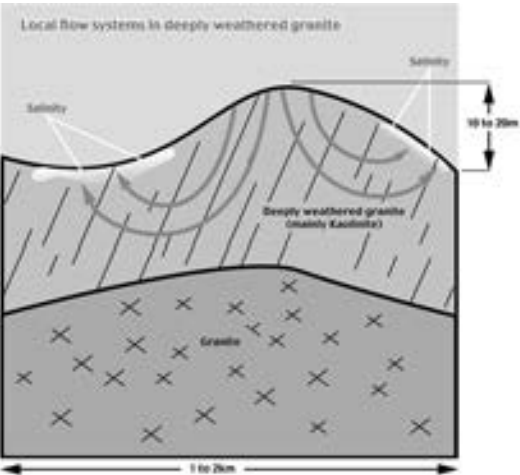
2.7.1 OVERVIEW

Local GFSs function within low relief granitic terrain in the upper Wimmera catchment.

The low relief of these otherwise granitic landscapes reflects deep weathering. The rock has been exposed to the elements over very long periods of geological time, and intensely decayed and chemically altered in the uppermost 20 to 50 metres. Much of the regolith (material above solid rock) is now formed of the decay products, largely kaolin rich clay. Chemical alteration, combined with erosion over long periods of time, has resulted in landscapes that are often quite subdued, and gently undulating.

These clay rich landscapes commonly contain appreciable amounts of salt. They are not easily leached of ions introduced through rainfall over the millennia. Salt accumulation occurs through salt exclusion in the root zone of deep-rooted native vegetation during transpiration.

FIGURE 17: CROSS-SECTION OF A LOCAL FLOW SYSTEM IN DEEPLY WEATHERED GRANITE (LOW RELIEF)



2.7.2 SALINITY PROCESSES

Groundwater flow through deeply weathered low relief granites is more sluggish, largely because the fine-grained regolith (material overlying solid rock) is poorly permeable (Stauffer 2000). Often the most permeable part of the landscape is the deepest parts of the regolith where weathering has been less complete. Here groundwater is able to migrate through cracks created by preferential mineral weathering.

Recharge occurs on the mid to upper slopes of sub-catchments and discharge occurs in valleys and at breaks of slope.

Recharge occurs generally throughout the catchment, and does not occur to a greater extent in areas where rock outcrops, as is the case in fractured rock systems.

TABLE 20: SNAPSHOT OF THE LOCAL FLOW SYSTEMS IN DEEPLY WEATHERED GRANITES (LOW RELIEF)

Total Area of System (ha)	9,876
Percentage of Wimmera Region	0.4%
Area of Mapped Discharge (ha)	35
Discharge as % of System	0.4%
Discharge as % of Wimmera salinity	0.2%
Woody Vegetation	1,099
% of GFS	11.1%

2.7.3 ASSET THREATS

These landscapes commonly contain appreciable amounts of salts and are considered a major contributor to Wimmera River saltloads. They also pose a potential risk to surface water quality, which is a significant asset in many of these areas. Some early signs of urban salinity exist around the township of Stawell.

2.7.4 MANAGEMENT OPTIONS

2.7.4.1 Biological

Perennial plant options might be effective where rainfall is less than about 600 mm. Again, as with high relief granites, significant issues with soil acidity and soil fertility must be addressed. Opting to improve management of native grass pastures may ultimately prove more efficient.

Considerable subdivision/rural lifestyle farming occurs in these areas. Many of these people will not be interested in pasture improvement given the associated management and labour inputs. It is likely to be more effective to target agro-forestry opportunities at these landholders.

Targeted tree planting affords a moderate benefit where tree belts can be established as interceptor belts on lower slopes (Clifton and Dyson 1998). Trees with a higher level of salt tolerance are required, and should be established parallel to the slope immediately above groundwater discharge zones. It is necessary to ensure that belts are established a few metres in elevation above discharge sites to avoid saline water logging and salt accumulation in the root zone.

2.7.4.2 Engineering

Groundwater pumping is only likely to be effective where low volume groundwater pumping might be applied to protect high value assets.

Generally, the low transmissivity of granite landscapes is problematic when considering traditional groundwater pumping options. Low volume groundwater pumping using air lift technology has been used with some success in these circumstances. Saline groundwater disposal remains an important issue when planning to undertake dewatering of saline landscapes.

In lower slope areas better management of drainage is considered important to reduce effects of run-off onto salt-affected lands.

2.7.4.3 Living With Salinity

Treatment involves fencing out affected areas and establishing salt-tolerant grasses such as Tall Wheat Grass, Puccinellia, Strawberry clover etc.

2.7.5 MANAGEMENT RECOMMENDATIONS

TABLE 21: MANAGEMENT RECOMMENDATIONS FOR LOCAL FLOW SYSTEMS IN DEEPLY WEATHERED GRANITES (LOW RELIEF)

Option	Position in the landscape	Proportion of Landscape	Recharge Reduction
Native Pastures	mid to upper slopes	At least 45%	23%
Perennial plants	mid to lower slopes	At least 45%	23%
Interceptor belts (agro-forestry)	Breaks of slope above saline lands	5-10%	30%

2.7.5.1 Implementation Opportunities

Many implementation initiatives for this GFS will be similar to those required for the high relief granite GFS. The focus in the low relief granites will be on establishing perennial plants and agro-forestry interceptor belts. Key components will:

- Provide environmental service payments and technical support to promote farm forestry opportunities for interception (break of slope) belts.
- Promote perennial plants on arable areas for larger scale commercial landholders.
- Provide incentives for groundwater pumping to protect high value assets.

2.7.5.2 Research and Development Recommendations

Investigate the extent to which saltloads can be managed through alternative land and water management

2.8 LOCAL FLOW SYSTEMS IN HIGHLY FRACTURED ROCKS

2.8.1 OVERVIEW

Much of the Wimmera uplands comprise folded and fractured sedimentary and metamorphic rocks, often referred to as metasediments. The fractured rock behaves as an aquifer with capacity to store and transmit groundwater (Dyson 1983).The groundwater system operates within rock open fractures, which are generally restricted to the upper 50 to 100 metres of the landscape.

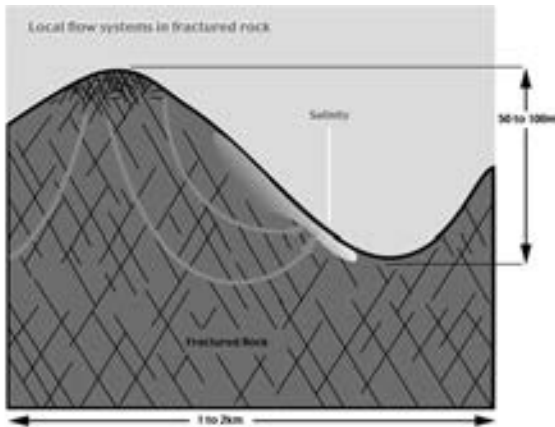
Where there is substantial relief (greater than 50 metres) the fractured rock aquifer breaks into local flow cells associated with each hill or range. Under these circumstances aquifer permeability follows the general shape of the landscape.

Groundwater movement through the steeper hills is restricted by less permeable rocks in the hill cores.

2.8.2 SALINITY PROCESSES

The aquifer is steeply inclined as is the hydraulic gradient driving groundwater flow. Where the land surface slope substantially reduces in the footslopes the reduction in hydraulic gradient frequently results in groundwater discharge. This occurs because the reduced gradient allows for more groundwater to flow into the break of slope, than can flow beyond it.

FIGURE 18: CROSS-SECTION OF A LOCAL FLOW SYSTEM IN FRACTURED ROCK



Where the groundwater is saline, as is often the case in these sedimentary rocks, saline seeps may develop from increased recharge following native vegetation clearing and agricultural pursuits.

Groundwater recharge occurs seasonally, over the winter period. More rainfall than evaporation during this period results in both run-off and infiltration, and where infiltration exceeds the soil's water-holding capacity, deep percolation to the underlying fractured rock adds to groundwater volume. This process tends to operate throughout the landscape where native vegetation has been removed, but is usually more significant locally on upper slopes and crests where soils are shallow and very permeable.

**TABLE 22: SNAPSHOT OF THE LOCAL FRACTURED ROCK GROUNDWATER FLOW SYSTEMS**

Total Area of System (ha)	39,065
Percentage of Wimmera Region	1.7%
Area of Mapped Discharge (ha)	15
Discharge as % of System	0.0%
Discharge as % of Wimmera salinity	0.0%
Woody Vegetation	17,363
% of GFS	44.4%

### 2.8.3 ASSET THREATS

This GFS is considered to make a significant contribution to Wimmera River saltloads and poses a threat to riparian vegetation along many creeks and tributaries.

The discharge areas although relatively small threaten high value agricultural land including vineyards.

### 2.8.4 MANAGEMENT OPTIONS

#### 2.8.4.1 Biological

Local fractured rock aquifer systems lend themselves well to treatment for salinity mitigation. They are moderately permeable, generally comprise groundwater at the lower end of the range of salinities that effect degradation, and together with steep hydraulic gradients comprise systems considered highly “responsive”. That is, they should respond well and quickly to changes in land management that effect a lower recharge.

The main options for recharge reduction are:

- Regenerating and establishing native trees/shrubs on non-arable upper slopes and hill crests.
- Retaining and enhancing native pastures tolerant of soil acidity and summer drought in the mid slopes, and establishing more traditional introduced perennial plants in more productive regions of the lower slopes.

Note: The extent to which native pastures will mitigate recharge in this terrain remains largely unknown. They are recommended on the basis that they afford a perennial plant option offering persistence in the face of adverse soil with poor water-holding capacity and extreme soil acidity.

Selective revegetation of discrete parts of the catchment probably afford the greatest opportunity for salinity management, with the added potential advantage of meeting broader natural resources management targets. Areas to be targeted would include those zones where excessive groundwater recharge in non-arable lands comprises a significant part of the landscape. Eg Slopes >20% as in the Wimmera Steep Hill Country Plan.

Some fractured rock systems might lend themselves to plantation forestry, (on slopes of >20% other issues with harvesting, roads and soil loss that limit the application of farm forestry to these terrains) particularly in higher rainfall areas. This activity would need to be pursued with some degree of caution, as the resulting reduction in run-off associated with the forestry may reduce water yield to the broader catchment, and even enhance stream salinity through reduction in dilution flows.

#### 2.8.4.2 Engineering

In many instances groundwater associated with local fractured rock aquifers is not highly saline, particularly within the mid to upper slope regions. Equally the fracture permeability provides some opportunity for limited groundwater harvesting for stock and domestic purposes. In some instances even very small scale irrigation may be possible. Aquifer dewatering through groundwater pumping is, thus, a salinity management option, particularly where extracted groundwater can be used to supplement farm water supplies and provide some limited economic advantages within a farming operation.

#### 2.8.4.3 Living With Salinity

Relatively high rainfall and low groundwater salinity produces groundwater seepages that are most frequently at the wetter and less saline end of the soil salinity spectrum. These areas lend themselves well to treatment with more traditional salt-tolerant grasses such as Tall Wheat Grass, Puccinellia, Paspalum, Strawberry Clover etc.



**Steep ridge, shallow soils, high recharge area east of Elmhurst.**

2.8.5 MANAGEMENT RECOMMENDATIONS

TABLE 23: MANAGEMENT RECOMMENDATIONS FOR LOCAL FRACTURED ROCK GROUNDWATER FLOW SYSTEMS

Option	Position in the landscape	Proportion of Landscape	Recharge Reduction
Revegetation/ regeneration Trees/shrubs on high recharge lands	>20% slope	10-20 %	24%
Native pasture	Steeper hill slopes(10-20% slope)	50-60 %	21%
Introduced high input perennial plants	Lower slopes (10-20%) in the more productive lands - south and east aspects	10 - 20%	5%
Groundwater pumping	Lower slopes	Asset protection and augment farm water supplies	
Saline agriculture	Salt affected lands	100% of affected areas	

2.8.5.1 Implementation Opportunities

Clear off-site impacts exist in this GFS particularly with water quality. Incentives will play a key role in facilitating land use and management change. The need to tailor-management options to different parts of the landscape will necessitate working with individual landholders to assess options and develop action plans.

The key components of an implementation strategy will include:

- Communicating GFS principles, highlighting the potential to have a local impact.
- A community facilitator/technical resource to work with and support landholders in developing management plans.
- Environmental service payments.
- Encouraging contracting services to provide skills and labour necessary for implementation.
- Further research and investigation of potential for native pastures, salt-tolerant native grasses and the economics and environmental costs of off-site impacts.
- Developing detailed GFS maps for the area (1:25,000) to be included in extension materials.

2.8.5.2 Research and Development Recommendations

Understanding the ability of native grasses to manage groundwater recharge to fractured rock aquifers.



Groundwater levels more than one metre above ground surface, Frenchmans.

2.9 INTERMEDIATE GROUNDWATER FLOW SYSTEMS IN FRACTURED ROCKS

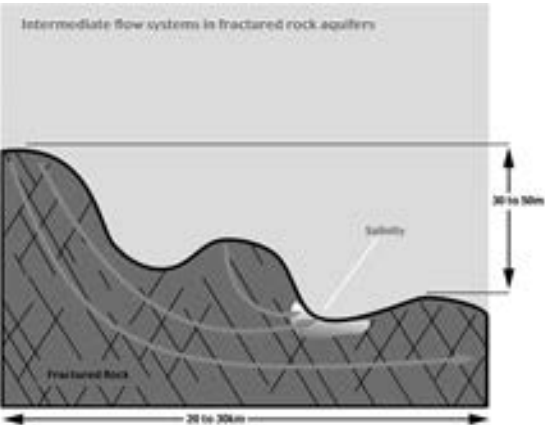
2.9.1 OVERVIEW

Intermediate GFSs occur within fractured sedimentary rocks of the Great Dividing Ranges where deep weathering is absent and relief is less steep. Groundwater is able to flow uninterrupted through the rock fractures over considerable distances, perhaps as much as 20 to 30 kilometres or more (Dyson 1983). Intermediate systems will often partially discharge within the upper catchments, particularly where the regional hydraulic gradient changes immediately below catchment headwaters. The highly folded and fractured sedimentary rocks of the upper Wimmera catchment contain vast amounts of salt stored within the rock matrix. This diffuses into the groundwater, giving it a salinity ranging from as little as 3,000 mg/l to more than 12,000 mg/l.

As in other regions throughout southern Australia groundwater has risen in response to land clearing over the past 150 years. The increase in groundwater discharge through fractured rock aquifers of the uplands has resulted in substantial increases in stream saltloads. Many streams now export in more than 5000 tonnes of salt each year from catchments that are less than a hundred square kilometres in area.

The saltload from many catchments comprising fractured rock ranges from 200 to 600 Kg/Ha per year. This is at least an order of magnitude greater than the mass of salt introduced annually through rainfall.

FIGURE 19: CROSS-SECTION OF AN INTERMEDIATE FLOW SYSTEM IN FRACTURED ROCKS



2.9.2 SALINITY PROCESSES

Groundwater recharge in the sub-catchments that comprise intermediate groundwater systems typically occur (although not exclusively) in the non-arable rocky headwaters that tend to characterise this terrain. Here the fractured rock aquifer either outcrops or is overlain by shallow skeletal soils of high permeability and low water-holding capacity. Annual groundwater fluctuations may be as great as five to six metres per year in response to seasonal rainfall.

2.9.3 ASSET THREATS

This GFS provides base flow water to some streams within the upper catchment and as such does contribute to saltloads. The contribution is not as significant as from the local fractured rock and deeply weathered fractured rock GFSs. There is a limited threat to agricultural land.

TABLE 24: SNAPSHOT OF THE INTERMEDIATE FRACTURED ROCK GROUNDWATER FLOW SYSTEMS

Total Area of System (ha)	65,617
Percentage of Wimmera Region	2.8%
Area of Mapped Discharge (ha)	177
Discharge as % of System	0.3%
Discharge as % of Wimmera salinity	0.8%
Woody Vegetation	7,752
% of GFS	11.8%

2.9.4 MANAGEMENT OPTIONS

2.9.4.1 Biological

Management strategies that attempt to control soil salinity and stream salinity in intermediate fractured rock groundwater systems are proving to be problematic. The difficulty arises for several reasons: Firstly the groundwater systems are large and in general watertables are already well elevated across most cleared catchments. Substantial down-basin groundwater flow already occurs and this will continue for some time irrespective of recharge control.

Secondly recharge is typically highest in poorly-arable, often skeletal soils of the catchment headwaters. Recharge management in these regions proves difficult, other than through revegetation. Low water-holding capacity of the soils, combined with summer drought, low fertility, and extreme acidity issues combine to create a very hostile environment for most agricultural pursuits.

Large-scale regeneration and revegetation of the non-arable rocky headwaters offers, perhaps, the greatest opportunity for salinity management within intermediate fractured rock systems. This is obviously outside most farmers' social and economic realm.

2.9.4.2 Engineering

Groundwater pumping affords an opportunity for localised salinity management in the intermediate fractured rock systems. It is usually possible to construct groundwater wells that will yield 3 to 4 litres a second, and in some instances as much as 20 to 30 litres a second. Disposal of saline groundwater is an issue, and would most likely require some form of evaporative basin.

2.9.4.3 Living With Salinity

Living with salt options present a range of alternatives ranging from establishing salt-tolerant grasses such as Tall Wheat Grass and Puccinellia, to potential small-scale aquaculture. In most intermediate GFSs the area of salt-affected land is small compared with the size of the catchment. The issue is more one of salt export via groundwater baseflow from streams rather than degradation of vast tracts of soils used for agricultural production.

2.9.5 MANAGEMENT RECOMMENDATIONS

2.9.5.1 Implementation Opportunities

An implementation opportunity for this GFS would largely focus on revegetating non-arable rocky headwaters. The major benefit of such revegetation will occur off site and incentives will be necessary to encourage change. Key components include:

- Environmental service payments.
- Using the community facilitator approach to raise community awareness, get landholders involved and identify areas for revegetation.
- Providing technical and labour support to revegetate areas and ongoing management support.

TABLE 25: MANAGEMENT RECOMMENDATIONS FOR INTERMEDIATE GROUNDWATER FLOW SYSTEM IN FRACTURED ROCKS

Option	Landscape position	Required adoption
Revegetation/ regeneration	Non-arable rocky headwaters	Large areas of catchment headwaters
Groundwater pumping	Where asset protection is required	In accordance with the requirement for protection of assets
Saline agriculture	Salt-affected lands	100% of affected areas

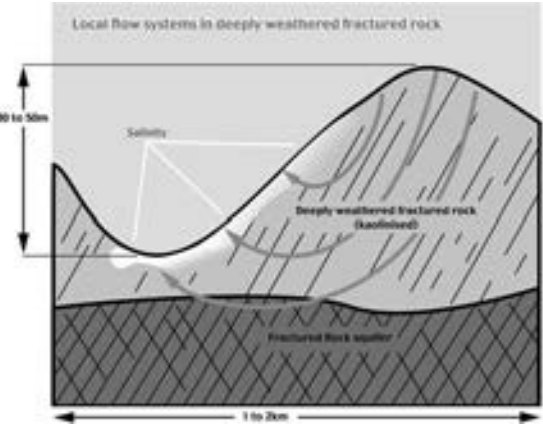


2.10 LOCAL AND INTERMEDIATE SYSTEMS IN DEEPLY WEATHERED FRACTURED ROCKS

2.10.1 OVERVIEW

Large areas of the upper Wimmera share the same fractured sedimentary and metamorphic fractured rock geology and comprise local and intermediate GFS throughout the uplands. In some places, much older landscapes are superimposed. Deep weathering of the land surface during either late Mesozoic or early Tertiary times, perhaps some 60 million years before present, chemically altered the rocks to a point where most of the minerals decayed and left behind a mixture of bleached kaolinite (often known as the pallid zone) and layers of iron oxides (laterite). This chemical alteration (deep weathering) persisted to depths of at least 50 to 100 metres, and was once widespread throughout the region. Erosion has removed most of these old land surfaces from the uplands. They persist, as residuals, in some areas and many of these occur throughout the upper Wimmera catchment. They are easily recognised, as they often appear as “benches” or flat-topped ridges. They are also evident from road cuttings and outcrops through the presence of bleached kaolin rich clays and ironstone.

FIGURE 20: CROSS-SECTION OF A LOCAL FLOW SYSTEM IN DEEPLY WEATHERED FRACTURED ROCK



Extensive deep weathering depletes the fracture network that otherwise gives the rock its capacity to transmit groundwater. Deeply weathered systems are much less permeable than fresh fractured rock systems. This lack of permeability causes saline groundwater to discharge more readily because the aquifer does not have the capacity to transmit large amounts of groundwater over large distances. Deep weathering is also significant because the residual kaolin rich clay provides an excellent fine-grained porous medium for storing salts introduced through rainfall over millennia. Salt stores in the deeply weathered rocks of the upper Wimmera catchment are very high as is groundwater found in them; often almost as saline as sea water.

1.10.2 SALINITY PROCESSES

Deeply weathered fractured rock systems are somewhat complex (Jenkin and Dyson 1983). The deeply weathered regolith overlies otherwise fractured rock at depth. This means the system behaves in two distinct ways. Firstly a very local sluggish GFS may operate in the deeply weathered regolith to produce simple recharge discharge cells causing small areas of salinity at many different elevations. Secondly saline groundwater from the regolith percolating to the underlying fractured rock is transmitted down-slope to the lower landscape. Here groundwater pressures rise and the deeper system becomes sub-artesian forcing saline groundwater to the land surface. Recharge occurs generally throughout the landscape, but can be much higher where the fractured rock aquifer underlying the saprolite is exposed through erosion in the upper slopes and crests.

TABLE 26: SNAPSHOT OF THE LOCAL AND INTERMEDIATE FLOW SYSTEMS IN DEEPLY WEATHERED FRACTURED ROCKS	
Total Area of System (ha)	64,225
Percentage of Wimmera Region	2.7%
Area of Mapped Discharge (ha)	179
Discharge as % of System	0.3%
Discharge as % of Wimmera salinity	0.8%
Woody Vegetation	11,587
% of GFS	18.0%

2.10.3 ASSET THREATS

This GFS is a major contributor to saltloads and is responsible for most salt originating from the upper catchment. Locally it poses a threat to Green's Swamp and is the cause of small areas of saline discharge on agricultural land.

## 2.10.4 MANAGEMENT OPTIONS

### 2.10.4.1 Biological

A good deal of the land that comprises deeply weathered fractured sedimentary rocks is used for cereal crop production. There appears to be little opportunity within a normal annual cropping cycle, whether under traditional fallow or conservation tillage, to reduce groundwater recharge to a point where the practice has value in salinity mitigation.

Instead some form of crop cycle that involves a deep-rooted higher water using perennial plant in the rotation is required. This might involve several years of perennial plant production followed by cropping, or even practices that allow both cropping and pasture to co-exist.

The difficulty with biological control of recharge in deeply weathered terrain, is slow response of the GFS that does not easily drain and recede following treatment. Reducing recharge may result in reduced groundwater heads within the catchment, but any reduction in groundwater head will take a long time to translate into a salinity benefit for salt-affected areas of the lower catchment. Experience suggests such lag times are likely to be at least 10 to 20 years.

Where the topsoil (gravel or clay) has been stripped from the upper landscape to expose the fractured rock aquifer, significant recharge zones may occur on upper slopes and crests. Revegetation might be a more permanent solution than perennial plants in these areas.

### 2.10.4.2 Engineering

Whilst it is possible to extract groundwater through pumping from deeply weathered fractured terrain, it has to date proved a less practical option, largely because of difficulties in disposing high salinity groundwater (often greater than 15,000mg/l) and low yield due to low permeability. Difficulties in locating sufficient fractures below the regolith can also make pumping technically unfeasible. The option would have some appeal where high value assets are to be protected, or if some enterprise was able to use the saline groundwater.

### 2.10.4.3 Living With Salinity

The salinity of saline groundwater discharge in combination with summer drought and winter waterlogging often make establishing salt tolerant grasses on high salinity deeply weathered terrain quite challenging. Tall Wheat Grass and Puccinellia can usually be established around margins of saline discharge sites, but considerable time and care is needed to achieve even moderate levels of establishment. Stock exclusion is essential in early stages of establishment, and careful grazing is essential thereafter.

Options that include saline enterprises, other than grazing, afford opportunities for entrepreneurs, but as yet few have been adopted in this terrain. Sufficient saline groundwater exists in most regions to establish enterprises such as saline aquaculture, and production of seaweed but practical research is insufficient to prove technical feasibility and niche market potential.

Many saline lands in the deeply weathered foothills also have some potential for halophyte production either for forage production, or perhaps in future, grain production (Distichlis). The farming community has little confidence in growing these salt-loving plants, largely because those who have attempted trials have experienced failures, most caused by adopting unsuited species or difficulties with agronomy.

## 2.10.5 MANAGEMENT RECOMMENDATIONS

### 2.10.5.1 Implementation Opportunities

Implementation opportunities for this GFS focus on encouraging establishment of lucerne pastures and/or use of lucerne phases with cropping rotations. This will require landholders to increase grazing enterprises and/or consider opportunities for commercial hay or seed production, which raises many lifestyle, labour and farm management issues. Key components of an implementation strategy could include:

- Providing technical advice and information to support establishing and managing perennial and lucerne pastures.
- Establishing field size demonstration sites with Landcare/community group involvement to trial management options.
- Full analysis of demonstration sites including productivity, economics, time and labour requirements, and groundwater impacts.
- Incentives to establish perennial plants.

### 2.10.5.2 Research and Development Recommendations

- Understanding flow cells and management strategies for fractured rock systems
- Impact of gravel extraction and kaolin mining on groundwater

**TABLE 27 MANAGEMENT RECOMMENDATIONS FOR LOCAL AND INTERMEDIATE GROUNDWATER FLOW SYSTEMS IN DEEPLY WEATHERED FRACTURED ROCKS**

Option	Location in the landscape	Proportion of Landscape	Recharge Reduction
Trees and shrubs	Upper slopes/ high recharge areas	<10%	12%
Perennial plants	mid to lower slopes	At least 44%	14%
Inter-cropping with lucerne pastures	mid to lower slopes	At least 40%	7%
Saline agriculture	Salt-affected lands	50% of affected areas	
Groundwater pumping	Lower landscape	As required to protect assets	

2.1.1 INTERMEDIATE FLOW SYSTEMS IN ALLUVIAL PLAINS

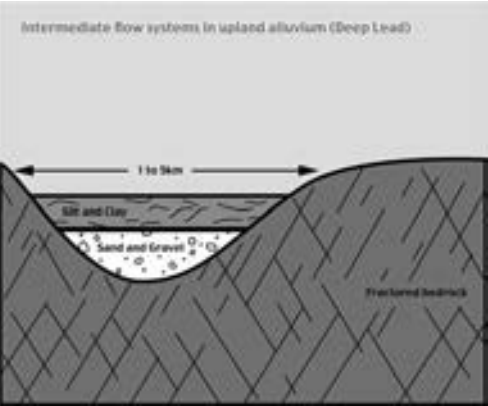
2.1.1.1 OVERVIEW

These GFSs occur within large tracts of alluvial sediments in valley floors and terraced floodplains of many major valleys in uplands of the Wimmera Catchment (Harrison 1993, and Macumber 1992). The alluvial sediments comprise a mix of coarse sand and gravel lying buried beneath clay and silt that form the contemporary floodplains.

2.1.1.2 SALINITY PROCESSES

Groundwater recharge occurs on the floodplain, either through seasonal deep drainage from soils used for agriculture, or through deep drainage below river systems and other surface water bodies.

FIGURE 21: CROSS-SECTION OF AN INTERMEDIATE FLOW SYSTEM IN ALLUVIAL PLAINS



In other regions of Victoria, these systems cause salinity through increased down-basin groundwater flow following agricultural development. Increased recharge causes more groundwater to be transported down-basin than that which can be accepted through flow into other systems. The consequence is a build up of groundwater pressures that ultimately lead to artesian conditions and development of saline groundwater discharge. The significance of down-basin groundwater flow to salinity within Wimmera valleys in future is uncertain. The groundwater system certainly appears active within the Mt. William Creek catchment, and it is probable that it may threaten salinity in other large valleys.

2.1.1.3 ASSET THREATS

Uncertainty surrounds the contribution of this GFS to saltloads in the Wimmera River. The system does pose a threat to water quality in Lake Lonsdale and is the cause of a large number of discharge areas on the associated floodplains.

TABLE 28: SNAPSHOT OF THE INTERMEDIATE GROUNDWATER FLOW SYSTEM IN ALLUVIAL PLAINS	
Total Area of System (ha)	200,615
Percentage of Wimmera Region	8.6%
Area of Mapped Discharge (ha)	4,495
Discharge as % of System	2.2%
Discharge as % of Wimmera salinity	20.7%
Woody Vegetation	24,570
% of GFS	12.2%

2.1.1.4 MANAGEMENT OPTIONS

2.1.1.4.1 Biological

Biological management of recharge is difficult in these systems because of the large scale at which they operate, and because they contain appreciable amounts of groundwater already involved in down-basin groundwater flow. Large-scale adoption of lucerne might afford some opportunities for salinity management where treatments are used with groundwater pumping. It is unlikely that a plant-based solution alone will be sufficient to realise salinity benefits within acceptable timeframes. Large scale timber plantations offer some potential as a control mechanism. Hobby farmers and others could potentially increase the level of plantation development for firewood production.

2.1.1.4.2 Engineering

Groundwater pumping affords opportunities for watertable management where local protection is required for high value assets, and may also be an option where water resources are required for industry. For example there may opportunities to tap into the Landsborough Deep Lead. Water quality is highly variable and allowances must be made for safe disposal of any saline groundwater.

2.1.1.4.3 Living With Salinity

A range of salt-tolerant plants is available for use on saline lands within upland alluvial valleys. These include species such as Tall Wheat Grass, Puccinellia, Strawberry Clover, etc. The volume of water available and presence of an aquifer that can be pumped also affords opportunities for a range of alternative and somewhat boutique industries, including saline aquaculture, and the production of alginate. Additional information on potential saline industries is available from the OPUS (Options for Productive Use of Salinity) web site, which can be accessed via the National Dryland Salinity Program's web page at [www.ndsp.gov.au](http://www.ndsp.gov.au).

2.11.5 MANAGEMENT RECOMMENDATIONS

TABLE 29: MANAGEMENT RECOMMENDATIONS FOR INTERMEDIATE GROUNDWATER FLOW SYSTEMS IN ALLUVIAL PLAINS

Option	Position in landscape	Proportion of Landscape
Large scale Lucerne	Floodplains	Greater than 50%
Tree plantations Groundwater pumping	Floodplains where assets are to be protected Potential for further pumping from Landsborough Deep Lead for Industry development	Consistent with aquifer development
Salt-tolerant grasses	Salt-affected areas	Established over 100% of affected area

2.11.5.1 Research and Development Recommendations

- Review salt and water balance for upland alluvial systems
- Local investigations to ascertain groundwater status at the juncture of the aquifers with the regional Parilla Sand aquifer
- Geophysical surveys to map sub-surface structures



Low salinity groundwater seeping from alluvial sediments, Joel Joel.

2.12 LOCAL FLOW SYSTEMS IN COLLUVIUM (GRAMPIANS SANDSTONE)

2.12.1 OVERVIEW

Large outwash fan deposits occur on foot-slopes of the Grampians Ranges, and form colluvial aprons that inter-finger with alluvial sediments from the adjacent floodplains. The fine-grained sands comprising the colluvium are derived from weathering and erosion of the Grampians sandstone. The outwash deposits form local GFSs that receive seasonal recharge from winter rainfall, and from inflows of groundwater from the Grampians sandstone. Flow through the colluvium carries groundwater from foothill slopes to the plains below. Groundwater discharge from the colluvium as small seepages and springs at the base of the foot-slopes. In some instances it flows from the colluvium out into floodplain where it partially recharges alluvial aquifers.

FIGURE 22: CROSS-SECTION OF A LOCAL FLOW SYSTEM IN COLLUVIUM

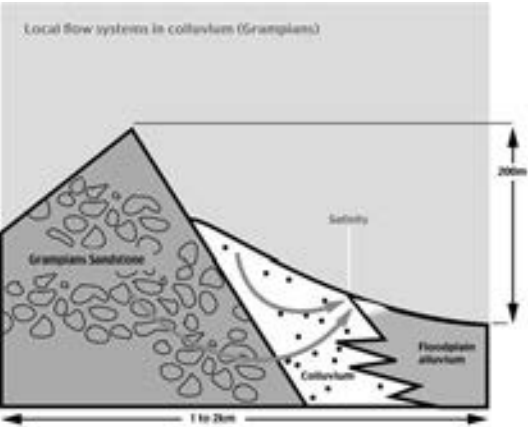


TABLE 30: SNAPSHOT OF THE LOCAL FLOW SYSTEMS IN COLLUVIUM (GRAMPIANS SANDSTONE)

Total Area of System (ha)	67,332
Percentage of Wimmera Region	2.9%
Area of Mapped Discharge (ha)	6
Discharge as % of System	0.0%
Discharge as % of Wimmera Salinity	0.0%
Woody Vegetation	59,945
% of GFS	89.0%

## 2.12.2 SALINITY PROCESSES

Salt stores in the colluvium are generally low, and the groundwater salinity is seldom greater than 2000 EC (us/cm). Salinity most commonly manifests as small seepages which cause some loss in agricultural production.

Groundwater discharge has, to some extent, always occurred at the base of the colluvium, even under native vegetation. Indeed, small springs commonly occur either within or immediately beyond the margins of the Grampians National Park. Recharge and discharge, appear to have been enhanced where the colluvium has been cleared of native vegetation and developed for agriculture.

## 2.12.3 ASSET THREATS

The water within this GFS is of relatively low salinity and could potentially be a future resource. The system has a minor impact on saltloads in the river system and poses a small threat to agricultural land.

## 2.12.4 MANAGEMENT OPTIONS

### 2.12.4.1 Biological

Where salinity issues pose a significant problem, several management strategies may be considered. Firstly, the perched nature of groundwater; particularly the prevalence of fresh shallow groundwater; implies that suitable vegetation banks with some capacity to act as phreatophytes (vegetation that can use groundwater for transpiration) might be deployed to lower the watertable in, or immediately upslope, of affected areas. This might involve re-establishing areas of native vegetation, or in some instances, possibly developing timber plantations. Perennial plants may also afford sufficient change in the water balance to ameliorate-affected lands, although significant soil acidity and soil fertility issues may need to be addressed.

### 2.12.4.2 Engineering

Low volume groundwater pumping may be deployed to lower the elevation of groundwater in or near affected areas. This option has an added advantage in that the extracted groundwater may be used to supplement stock and domestic water supplies.

### 2.12.4.3 Living With Salinity

A wide range of salt-tolerant grasses may be deployed to gain production from moderately affected sites. Among the commonest of these are Tall Wheat Grass and Puccinellia.

## 2.12.5 MANAGEMENT RECOMMENDATIONS

### 2.12.5.1 Research and Development Recommendations

- Understand the contribution of this system to other GFS and the impact it has on water supply to the key water catchments in the Wimmera



**Grampians colluvium GFS.**

**TABLE 31: MANAGEMENT RECOMMENDATIONS FOR LOCAL FLOW SYSTEMS IN COLLUVIUM GROUNDWATER FLOW SYSTEMS**

Option	Position in Landscape	Proportion of Landscape	Recharge Reduction
Perennial plants	Throughout the landscape above seepage	Up to 90%	47%
Interception plantations or woodlots	Immediately upslope of affected areas	5-10 %	53%
Groundwater pumping	Immediately above affected areas	Dependent on R&D	
Salt-tolerant grasses	On affected areas	All of affected area	



### 3.1 VISION

#### 3.1.1 INTRODUCTION

The Wimmera RCS identifies nine major groups of catchment assets, of these the following six are considered to be most at risk from salinity:

1. Wetlands and streams of the Wimmera River Basin
2. Terminal lakes of the Wimmera River Basin
3. Agricultural land
4. Wetlands and streams of the Millicent Coast Basin
5. Remnant vegetation
6. Groundwater

The steering committee has identified an initial 20-year vision for each of these asset groups. These visions portray the ideal outcome of successful salinity management in the region over the next 20 years. This plan provides detailed direction for the first five years of the task.

#### 3.1.2 STREAMS OF THE WIMMERA RIVER BASIN

The vision is for an ecologically-healthy Wimmera River with sustainable environmental flows and water quality sufficient for recreation, stock and domestic purposes and able to sustain viable populations of native flora and fauna. As a result, the community will again be able to observe species that are an indicator of river health such as platypus.

A major engineering program in the lower Wimmera will be a significant part of achieving this vision, as will the return of substantial environmental flows to the river as a result of implementing the Wimmera Mallee Pipeline Project.

#### 3.1.3 TERMINAL LAKES

As a result of the improved health of the streams of the Wimmera River Basin the environmental values of the terminal lakes ecosystems will improve providing the opportunity for:

- Return of tourism to these areas;
- Vibrant recreational fishing;
- Regular sailing events;
- An overflow regime into Albacutya and beyond that is close to the natural regime; and
- Healthy vegetation and increased biodiversity.

#### 3.1.4 WETLANDS AND STREAMS OF THE MILLICENT COAST BASIN

The Wimmera wetlands will be recognised locally, nationally and internationally for their function, health, uniqueness, diversity, and ability to support a diverse range of flora and fauna. These wetlands will be of significant environmental, cultural and economic value to the community and will support initiatives such as:

- An ecotourism industry based on wetland systems and wilderness values;
- An educational centre.

#### 3.1.5 AGRICULTURAL LAND

The productivity of agricultural land in the Wimmera Region will improve while its capacity to accommodate a range of different industries has been maintained. A better understanding of the social structure, needs and priorities of the region will allow implementation and communication programs to be tailored to address gaps in adoption through means other than just cash payments. Landholders in the region will have the capacity to operate without subsidies and their management practices will:

- More closely match land capability with land use.
- Use more water where it falls and reduce contributions to recharge.
- Deal with local and intermediate GFSs.
- Reduce and eliminate off-site impacts.
- Be recognised socially and financially for the environmental services that they provide.
- Capture opportunities for producing product from saline resources.

#### 3.1.6 REMNANT VEGETATION

Remnant vegetation will be recognised for both its intrinsic value and importance it has in mitigating land degradation issues. Native vegetation will be managed sustainably to maintain biodiversity and provide a healthy catchment to allow people opportunities to live, work and prosper. There will be a reversal, across the entire landscape, of the long-term decline in the extent and quality of native vegetation in the Wimmera Catchment Region, leading to a Net Gain of native vegetation.

#### 3.1.7 GROUNDWATER

Through sustainable groundwater use, groundwater quality in the limestone aquifer will be maintained to ensure sustainable supply for current and future domestic (including human consumption), stock and irrigation.

## 3.2 INVESTMENT CLASSIFICATION OF GROUNDWATER FLOW SYSTEMS

### 3.2.1 INVESTMENT CLASSIFICATION FRAMEWORK

#### 3.2.1.1 Groundwater Flow System Characteristics

Each GFS in the Wimmera was assessed on the basis of the following four key characteristics:

1. Asset threat - the contribution of the GFS to saltloads in the Wimmera River and/or threat posed to significant catchment assets.
2. Public Benefit - the proportion of benefits which accrue to the public from managing the GFS.
3. Capacity to influence - the technical, social and economic capacity of available management options to influence the GFS.
4. Timeframe - the timeframe required for management options to have a measurable impact on the GFS.
  - Very Short Term - 1 to 10 years
  - Short Term - 10 to 30 years
  - Medium Term - 30 to 50 years
  - Long Term - 50 to 100 plus years

#### 3.2.1.2 Investment Classifications

The investment classification for each GFS was then set on the basis of a mix of characteristics.

- Implementation (priority GFS for strategic public investment in implementation initiatives) - GFS is a major contributor to saltloads and/or poses a major threat to a significant asset. There is medium to significant capacity to influence the GFS in the short to medium term and benefits will largely accrue to the public.

- Research and Development - GFS is a major contributor to saltloads and/or poses a major threat to a significant asset. However there is limited capacity to influence the GFS and/or any influence will occur over the medium to long term; or
  - GFS is a medium contributor to saltloads and/or poses a medium threat to a significant asset and there is medium to significant capacity to influence the GFS in the short to medium term.
- Co-Investment - GFS is a medium to low contributor to saltloads and/or poses a medium to low threat to a significant asset, the timeframe for influence is in the medium to long term and/or the benefits largely accrue to private individuals. Future salinity management investment will focus on providing support to encourage and facilitate investment and implementation of works by private landholders and other funding sources. This could include investment in demonstration, communication and extension activities.

**Table 32 provides a summary of the investment classification of each GFS and rationale behind the classification. Further detail on the assessment against each GFS characteristic is provided in Table 33.**

**TABLE 32: INVESTMENT CLASSIFICATION OF WIMMERA REGION GROUNDWATER FLOW SYSTEMS**

Investment Classification	Groundwater Flow System	Rationale
Implementation	Local flow systems in deeply weathered granite (low relief) Local flow systems in highly fractured rocks Local and intermediate flow systems in deeply weathered fractured rock.	These GFSs pose a major threat to key assets, management options are relatively well understood and have the potential to influence the system in the short term. While there are still some R&D questions relating to these systems they would be the focus for public investment in implementation initiatives.
Research and Development	Regional flow systems in Parilla Sands Local flow systems in weathered granite (high relief) Intermediate flow systems in alluvial plains Local flow systems in colluvium (Grampians Sandstone)	While these GFSs pose significant threats to key assets there is limited capacity of current management options to influence these systems. If assets are to be protected in the long term management options will need to be developed for these GFSs. Therefore these systems will be the focus for public investment in R&D
Co-investment	Local flow systems in sand dunes (Lowan Sands) Local flow systems in Woorinen sediments Intermediate flow systems in fractured rocks	These systems pose limited threats to public assets, however available management options could have a significant influence in the very short term. Public investment in these systems should focus providing information and initiatives to facilitate private investment for private gain. These systems provide the potential for quick benefits for broader salinity management in the Wimmera region.

**TABLE 33: ASSESSMENT OF THE CHARACTERISTICS AND PRIORITY LEVELS OF GROUNDWATER FLOW SYSTEMS IN THE WIMMERA**

<b>GFS</b>	<b>Asset Threat</b>	<b>% Benefits Accruing to the Public</b>	<b>Capacity to Influence</b>	<b>Timescale for Influence</b>	<b>Investment Classification</b>
Local flow systems in sand dunes (Lowan Sands North)	Minor Some loss of agricultural land in depressions and limited threat to native vegetation	5%	Significant Some social constraints due to absentee landholders	Very Short Term	Co-Investment
Local flow systems in sand dunes (Lowan Sands South)	Minor to Medium Poses some threat to Lake Wallace, Edenhope water supply and Mosquito Creek	35%	Medium Not as well understood as the northern area. Limited community drive to tackle problem and a lack of infrastructure to tackle clay spreading	Very Short Term	Co-Investment
Local flow systems in Woorinen sediments	Minor Small areas of agricultural land and some remnant vegetation in low lying areas. Potentially some overland flow to creeks in wet years	10%	Medium to Significant Well understood technically but there are economic and social constraints to incorporating lucerne into cropping system	Very Short Term	Co-Investment
Regional flow systems in Parilla Sands	Major Major contributor of saltloads to the Wimmera River. Poses threats to wetlands in the region and Lake Hindmarsh. Cause of urban salinity in the Jeparit area.	90%+	Limited Major options involve engineering interventions and there are many R&D questions unanswered	Long Term	R&D
Regional flow systems in Parilla Sands (Millicent Coast Basin)	Medium to Major Poses threats to wetlands in Edenhope area, Lake Wallace and Mosquito Creek.	90%	Medium Potential for surface drainage and some revegetation opportunities	Short to Medium Term	Implementation /R&D
Local flow systems in weathered granites (high relief)	Minor to Medium Less salt in landscape so overall not a major contributor, however may pose a threat to some smaller creeks and tributaries. Some agricultural land threatened at break of slope	90%	Medium Groundwater interception is still in the trial phase and is capital intensive. Other options may reduce run-off in an area where surface water is a significant asset	Short Term	R&D
Local flow systems in deeply weathered granites (low relief)	Major Major contributor to saltloads and potential risk to surface water quality. Some early signs of urban salinity around Stawell	80%	Medium Much of the area has poor soils and granite outcrops which may limit the capacity to establish perennial plant and trees	Short to Medium Term	Implementation
Local flow systems in highly fractured rocks	Major Significant contribution to saltloads and threat to high value agricultural land, including vineyards. Also poses a threat to riparian vegetation	75%	Medium to Significant Further R&D required on the ability of native pastures to influence the system.	Short Term	Implementation
Intermediate flow systems in fractured rocks	Medium Making a contribution to saltloads but not as significant as other GFS. Threat to base flow water quality	90%	Limited Long flow paths and inertia in these systems. System not very well understood in the Wimmera	Long Term	Co-Investment
Local and intermediate flow systems in deeply weathered fractured rocks	Limited threat to agricultural land Major Contributes most of the salt originating from the upper catchment. Poses a threat to Greens swamp and is the cause of small discharge areas	70%	Medium Further R&D required to identify suitable locations for lucerne and interceptor belts and need to deal with economic and social constraints to lucerne adoption.	Short Term	Implementation

**TABLE 33 CONTINUED: ASSESSMENT OF THE CHARACTERISTICS AND PRIORITY LEVELS OF GROUNDWATER FLOW SYSTEMS IN THE WIMMERA**

GFS	Asset Threat	% Benefits Accruing to the Public	Capacity to Influence	Timescale for Influence	Investment Classification
Intermediate flow systems in alluvial plains	Medium Uncertain of the contribution to saltloads in the Wimmera River; but poses a threat to the water quality in Lake Lonsdale. Loss of large areas of agricultural land on the floodplains	75%	Medium Uncertainties remain about the scale and hydraulics of the system. R&D required to gain a better understanding of the system	Medium Term	R&D
Local flow systems in colluvium - (Grampians Sandstone)	Minor Some threat to agricultural land. Low EC water in the system is a potentially a resource which could be utilised in the future	25%	Significant Options available for plantation forestry and groundwater pumping	Short to Medium Term	Co-Investment

## 3.3 HOW IS IT ALL GOING TO HAPPEN?

The plan for the future is based on the following four major components:

1. Management Arrangements
2. Implementation Strategy
3. Research and Development Needs
4. Monitoring and Evaluation

### 3.3.1 MANAGEMENT ARRANGEMENTS

#### 3.3.1.1 Current Arrangements

Management of the previous Wimmera Catchment Salinity Plan was co-ordinated through the CMA with funding allocations and monitoring of implementation undertaken by the Land Issues FC. Technical expertise and services to support implementation were provided by the Catchment and Agricultural Services division of DPI and hydrogeological support was provided by CLPR and SKM.

To support the review of the previous plan and development of a second generation plan a steering committee has been established which includes representatives from:

- Wimmera CMA Board
- Land Issues Committee
- DPI
- Wimmera CMA staff
- Grampians Wimmera Mallee Water Authority
- Hydrogeological input from CLPR and SKM on an as-needed basis

This steering committee has provided a forum for the range of potential stakeholders/providers in the new plan. The group has shared knowledge and understanding, developed ownership of the process and, as such, provides a useful model for future management arrangements.

#### 3.3.1.2 Future Management Model

The proposed model builds on strengths of the current management arrangements and strengthens the steering committee's role in providing technical direction. The key components of this management model are:

##### CMA

Set catchment priorities through the RCS, establish budgets, co-ordinate implementation of the plan by providing executive support to the Land Issues FC, monitor strategic direction and communicate to stakeholders and providers.

##### Land Issues Functional Committee

Receive advice and project bids from the technical group, allocate funds against priorities, provide advice to CMA during priority setting process, provide direction to the Technical Group and monitor implementation against targets.

##### Technical Working Group

Consisting of DPI, Hydrogeological providers, Land Issues FC, Program Manager and Research Manager. The group would meet 3-4 times per year to share information/ideas across disciplines, develop joint understanding, resolve technical issues, provide advice to Land Issues FC and ensure technical merit of project bids submitted to this committee.



**Staff involved in plan implementation on a field tour inspecting groundwater pumping near Jeparit.**

### Research and Implementation Working Groups

On an as-needed basis, small groups may come together to work through a specific research or implementation issue/project. These groups would be:

- Initiated upon the request of the Technical Working Group.
- Be chaired by a Technical Working Group member.
- Meet 1-2 times per year to deal with relevant issue.
- Involve relevant staff from a range of providers.
- Provide a report back to the Technical Working Group.

The management model outline will be supported by a Program Manager from the CMA and a Research Linkage Manager:

#### Program Manager

The role of the allocated CMA Program Manager will include:

- Ensure smooth co-ordination or plan implementation
- Monitor budgets against targets
- Provide executive support to the Land Issues FC and Technical Working Group
- Provide reports and advice back to the CMA Board and funding bodies
- Co-ordinate monitoring activities and regular monitoring reports
- Seek funding opportunities

#### Research Linkage Manager

The concept of the Research Linkage Manager is two fold, firstly to ensure adequate linkages between the Wimmera and other state and national salinity programs and secondly to strengthen the scientific research, demonstrations and trials implemented in the Wimmera. The role will include:

- Build linkages with other state and national R&D programs
- Attract state and national R&D funding/initiatives to the Wimmera Region
- Provide R&D guidance to establish field demonstrations, data collection and appropriate monitoring
- Input to the Technical Working Group
- Ensuring adequate communication of research outcomes to stakeholders

#### Salinity Technical Co-ordinator

The Salinity Technical Co-ordinator would have primary responsibility to co-ordinate delivery of implementation initiatives. Specific functions would include:

- Co-ordinate service delivery of DPI projects
- Staff supervision and management
- Co-ordinate wider DPI involvement

An estimated \$175,000 per year will be required to provide the level of management support required.

Resource	Requirement
Program Manager	1.0 FTE
Salinity Technical Co-ordinator	0.6 FTE
Research Linkage Manager	10-12 days per year
<b>Estimated Resource Requirement</b>	<b>\$175,000 p.a</b>



**Field briefings for neighbouring regions and Federal and State investors in salinity issues is an important activity.**

## 3.3.2 IMPLEMENTATION STRATEGY

### 3.3.2.1 Implementation Principles

The implementation strategy has been prepared on the basis of a series of key principles developed with the steering group and through workshops with key providers. These include:

- Target implementation funding at GFSs classified for implementation to ensure that relevant implementation strategies are adequately resourced.
- Fully fund initiatives in order of priority where funding is limited.
- Provide financial incentives where there are clearly demonstrable off-site benefits (public benefits).
- Provide financial incentives consistent with incentive rates outlined in the RCS.
- Target initiatives at providing support to individuals to adopt management options which meet individual needs.
- Integrate initiatives within and across GFSs.
- Establish all demonstrations and trials with sufficient scientific rigour, data collection and ongoing monitoring to allow full evaluation of outcomes.
- Follow through and evaluate all initiatives against outcomes.
- Use community facilitators for initiatives which have a specific focus and where local knowledge, contacts, respect and networks could be a significant advantage to achieving project objectives. These roles may be employed through local Landcare or Landcare network or industry groups.
- Provide adequate technical support and linkages to community facilitators.

### 3.3.2.2 Proposed Implementation Initiatives and Resources

Table 34 (overleaf) provides an overview of the implementation initiatives proposed for each GFS in the Wimmera. Over the next five years the aim is to start the process of implementing initiatives with a view to achieving 10-20% of the ultimate target for each GFS. On this basis, a summary of the key resource requirements is provided in Table 35 (page 47). Table 36 (page 48) outlines proposed implementation initiatives for each GFS.



**TABLE 34:INDICATIVE TECHNICAL SUPPORT RESOURCES REQUIRED TO UNDERTAKE PROPOSED IMPLEMENTATION ACTIVITIES**

	Technical Support	FTE	Main Function
<b>R 2.1 Local flow systems in highly fractured rocks</b>			
R 2.1.1	Community Facilitator	0.6	Facilitate landholder participation and implement management options.
R 2.1.2	Trees	0.5	Provide technical and extension advice to support the revegetation of steeper rocky outcrop areas.
R2.1.3	Pastures	0.5	Provide technical and extension advice to establish and manage perennial plants.
R 2.1.4	Native Pastures	0.5	Develop recommendations for and promote the role of native pasture management in recharge control.
<b>R 2.2 Local flow systems in deeply weathered granites (low relief)</b>			
R 2.2.1	Pastures	0.5	Provide technical and extension advice to establish and manage perennial plants
R 2.2.2	Trees	1.0	Drive BOS interceptor belts in low relief granites
<b>R 2.3 Local and intermediate flow systems in deeply weathered fractured rocks</b>			
R 2.3.1	Perennial Pasture	1.0	Develop information packages, establish focus farms and provide technical and extension support to establish and manage perenial pastures.
R 2.3.2	West Wimmera	1.0	Establish and monitor salinity management demonstration sites. Provide technical support in West Wimmera. Link with the CMA drainage strategy undertake feasibility study of community drainage in the Edenhope area
R 2.3.3	Agronomy / Landholder Investment	1.0	Establish and manage demonstration sites including low input demonstration in the north and lucerne in cropping systems. Maintain existing sites. Develop appropriate information and support mechanisms to facilitate private investment.
<b>R 2.4 Regional flow systems in Parilla Sands</b>			
R 2.4.1	Saline Resources	1.0	Identify, promote and demonstrate opportunities for productive use in the Wimmera
<b>R 2.5 Region wide resources</b>			
R 2.5.1	Community Education	1.0	Raise awareness of the GFS approach and support project officers. Link into Nap communications programs and other CMA communications initiatives
R 2.5.2	Research Officer	1.0	Develop Wimmera Environmental Services Scheme
R 2.5.3	Saline Agriculture	1.0	Provide technical support and demonstrate options for salt tolerant agriculture/species
<b>Total</b>		<b>10.6</b>	<b>(approx \$800,000 p.a.)</b>

**TABLE 35: INDICATIVE FIVE YEAR GRANT/WORKS BUDGET REQUIRED TO UNDERTAKE PROPOSED IMPLEMENTATION ACTIVITIES**

	Activity	Funding required over five years (\$)	Description
<b>R 3.1 Local flow systems in highly fractured rocks</b>			
R 3.1.1	Revegetation grants - Trees	1,000,000	900ha of trees and native vegetation establishment and approximately 100km of fencing.
R 3.1.2	Environmental Services Scheme	250,000	Funding to support change in land use from agriculture to providing environmental services for public benefits
<b>R 3.2 Local flow systems in deeply weathered granites (low relief)</b>			
R3.2.1	Revegetation grants - BOS trees	330,000	200ha of BOS plantations and 50km of fencing
R3.2.2	Environmental Services Scheme	50,000	Funding to support change in land use from agriculture to providing environmental services for public benefits
<b>R 3.3 Local and intermediate flow systems in deeply weathered fractured rocks</b>			
R 3.3.1	Revegetation grants - Pastures	250,000	2,800ha of perennial pastures
R 3.3.2	Revegetation grants- Trees	550,000	500ha trees and native vegetation and 60km of fencing
R 3.3.3	Environmental Services Scheme	60,000	Funding to support change in land use from agriculture to providing environmental services for public benefits
R 3.3.4	Applied R&D	50,000	Develop information packages, establish focus farms to support the establishment and management of perennial pastures.
<b>R 3.4 Regional flow systems in Parilla (Edenhope area) and local flow systems in sand dunes (Lowan Sands south)</b>			
R 3.4.1	Applied R&D	100,000	Undertake initial feasibility study into potential for surface drainage schemes in the Edenhope area
R3.4.2	Applied R&D	50,000	Establish and monitor salinity management demonstration sites.
<b>R 3.5 Local flow systems in sand dunes (Lowan Sands North) and local flow systems in Woorinen sediments</b>			
R 3.5.1	Applied R&D	30,000	Establish and manage demonstration sites including low input demonstration in the north and lucerne in cropping systems. Maintain existing sites.
<b>R 3.6 Region-wide resources</b>			
R 3.6.1	Communication Resources	100,000	Develop and distribute communication materials
R 3.6.2	Revegetation - Discharge	60,000	1,000ha of salt-tolerant species established on and around discharge sites
R 3.6.3	Applied R&D	80,000	Establish & monitor demo sites for discharge management and saline agriculture
<b>Total</b>		<b>2,960,000</b>	

**TABLE 36: PROPOSED IMPLEMENTATION INITIATIVES FOR EACH GROUNDWATER FLOW SYSTEM**

GFS Priority	Management Recommendations	Proposed Implementation Initiatives	Linkages	Resource Requirements
<b>R 4.1 Local flow systems in highly fractured rocks</b>				
Implementation	Revegetation of non-arable areas Native pastures on steeper slopes Perennial plants on lower slopes Saline agriculture Pumping for asset protection	R 4.1.1 Develop a regional framework for Environmental Service payments which adds local detail, credit values and assessment procedures to the state framework R 4.1.2 Local facilitator to identify relevant local landholders, involve them in a process of developing suitable management options for their land and assist implementation. R 4.1.3 Technical support to assist local facilitator Trees/agro-forestry Native pasture management Perennial plants R 4.1.4 Incentives to establish interception belts R 4.1.5 Develop and distribute 1:25000 GFS maps R 4.1.6 Communicate the GFS approach and potential for local impact	State environmental services project      Region-wide communication program	Full time research officer for 2 years   3 days/week for 5 years
<b>R 4.2 Local and intermediate flow systems in deeply weathered fractured rocks</b>				
Implementation	Perennial plants Revegetation of high recharge areas Saline agriculture Pumping for asset protection	R 4.2.1 Provide incentives for lucerne in high priority areas. Paid in two instalments based on the Mallee and North Central models R 4.2.2 Perennial plants Technical Support Officer Develop information package Establish focus farms to cover grazing management, and cropping rotations with full production and economic figures. R 4.2.3 Technical support to identify high recharge areas for trees and provide establishment advice and incentives.		Full time project officer for 3 years
<b>R 4.3 Local flow systems in deeply weathered granites (low relief)</b>				
Implementation	Perennial plants Interceptor belts Pumping for asset protection	R 4.3.1 Incentives for break of slope interceptor belts (use of higher rates where there are biodiversity or other multiple benefits) R 4.3.2 Technical Support Officer - Trees Engage Landcare and other existing groups Integrate initiative into existing Local action plans Identify BOS areas and landholders Organise logistics and physically drive project Build links with other vegetation initiatives R 4.3.3 General Perennial plant advice and information	Other vegetation plans  Pasture extension in other Gasís	Full time for 5 years
<b>R 4.4 Regional flow systems in Parilla Sands</b>				
R&D	Groundwater pumping Near river revegetation Saline agriculture Productive use of saline resources	R 4.4.1 Community Awareness/Education Officer Raise awareness of GFS approach Work with Landcare groups, media & schools Provide support to program managers Initial focus on priority GFSs	CMA Communications, Waterwatch	3 days per week for 3 years
Implementation		R 4.4.2 West Wimmera Technical Support Officer Support CMA Drainage Strategy and develop options for Edenhope area Establish and maintain clay spreading demonstration sites Promote agro-forestry and pasture opportunities Promote saline agriculture opportunities R 4.4.3 Build linkages to pipeline project & identify appropriate environmental flows R 4.4.4 Technical Support - Productive Use of Saline Resources Identify Wimmera opportunities Promote new industries/opportunities Demonstration sites for new industries	CMA Community Drainage Strategy  Pipeline Project  Existing NHT project	Full time for 5 years   Full time project officer for 5 years

**TABLE 36 CONTINUED: PROPOSED IMPLEMENTATION INITIATIVES FOR EACH GROUNDWATER FLOW SYSTEM**

<b>GFS Priority</b>	<b>Management Recommendations</b>	<b>Proposed Implementation Initiatives</b>	<b>Linkages</b>	<b>Resource Requirements</b>
<b>R 4.5 Local flow systems in weathered granite (high relief)</b>				
R&D	Perennial plants Groundwater interception tree belts Groundwater pumping (interception)	R 4.5.1 Incentives for groundwater pumping if research proves favourable R 4.5.2 General technical support for BOS interceptor belts/farm forestry R 4.5.3 Incentives to establish interception belts R 4.5.4 General Perennial plant advice	Pumping R&D project	
<b>R 4.6 Intermediate flow systems in alluvial plains</b>				
R&D	Large scale deep rooted perennial plant establishment Timber plantations Groundwater pumping Salt tolerant grasses	R 4.6.1 Lucerne Technical Support Officer R 4.6.2 General perennial plant technical support R 4.6.3 Tech support - trees/farm forestry		
<b>R 4.7 Local flow systems in sand dunes (Lowan Sands Nth)</b>				
Co invest	Agro-forestry - interception Clay spreading Protection of remnants Establish shelterbelts/corridors Lucerne/Tagasaste	R 4.7.1 Establish and manage a low input demonstration site for agro-forestry interception R 4.7.2 Provide clay spreading information & technical support R 4.7.3 Develop support mechanisms for clay spreading including equipment sharing options and encourage provision of interest rate support		
<b>R 4.8 Local flow systems in sand dunes (Lowan Sands South)</b>				
Co invest	Agro-forestry - interception Clay spreading Lucerne	R 4.8.1 Build linkages with plantation companies R 4.8.2 Establish 2-3 demonstration sites & subsequent information packages	clay spreading research in SA	
<b>R 4.9 Local flow systems in Woorinen sediments</b>				
Co Invest	Lucerne Agro-forestry - interception Improved surface drainage	R 4.9.1 Establish links to WM pipeline farm planning program R 4.9.2 Establish demonstration sites including high water use crops Agro-forestry Lucerne & stock management R 4.9.3 General lucerne extension support		

TABLE 36 CONTINUED: PROPOSED IMPLEMENTATION INITIATIVES FOR EACH GROUNDWATER FLOW SYSTEM

GFS Priority	Management Proposed Implementation Initiatives Recom- mendations	Linkages	Resource Requirements
<b>R 4.10 Intermediate flow systems in fractured rocks</b>			
Co invest	Revegetation of poorly arable areas Pumping for asset protection Saline agriculture	R 4.10.1 Environmental Services Payments R 4.10.2 Community facilitator R 4.10.3 Technical support - trees	
<b>R 4.11 Local flow systems in colluvium (Grampians Sandstone)</b>			
Co invest	Perennial plants Interception plantations or woodlots Groundwater pumping Salt-tolerant grasses	R 4.11.1 General perennial plants technical support R 4.11.2 General technical support - trees	



Groundwater drilling, Langi Ghiran.



### 3.3.3 INCENTIVE RATES

The proposed incentive rates are revised from the Wimmera RCS and are shown in Table 37 (below). The incentive rates for remnant vegetation, revegetation and revegetation fencing could be applied directly to where revegetation and break of slope interceptor belts are proposed as a salinity management option in priority GFSs for implementation. Any additional incentives proposed should be consistent with principles behind the rates in the RCS table.

### 3.3.4 ADDITIONAL INCENTIVES REQUIRE FOR SALINITY MANAGEMENT

#### 3.3.4.1 Perennial Plant Establishment

Perennial plant establishment is a key management option in the deeply weathered fractured rock GFS, which is a priority for implementation initiatives under this Salinity Action Plan. This GFS is a major contributor to Wimmera River saltloads and implementing salinity management initiatives in this area will generate significant public benefits. This provides justification for some form of public incentive for perennial plant establishment. The incentive rates for this activity are to be developed following a review of other Victorian CMA pasture incentive programs.

**TABLE 37: REGIONAL CATCHMENT STRATEGY INCENTIVE RATES (JULY 2004)**

Activity	Priority	WCMA cost share	Criteria	Incentive	Unit
Remnant vegetation fencing	VH	100%	Very high, high or medium conservation significance, with Trust for Nature Conservation covenant in place	\$ 3.55	m
	H	75%	High to Very High Conservation significance	\$ 2.65	m
	M	65%	Medium to Low conservation significance	\$ 2.30	m
Land class fencing	M	60%	Fencing land class 4 & 5	\$ 2.15	m
Revegetation fencing	VH	80%	Very High Conservation significance potential	PMP* \$ 2.85	m
		70%		No PMP \$ 2.50	m
	H	70%	High Conservation significance potential	PMP \$ 2.50	m
		60%		No PMP \$ 2.15	m
	M	55%	Medium Conservation significance potential	PMP \$ 1.95	m
		45%		No PMP \$ 1.60	m
	L	35%	Low Conservation significance potential	PMP \$ 1.25	m
		25%		No PMP \$ 0.90	m
Revegetation	H	80%	Plants: 80% of cost of plants, guards and follow up weed control for 12 months.	\$ 1.00	each
	H	80%	Direct Seeding: 80% of cost of seed and follow up weed control for 12 months.	\$ 160	km
Erosion control works	VH	80%	Works are part of an existing Property Management Plan / whole farm plan	Up to 80% of cost of Priority works	
	H	60%	No Property Management Plan / Whole Farm Plan completed	Up to 60% of cost of Priority works	
Saline Pasture	M	20%		\$48	ha
Saltbush	M	65%	Costing includes cost of plants and mounding.	\$0.25	each
Fencing to protect salinity management works#	VH	80%		PMP \$ 2.85	m
		70%		No PMP \$ 2.50	m
	H	70%	Works in "implementation" priority GFS	PMP \$ 2.50	m
		60%	Works in R&D priority GFS	No PMP \$ 2.15	m
	M	55%		PMP \$ 1.95	m
		45%	Works in "Co-investment" priority GFS	No PMP \$ 1.60	m
	L	35%		PMP \$ 1.25	m
		25%	Discharge Fencing	No PMP \$ 0.90	m

\* To be eligible for higher rates, inspecting officer must sight completed Property Management Plan or Whole Farm Plan

# Higher incentive rates may be available for salinity works if they have conservation outcomes. In such cases rates for revegetation may be applied.

## 3.3.5 RESEARCH AND DEVELOPMENT NEEDS

### 3.3.5.1 GFS Knowledge Gaps and Research and Development Needs

The R&D background paper discusses the knowledge gaps and R&D needs for each GFS. These are summarised in Table 38 (page 55).

### 3.3.5.2 Priority Research and Development Needs

The priority needs for R&D within the Wimmera focus on identifying the salt and water balance of both catchments and GFSs. Groundwater systems can be grouped into three broad categories on the basis of the current information base and understanding of salinity processes:

1. **Well Understood** - systems where the information base and understanding of salinity processes is sufficiently well advanced to be confident in recommending salinity management strategies.
2. **Developing Understanding** - systems where processes of salt generation are clear but their ability to be managed is uncertain.
3. **Theoretical** - groundwater systems where understanding of both landscape processes and their potential to be managed for salinity mitigation remains largely theoretical.

A well-structured salt and water balance program is needed within an overall research and development portfolio for the Wimmera Region. It should be management focussed, driven by the need to resolve questions about the performance of landscapes and groundwater systems to ascribe best management practices. The program should, in the first instance, address those areas where salinity has a significant impact in regions where the hydrological processes involved in salt generation and best management practices are least clear. Region-wide R&D needs are summarised in Table 39 (page 57).

### 3.3.5.3 Landscape Processes at Catchment/Groundwater Flow System Level

Four main areas have significant salinity issues and considerable uncertainties regarding best management practices. These are:

- (a) The Mount William Creek catchment;
- (b) Local flow systems in low relief deeply weathered granites;
- (c) Local flow systems in deeply weathered fractured sedimentary rocks; and
- (d) Sub-regional (intermediate) flow systems in upland alluvium.

These four systems have very large salt stores, and contribute large quantities of salt to the streams of the Wimmera.

### 3.3.5.3.1 Mount William Creek Catchment

The Mount William Creek Catchment comprises a complex array of GFSs. Local GFSs with high salt stores discharge salts to the surface catchment, local flow systems low in salinity also appear to feed groundwater into a sub-regional system, and the sub-regional system appears to partially discharge at the lower extremities of the catchment. Equally the sub-regional system appears to have potential to recharge the upper extremities of the regional Parilla Sand aquifer.

The Mount William Creek catchment generates some 20,000 tonnes of salt per annum, and is a significant salt source in the Wimmera Region. The catchment also generates large quantities of down-basin groundwater flow. The component salt loads and contribution for each GFS in the catchment and the fate of both salt and groundwater remain largely unknown. In the absence of this knowledge, it is difficult to ascribe forms of management that specifically target salt reduction within a defined timeframe.

*Recommendation: Apply salt and water balance principles together with groundwater modelling to ascertain the aggregate water balance based on the performance of the component GFSs*

### 3.3.5.3.2 Local Flow Systems in Low Relief Granites (deeply weathered)

The understanding of deeply weathered granite systems is well established in southern Australia, although it is subject to local variation based on geological and geomorphic conditions. The high salt store and low permeability of these systems make them particularly troublesome from a management perspective. They do not respond well to recharge management, because groundwater flow is sluggish, and recedes very slowly. Equally these systems are difficult to manage from an engineering perspective because they seldom have sufficient permeability to allow for groundwater pumping or drainage. Research is needed to resolve uncertainty about contribution of salt loads to regional streams and the capacity for this to be managed through either biological or engineering means.

*Recommendation: Apply salt and water balance principles together with numerical modelling to further ascertain the water balance of catchments comprising this GFS and where control management should be applied.*

### 3.3.5.3.3 Local Flow Systems in Deeply Weathered Fractured Sedimentary Rock

The hydro-geological setting for this landscape provides for a range of flow cells that operate from a very localised paddock scale through to something approaching a sub-regional scale. Like the low relief granite systems the terrain is deeply weathered, with a high salt store. At depth the weathered low permeability regolith gives way to a fractured rock aquifer. The difficulties with managing this system are similar to those in managing deeply weathered granitic terrain in that the landscape has low permeability and groundwater flow occurs at a range of scales.

The landscape presents as a partially-dissected tableland. In some places it has well developed soils capable of accepting deep-rooted perennial vegetation such as lucerne, while in other areas soil development is negligible and the land surface comprises outcropping kaolin rich clays formed from decomposing sedimentary rocks.

The sluggish nature of the GFS, poor soil conditions in much of the area, and high salt stores all point toward real difficulties in understanding how this flow system might be best managed to reduce the salinity impact.

As with the other priority flow systems, answers to how this system might be best managed will only be realised through a better understanding of the water and salt balance.

*Recommendation: Apply salt and water balance principles together with numerical modelling to further ascertain the water balance of catchments comprising this GFS.*

### 3.3.5.3.4 Sub-regional Flow Systems in Upland Alluvium

Similar to the Mount William Creek catchment, most of the large upland valley floodplains comprise alluvial aquifers that transmit considerable volumes of groundwater down-basin.

The water balance of these systems is not well understood and the threat they pose from a salinity perspective is largely unknown.

Along the northern margins of the uplands, the alluvial aquifers merge with the marine sediments of the Parilla Sand, and have some potential to recharge this regional aquifer. The extent to which this occurs, and the hydro-geological circumstances at the juncture of the two systems, however, remains largely unknown.

*Recommendation: Apply salt and water balance principles together with groundwater modelling to further ascertain the water balance of catchments comprising this GFS.*

### 3.3.6 CATCHMENT SALT AND WATER BALANCES

Considerable information exists for the Wimmera Region providing insight into spatial distribution of salt generation throughout the catchment. The information exists as discrete data sets and has not been assembled and analysed to support an understanding of relationships between salinity and dynamics of groundwater processes that impact on salt wash-off and base flow processes.

In-stream salinity is reported either as saltloads, average concentrations, or flow-weighted averages. These are all concepts that tend to be constructed for indicative and comparative purposes. They are very useful, but provide little insight into understanding spatial and temporal variability that affords the opportunity to correlate salinity status with catchment groundwater processes and potential management activities. The stream-flow information does not inform management decisions.

Salinity flow relationships need to be better analysed so that salt generation in streams can be better correlated with the physical processes operating within GFSs. Salinity and flow data need to be segmented and analysed on the basis of (a) low-flow and high salinity circumstances, (b) moderate flow and moderate to high salinity circumstances, and (c) high flow and low salinity circumstances. This would provide a much greater insight into catchment processes, and a much greater insight into how salt export might be managed to avoid the most damaging flows and opportunities to achieve end of valley salinity targets.

*Recommendation: Further analyses of stream-flow data to link salt flow processes to landscape processes, and to determine the extent to which conjunctive management might be practised to mitigate stream salinity and salt loads*



**Aerial view of Great Western Paired Catchment trial site.**

### 3.3.7 BIOLOGICAL MANIPULATION OF WATER BALANCE OF CATCHMENTS

#### 3.3.7.1 Lucerne and Other Introduced Perennial Plants

Whilst understanding of the performance of landscapes in the context of GFSs has increased markedly over recent years, knowledge of the ability of farming systems to deliver required changes in landscape hydrology is lacking in many areas. The relationship between soils, water and vegetation with a particular emphasis on root zone hydrology remains a high priority for further R&D.

Dryland lucerne continues to be regarded as the optimum pasture for recharge management, largely because it has been used successfully for these purposes in many regions throughout Australia and North America. Indeed lucerne grown at Burkes Flat in the Avoca catchment, and at Marnoo in the Avon-Richardson catchment during the latter half of the 1980s demonstrate that in the right groundwater system the plant can lower groundwater levels by up to five metres. The difficulty with lucerne is that it cannot be grown everywhere. It requires fertile soils free from waterlogging and soil acidity issues, as it is quite prone to aluminium and manganese toxicity issues.

Practical applied research and development is required to demonstrate lucerne's performance in recharge mitigation in GFSs where this option is appropriate. This requirement extends equally to using other introduced perennial grasses with potential for salinity management.

#### 3.3.7.2 Native Grasses

There is a high reliance on summer active native grasses in managing recharge in the more marginal agricultural lands of the Wimmera uplands. The extent to which such pastures have the capacity to mitigate, reduce, or impact on landscape hydrology remains largely conjecture. The option has been widely promoted throughout eastern Australia, but little scientific information is available to support the assertion. There is a clear need to gather information on the performance of native grasses in recharge mitigation. This research is likely to be both expensive and exacting, and it is recommended that this area of endeavour be explored in conjunction with partners such as the CRC for Catchment Hydrology, or the CRC for Plant Based Solutions.

#### 3.3.7.3 Engineering Options to Protect Assets

Applying engineering options, including groundwater pumping, is likely to play a significant role in salinity management and asset protection in the Wimmera in future. They have application in managing groundwater levels where regional watertables threaten both natural and man made assets and infrastructure within the trench of the Wimmera River.

Equally, engineering options have considerable potential in avoiding salinity in the weathered granites of the uplands. Here pumping can remove fresh groundwater from the flow system whilst it is in transit to the lower catchment, taking it out of the flow system before it has the opportunity to add to salinity issues.

The main R&D issues focus on proving the application for the technology and developing standards and protocols for applications.

#### 3.3.7.4 Productive Use

An extensive range of options are now available with potential to realise profitable returns from industries and enterprises that focus on gaining production from saline land and water resources. These range from the more conventional approaches involving the growth of halophytic vegetation and salt-tolerant grasses on affected soils through saline aquaculture, alginate production from seaweed, saline horticulture, mineral harvesting, and even energy generation.

Most of these industries are very specialised, and fill particular niche markets. Equally most of them are in their infancy and in need of financial and technical support to prove their viability. This area of research and development is particularly significant in regional systems where it can be applied in conjunction with engineering strategies that release saline groundwater through groundwater pumping.

*Recommendation: Research and development focussing on production from saline land and water resources, particularly in those regional systems where few other options are available, and where groundwater pumping realises a saline groundwater resource*

**TABLE 38: ASSESSMENT OF GROUNDWATER FLOW SYSTEM KNOWLEDGE GAPS, RESEARCH AND DEVELOPMENT NEEDS AND POTENTIAL RESEARCH PARTNERS**

	<b>GFS Priority</b>	<b>Knowledge Gaps</b>	<b>R&amp;D needs</b>	<b>Potential partners</b>
<b>R 5.1 Regional flow systems in Parilla sands</b>				
	R&D	Understanding the capacity of engineering intervention to support in-stream salinity and biodiversity aspirations	Technologies required to achieve salinity and biodiversity related outcomes	CRC for Catchment Hydrology CSIRO (Land and Water)
		Knowledge of the capacity for in-stream groundwater interception from deep pools	Understanding whether in-stream dewatering presents a practical means of realising salinity and biodiversity outcomes	CRC for Catchment Hydrology CSIRO (Land and Water)
		Knowledge of groundwater flow paths into the river including understanding the impact of the near river zone and location of concentrated points of flow into the river		
		Understanding technology required to achieve effective asset protection through groundwater pumping and disposal	Greater understanding of technology required to optimise pumping yields in concert with evaporative capacity of small scale disposal basins	CRC for Catchment Hydrology
		Practical knowledge of what might and might not be achieved in establishing niche market industries based upon production from saline land and water resources	Field evaluation and testing of promising technologies	CRC for Polymer Research CRC for Plant Based Solutions? SA Centre for Innovation?
<b>R 5.2 Local flow systems in weathered granite (high relief)</b>				
	R&D	The effectiveness of low volume groundwater pumping in salinity mitigation The effectiveness of interception plantations on managing salinity The impact of plantations and groundwater pumping on baseflow  Most effective location of break of slope plantations/interceptor belts Understanding linkage between this GFS and the upland colluvium	Evaluating technology, developing standards & protocols for salinity management, water use and other natural resource management issues Tools to identify the optimum positioning in the landscape for groundwater pumping Instrumented trials to report on impact of groundwater pumping and interception plantations on groundwater elevations and baseflow	CRC for Landscape, Environment and Mineral Exploration
<b>R 5.3 Intermediate flow systems in alluvial plains (deep leads)</b>				
	R&D	Understanding salinity risk and implications for land and water management within the Wimmera catchment	Review salt and water balance for upland alluvial systems  Local investigations to ascertain groundwater status at the juncture of the aquifers with the regional Parilla Sand aquifer Geophysical surveys to map sub surface structures	CRC LEME (Land, Environment, Mineral Exploration)
<b>R 5.4 Local flow systems in highly fractured rocks</b>				
	Implement ation	Understanding the ability of native grasses to manage groundwater recharge to fractured rock aquifers	Need to understand the hydrology of native grasses as it applies to recharge management within fractured rock aquifers	CRC for Plant Based Solutions CRC for Catchment Hydrology Agriculture Victoria Murray-Darling Basin Commission



**TABLE 38 CONTINUED: ASSESSMENT OF GROUNDWATER FLOW SYSTEM KNOWLEDGE GAPS, RESEARCH AND DEVELOPMENT NEEDS AND POTENTIAL RESEARCH PARTNERS**

	<b>GFS Priority</b>	<b>Knowledge Gaps</b>	<b>R&amp;D needs</b>	<b>Potential partners</b>
<b>R 5.5 Local flow systems in deeply weathered granites (low relief)</b>				
	Implement ation	Extent to which salt loads can be managed through alternative land and water management	Review of contemporary approaches to achieving a more favourable salt and water balance in similar terrain throughout Australia	Department of Agriculture Western Australia Primary industries and Resources South Australia CSIRO (Land and Water) CRC LEME Agriculture Victoria - Rutherglen
<b>R 5.6 Local and intermediate flow systems in deeply weathered fractured rocks</b>				
	Implement ation	Understanding flow cells and management strategies for fractured rock systems Impact of gravel extraction and kaolin mining on groundwater	Establish with greater certainty the nature of groundwater flow relative to terrain, and the feasibility of lucerne for recharge mitigation	CRC for Plant Based Solutions CRC LEME CRC for Catchment Hydrology CSIRO (Land and Water)
<b>R 5.7 Local flow systems in sand dunes (Lowan Formation)</b>				
	Co- investment	Impact of clay spreading and associated farming system changes on recharge in the southern section of the Lowan sands	Demonstration sites and monitoring of clay spreading in the southern area.  Need to produce fact sheet style information-knowledge transfer products Impact of clay spreading on water balance Potential post-graduate style projects	Industry partners  Industry RIRDCis Landcare groups
<b>R 5.8 Local flow systems in Woorinen sediments</b>				
	Co- investment	Information products to communicate current options for salinity management  Some uncertainties re root zone hydrology	Potential R&D to investigate the impact of toxic elements in the root zone on production of some alkaline soils	Industry partners
<b>R 5.9 Local flow systems in colluvium (Grampians Sandstone)</b>				
	Co- investment	Understanding the contribution of this system to other GFSs and the impact it has on water supply to the key water catchments in the Wimmera.  Define Woorinen/Lowan/Parilla salinity issues in the Edenhope region	Understanding the influence of groundwater flow from the colluvium on the salt and water balance of upland alluvial system (specifically Mt. William Creek catchment)  Analyses and review of existing groundwater information, and possible additional shallow drilling investigations	Wimmera Mallee Water  Local issue

**TABLE 39: REGION-WIDE RESEARCH AND DEVELOPMENT NEEDS**

Knowledge gaps	R&D needs	Potential partners
<b>R 5.10 Assessment of the salt and water balance of Groundwater Flow Systems in the Wimmera Region</b>		
<p>Understanding the processes by which salt enters Wimmera streams</p> <p>Understanding the impact and timing of high salinity - low to moderate flows</p> <p>Opportunities to better manage the low to moderate flow - high salinity stream-flow regimes</p> <p>Appreciation of surface water - groundwater interactions for GFSs</p> <p>Appreciation of the role of soils and impact of root zone processes in the context of groundwater recharge</p> <p>Availability of accurate data on the current extent and severity of discharge.</p>	<p>Further analyses of stream flow and salinity data to better understand the potential to manage saltloads and stream salinity</p> <p>Modelling of surface water &amp; groundwater interactions at the scale of individual GFSs</p> <p>Simulation modelling and practical applied research and development trials to ascertain optimise farming systems for recharge mitigation</p> <p>Applied R&amp;D to ascertain the impact of various pasture management strategies on the water balance and groundwater elevations</p> <p>Apply remote airborne geophysics to further define landscape hydrology and hydro-geology</p> <p>Develop a digital elevation model for the region</p>	<p>CRC for Catchment Hydrology</p> <p>CSIRO (Land and Water)</p>
<b>R 5.11 Optimum management of groundwater recharge in appropriate groundwater flow systems</b>		
<p>Impact of native grass pastures on landscape hydrology</p> <p>The role and best management of lucerne and other introduced perennial plants in achieving salinity management</p> <p>Understanding the capacity to develop alternative niche industries based upon saline resources</p>	<p>Applied research and development in support of entrepreneurs</p>	
<b>R 5.12 Options for productive use of saline land and water resources</b>		
<p>Native salt-tolerant plants as alternatives to Tall Wheat Grass and Puccinellia.</p> <p>Further understand the groundwater processes operating and potential impact of management options at a broadscale.</p>	<p>Investigate, trial and demonstrate native salt-tolerant alternatives.</p> <p>Investment in groundwater modelling, to improve understanding, and develop a decision assistant, communication tool.</p>	
<b>R 5.13 Local Government Information Support</b>		
<p>Current and potential impact of salinity on local government infrastructure</p> <p>Potential management strategies/intervention options to protect local government infrastructure</p>	<p>Detailed GIS mapping and modelling of potential salinity discharge in relation to local government infrastructure to assist in future decisions relating to infrastructure design, locations, management and maintenance</p>	<p>Local Government</p>
<b>R 5.14 Assessment of Wimmera Region Biodiversity Assets</b>		
<p>Current extent of biodiversity assets</p> <p>Pre 1750's biodiversity of the region</p> <p>Salinity threat to biodiversity assets for various management scenarios</p> <p>Biodiversity and ecological values of the Wimmera River</p>	<p>A detailed study of the Wimmera Region's biodiversity significance and potential impacts of a range of salinity outcomes on the extent and quality of biodiversity assets. Including identifying the full benefits of the biodiversity and ecology of the river</p>	

TABLE 39 CONTINUED: REGION-WIDE RESEARCH AND DEVELOPMENT NEEDS

Knowledge gaps	R&D needs	Potential partners
<b>R 5.15 Socio - Economic Assessment</b>		
<p>Incorporating social data (CSU study) into the development of implementation and communication initiatives</p> <p>Limited understanding of opportunities to modify attitudes to different landscape values and practice change</p> <p>Lack of suitable incentive measures other than of financial grants</p> <p>Change in social indicators over time</p> <p>As salinity will struggle to gain attention as an issue in its own right, how to link salinity in to the broader regional socio-economic picture.</p> <p>What threat does salinity pose to priority social issues identified in the study?</p> <p>What opportunity does the desire of landholders to leave their property in 'better condition' for adoption of salinity management practices?</p>	<p>Further social investigations and testing of incentive opportunities based on social characteristics of the region</p> <p>Investigating social networks and learning mechanisms/forums such as Topcrop and Landcare and their role in driving implementation</p> <p>Repeat of the CSU study after 5 years of implementation</p> <p>Investigate how future salinity management initiatives need to be developed and implemented with due consideration of their interaction with the region's socio-economic structure.</p> <p>What are the social opportunities from implementing salinity management options, employment, new industries, etc</p> <p>How can salinity management be linked more closely with regional development?</p> <p>There is a need to better understand landholders' definition of "better condition".</p>	
<b>R 5.16 Lucerne Suitability Assessment Report</b>		
<p>Limited understanding of suitability of lucerne within upper Wimmera landscapes</p>	<p>A detailed study and assessment of the suitability of lucerne for the range of GFSs and landscapes within the Wimmera Region.</p>	

### 3.3.8 MONITORING AND EVALUATION

#### 3.3.8.1 Monitoring Principles

- Eventually relate all monitoring activities to a GFS.
- Establish over time an appropriate minimum level of monitoring for each GFS including:
  - A representative set of groundwater bores to cover the different climate, land uses and management options that exist for the GFS;
  - A gauging station at the outfall of the GFS to monitor saltloads, flow rates and salt concentrations; and
  - A database of known land use change in the GFS eg. pasture establishment, interceptor belts, groundwater pumps etc.
- Establish a set of targets for each GFS to cover NRM outcomes and works implemented. These should include:
  - NRM targets - discharge area, saltload, salt concentration thresholds (e.g. Under X EC for Y% of the time); and
  - Works Targets - area desired of management change.
- Prepare annual monitoring reports which link NRM and works targets for each GFS.

#### 3.3.8.2 Evaluation Principles

- The Technical Working Group will provide the Land Issues FC with an annual evaluation of the plan's implementation. This evaluation will include:
  - An overview of the works implemented;
  - An assessment of the effectiveness of works implemented on the basis of monitoring data;
  - Progress on research and development initiatives;
  - A review of other relevant state and federal initiatives and their implications to the Wimmera; and
  - An overview of changes in the knowledge and understanding of each GFS and the implications for the initiatives outlined in the salinity plan.
- After five years the Land Issues FC will commission an independent review and evaluation of this salinity action plan including assessments of:
  - Effectiveness of works implemented;
  - Effectiveness of the delivery mechanisms used;
  - Appropriateness of the cost-sharing arrangements;
  - Success of the R&D initiatives in addressing knowledge gaps;
  - Social impact and changes in social structure in the region through a repeat of the CSU study;
  - Effectiveness of the monitoring program;
  - Progress towards achieving outputs identified in the plan;
  - Potential for the plan to impact on future salt loads and potential environmental benefits; and
  - Availability of new knowledge and technology and how these might be applied to improve salinity management in the Wimmera.

### 3.3.8.3 Bore Monitoring Network

At least 717 bores or piezometers have been constructed throughout the Wimmera over the last two decades. Of these, 677 are monitored on a regular basis. Bores are monitored at a range of intervals in accordance with priorities developed under a 2000 review of groundwater monitoring. The frequency of bore monitoring is outlined in Table 40.

**TABLE 40: GROUNDWATER MONITORING - WIMMERA REGION**

Frequency of monitoring	Number of bores/piezometers
Monthly	289
Quarterly	295
Bi-annually	73
Annually	20
<b>Total</b>	<b>677</b>

Groundwater bores/piezometers and piezometers are monitored by a range of agencies with responsibilities that range from catchment/salinity management, through to water resource management and R&D. Groundwater data is collected by DPI (Centre for Land Protection Research), Grampians Wimmera Mallee Water Authority, and SKM.

Groundwater monitoring has been established for a wide variety of purposes. These include meeting requirements to monitor groundwater resources in the West Wimmera's freshwater aquifers, research and investigations to understand landscape groundwater processes from a salinity perspective, and monitoring to determine the impact of land use and best land management practices on salinity management and mitigation.

The wide array of purposes for establishing groundwater monitoring has led to considerable geographic diversity in bore placement. This diversity is illustrated in Table 41.

#### 3.3.8.3.1 Lower Wimmera

From the general perspective of monitoring groundwater systems, and assessing trends that have implications in terms of salinity risk, the coverage afforded by bores in the lower Wimmera is generally quite good. The regional network provides an understanding of the flow regime within the regional - Murray-Darling Basin aquifers, including local influences from recharge within, for example, the floodplain of the lower Wimmera River.

The adequacy of the bore network in the Lower Wimmera is a function of both the large number of wells, and the predominantly regional nature of the groundwater systems. Variability in the landscape-groundwater systems is much less than that found in the Wimmera uplands' GFSs.

Groundwater monitoring is also adequate from a perspective of understanding local GFSs in superficial sediments of both the Lowan and Woorinen formations that overlie the regional aquifers of the Lower Wimmera. Additional monitoring would be beneficial in recording the performance of local salinity mitigation strategies and providing feedback to participating landholders and the regional Landcare network.

**TABLE 41: BORE LOCATION BY AQUIFER AND GROUNDWATER FLOW SYSTEM - WIMMERA REGION**

Aquifer	Groundwater Flow System	No. of bores
<b>UPLANDS</b>		
Fractured metasediments	Includes Local GFS in highly fractured rock, Local and Intermediate GFS in deeply weathered fractured rock and Intermediate GFS in fractured rock	72
Granites	Includes Local GFS in weathered granites and Local GFS in deeply weathered granites	30
Grampians Colluvium	Local GFS in colluvium (Grampians Sandstone)	11
Tertiary Gravels	Local perched GFS in hill-slope gravel deposits	10
<b>LOWER WIMMERA (PLAINS)</b>		
Parilla Sands	Regional GFS in Parilla Sands	233
Shepparton Formation	Local GFS in alluvial sediments (a)	250
Renmark Formation	Regional GFS in alluvial aquifers	41
Murray-Group Limestone	Regional GFS in Murray Group Limestone	56
Blanchetown Clay	Local GFS in alluvial clay deposits	10
Coonambidgal Formation	Local GFS in alluvial sediments (b)	4

### 3.3.8.3.2 Upper Wimmera

Establishing bores and piezometers in the Upper Wimmera catchment has occurred to a much lesser extent than in the Lower Wimmera, with only 123 bores/piezometers constructed. This represents 15% of total bores in the Wimmera Region. Clearly the reason for this lesser amount has to do with (a) greater emphasis on groundwater resources monitoring in the Western Wimmera, (b) greater interest, historically, in understanding regional aquifers of the Murray-Darling Basin, and (c) technical difficulties in establishing groundwater wells in the often rocky upland terrain. Of the 123 bores and piezometers established throughout the uplands 72 are recorded as being located in fractured metasediments. This means that they are located either within (a) Local GFS in fractured rocks, (b) Local GFS in deeply weathered fractured rocks, or within (c) Intermediate GFS in fractured rocks. The proportion of bores in each GFS remains uncertain, however; this should be resolved in the immediate future through producing a 1:100,000- scale map of the GFSs of the Upper Wimmera Catchment.

Some 30 bores/piezometers are recorded as being in the granites of the uplands, including both the Local GFS in Weathered Granites and Local GFS in Deeply Weathered Granites. As with the fractured rock GFS, the question of which bores lie within which GFS will be resolved with production of the 1:100,000 GFS map for the Upper Catchment.

Of the remaining upland bores/piezometers, 10 exist within the Tertiary Gravel deposits generally formed over deeply weathered fractured rocks, and a further 11 are within the Local GFS in Grampians Colluvium.

### 3.3.8.3.3 Millicent Coast Basin

Most bores have been installed since 1995, with only a few having installed in the 1980s. Key points about groundwater monitoring are:

Most bores in the South-West Wimmera (area around Edenhope and Mosquito Creek) are monitored on a quarterly basis by DPI. Regular monitoring is yet to be addressed in the Telopea Downs area.

The best coverage of salinity monitoring bores in the Millicent Coast is in the Edenhope area and the Mosquito Creek Catchment. About 35 bores are monitored, most in the Parilla Sands GFS. Initially most bores were established in or near discharge areas which revealed little information about groundwater processes occurring elsewhere in the wider landscape. The network has since been enhanced so that there are transects covering cross-sections of the landscape.

A small number of bores is in the Lowan Sands South GFS on the catchment divide near Kadnook, between the Wimmera and Glenelg-Hopkins CMA areas. These bores provide background monitoring prior to an area being planted out to a large Blue Gum Plantation. This is one of the few places in Victoria where this scenario is known to exist and is one of the main reasons why these sites are continuing to be monitored. In the Telopea Downs area, the bore monitoring network is only known to have two bores established near the Telopea Downs Hall in 1999, with another four established some time ago at a salinity treatment trial site by the local Landcare group, west of the Telopea Downs Hall. These are situated in the Lowan Sands North GFS.

A small number of bores also exist in the sandy lunette on the eastern side of White Lake and are continuing to be monitored by DPI. These were established in about 1989 as part of pasture trials. In more recent times, mineral sands mining in the area has resulted in more bores to monitor groundwater movement. A distinction also needs to be made between monitoring for salinity management and that associated with aquifer management (ie. the limestone and border zone monitoring).



#### **3.3.8.3.4 Monitoring within Groundwater Flow Systems**

While it has not been possible to ascertain within any great confidence the exact location of bores and piezometers within the upland GFSs, it is clear that the monitoring network is not sufficiently well developed to reflect an adequate understanding of each system's performance in response to climate, land use and land management. The understanding, at present, requires importing knowledge from elsewhere to fill some gaps.

The main issues in developing an adequate monitoring network in the uplands appear to have been the cost of establishing deep wells high in the landscape of otherwise rocky terrain, or terrain where deep regolith (deeply weathered rock) prevails. The relatively lower cost associated with shallow auger hole technology compared with rotary percussion rigs required to drill to greater depths, has seen most wells constructed in the lower landscape where rock penetration was less of an issue. The difficulty with this approach is that understanding groundwater processes and, in some instances, trends in groundwater in response to land use, land management, and climate remains somewhat incomplete.

The minimum groundwater monitoring requirement for any GFS involves bores/piezometers established down a flow line extending from upper regions of the landscape through mid-slopes and on to drainage depressions/valley floors. Consistent with this philosophy, the minimum requirement is for bores/piezometers located within recharge areas, transmission zones and discharge areas. The cost of establishing monitoring programs consistent with this approach in a great number of sub-catchments comprising a GFS will be prohibitive. It will be important that at least some catchments within each GFS meet this requirement.

Adequacy of the present groundwater monitoring system in meeting the above requirement is less than transparent. Considering groundwater processes down a flow-line were not a prime factor in establishing the network, and equally the objective in establishing many wells was not one of constructing a conceptual model of landscape performance. The existing system needs auditing at the sub-catchment/GFS level to establish the extent to which present monitoring meets or partially meets the minimum requirement at landscape/groundwater system scale.

While the system has some inadequacies in terms of location of wells down groundwater flow paths, and some issues in describing aspects of conceptual models of groundwater behaviour (from a local Wimmera perspective), a considerable amount of useful information has been collected over more than two decades. Inferences from this data, when considered in the context of similar data from elsewhere in Victorian uplands, are powerful.

*Recommendation:*

*That the present Wimmera uplands groundwater monitoring system be reviewed to understand how it might be incorporated into an overall framework based on conceptual models of groundwater behaviour within each GFS, consistent with reporting on salinity issues in response to climate, land use, and land management.*

#### **3.3.8.3.5 Surface Water Monitoring**

An extensive network of stream gauging stations is present throughout the Wimmera. In Victoria, about 40 gauging stations were established 20 to 30 years ago to assess water yield and quality in the main streams, and their immediate tributaries, and within the network of channels. Given that the objective at the time was to gather information concerning the amount of water coming from the catchments following rainfall, it is not surprising that most stations are located either within the major streams, or in their tributaries near the confluence with the main streams.

These older gauging stations measure surface water flow continuously, whilst water quality is/was measured by monthly sampling and laboratory analyses. This makes computation of annual saltloads at each station somewhat difficult, as it necessary to assign salinity to all flows based upon monthly records. A standard computational technique is normally adopted that assigns a flow-weighted average salinity.

#### **3.3.8.3.6 Continuous Flow and Salinity Recorders**

In the late 1980s and early 1990s seven gauging stations in the Wimmera catchment were upgraded to supply both continuous flow and continuous salinity data. This allowed direct computation of saltloads by simply multiplying flow and salinity data over time. This new, and more accurate information, suggests that computations made on the basis of continuous flow-monthly salinity data are flawed. The 1980s estimates appear far too low when compared with those based on the 1990s continuous data (SKM, 2001). Indeed, in some instances, the Hooke estimates for the same locations are one quarter to half of the 1990s estimates based on continuous flow and continuous salinity data. It is unlikely that this difference can be explained by climatic variation, as higher surface flows in the 1980s decade should have realised greater saltloads than those of the drier 1990s.

Implications of the variance between saltloads calculated from continuous flow-monthly salinity data and continuous flow-continuous salinity data are profound, for it is possible that average saltloads throughout the system are at least twice as large as those indicated by the earlier data.

Early computations should be internally consistent, as the same method has been applied across all stations. This means that relative proportions of saltloads from different parts of the catchment should be correct.



**Monitoring over the last 15 years at this Great Western site indicates revegetation lowering the watertable at 25cm/yr.**

### 3.3.8.5.2 Capacity to Inform Salinity Mitigation

The present surface water-monitoring network affords little opportunity to provide information to help understand landscape-stream interactions, except at the broadest level where it provides indicative information on relative saltloads arising from large parts of the catchment. The difficulty lies in the fact that most gauging stations are in the lower catchment within main streams or main tributaries immediately above the confluence with main streams. At this point salinity is strongly buffered by large surface water flows relative to salt flows. Equally gauging stations most often measure combined saltloads from several different GFSs. These issues, when combined with those arising from different flow-salinity technologies, indicate the present system does not afford opportunities to relate salt in-stream flow to the function of landscape-groundwater processes within GFS. Project Platypus funds a series of gauging stations within the upper catchment which provide valuable information and where these are located within relevant GFS options for their continued funding need to be explored.

A functional understanding of relationships between stream salt flows and salinity processes within landscapes is only likely to be achieved where continuous flow-continuous salinity stations can be established at the point where stream-flow exits a GFS.

*Recommendation:*

*Consider establishing at least an additional two gauging stations in the Upper Wimmera catchment at sites consistent with monitoring salt flows generated by landscape processes. These should be established to monitor salinity processes within local GFS in deeply weathered granites, and local GFS in deeply weathered fractured rocks.*

### 3.3.8.5.3 Millicent Coast

Surface water flow in the Millicent Coast area is mainly dominated with wetland systems that flow in a north-westerly direction and stream systems that flow west into SA. Key points about these are:

1. Due to the location of wetlands in the landscape, they will probably be one of the first environmental features to show the effects of any changes to salinity. Monitoring vegetation changes and changing water salinity levels is a valuable way of detecting early warning signs of emerging salinity trends. To date, the only regular wetland monitoring is salt and water levels of Lake Wallace at Edenhope by Grampians Wimmera Mallee Water.
2. Four sub-catchments in the Millicent Coast all straddle the state border and have well defined creek systems that flow into South Australia. To date, there is no regular surface water monitoring of these waterways, with the exception of the Mosquito Creek which is monitored by the Department of Land, Water, Biodiversity and Conservation at Struan.
3. Potential exists to develop joint surface water monitoring programs for these cross-border tributaries, especially given that the Morambro Creek area just over the border west of Frances has been declared a Water Supply Protection Area.
4. The Mosquito Creek is also significant in that it is the most degraded of all the creek systems in the West Wimmera (particularly the upper part of the northern branch) and flows westerly over the border into the Ramsar-listed Bool Lagoon in SA.

**TABLE 42: EXTRA MONITORING INFRASTRUCTURE REQUIRED**

Groundwater Flow System	Surface Water Monitoring		Auger hole piezometers		Rotary/mud bores & piezometers		Total Cost
		Cost		Cost		Groundwater Flow System	
Local GFS in sand dunes (Lowan Sands)	-	-	5	\$3500	-		\$3,500
Local GFS in Woorinen Formation	-	-	0	-	-	-	-
Regional GFS in Parilla Sands	-	-	-	-	5	\$30,000	\$30,000
Local GFS in highly Fractured Rock	1	\$15,000	-	-	10	\$60,000	\$75,000
Local GFS in weathered granites (high relief)	1	\$15,000	-	-	12	\$60,000	\$75,000
Local GFS in deeply weathered granites (Low Relief)	1	\$15,000	-	-	10	\$60,000	\$75,000
Local/Intermediate GFS in Deeply Weathered Fractured Rock	1	\$15,000	-	-	10	\$60,000	\$75,000
Intermediate GFS in Fractured Rock	-	-	-	-	2	\$12,000	\$12,000
Intermediate GFS in Alluvial plains	-	-	-	-	10	\$100,000	\$100,000
Local GFS in Colluvium -Grampians Sandstone	-	-	-	-	5	\$30,000	\$30,000
<b>Totals</b>	<b>4</b>	<b>\$60,000.00</b>	<b>5</b>	<b>\$3500.00</b>	<b>64</b>	<b>\$412,000.00</b>	<b>\$472,000.00</b>

### 3.4 SALINITY ACTION PLAN TARGETS

**TABLE 43: NRM AND WORKS TARGETS FOR THE IMPLEMENTATION OF THE WIMMERA REGIONAL SALINITY ACTION PLAN**

GFS	Outcome Sought	20 Year NRM Target	Works Targets 20 Year Outputs	5 Year Outputs
<b>Local flow systems in highly fractured rocks</b>				
	Reduced contribution to Wimmera saltloads Protection of high value agricultural land	50% reduction in recharge 10% decrease in discharge area 50% reduction in salt-load	4,500 ha trees and native vegetation 13,000 ha improved native pasture management 4,500 ha of perennial plants	900 ha trees and native vegetation 2,600 ha improved native pasture management 900 ha perennial plant
<b>Local flow systems in deeply weathered granites (Low relief )</b>				
	Reduction in Wimmera saltloads Protection of Stawell township	40% reduction in recharge 20-30% reduction in saltload	900 ha break of slope trees 8,000 ha perennial plants	200 ha break of slope 1600 ha perennial plants BOS locations mapped
<b>Local and Intermediate flow systems in deeply weathered fractured rock</b>				
	Reduction in Wimmera River saltloads Protection of Greens Swamp	30-40% reduction in recharge 10-20% reduction in salt load	5,000 ha trees and native vegetation 42,000 ha perennial plant	500 ha trees and native vegetation 2,800 ha perennial plant Perennial plant management information packages Identification of suitable locations for perennial and lucerne and best management for recharge control
<b>Regional flow systems in Parilla Sands (Edenhope area) &amp; Local flow systems in sand dunes (Lowan Sands South)</b>				
	Protection of Lake Wallace for water supply to Edenhope Improved water quality in Mosquito Creek	Reduced EC level of Lake Wallace and Mosquito Creek	Appropriate salinity control options based on R&D findings implemented across region Riparian zone of Mosquito Creek revegetated	Feasibility study of environmental, social and cost effective drainage as a salinity control option Implementation of drainage scheme in subject to outcomes of feasibility study. 30% of Mosquito Creek revegetated Understanding impact of clay spreading on recharge in high rainfall zone Linkages developed with agro-forestry companies
<b>Regional flow systems in Parilla Sands</b>				
	Protection of key assets in the Wimmera river from the impacts of saltloads from the Parilla GFS	Reduction in the impact of saltloads from the Parilla GFS on the Wimmera River	Implementation of engineering protection options Wimmera Mallee Pipeline implemented to return substantial environmental flows to the Wimmera River	Improved understanding of engineering options available to manage salinity impacts on key assets associated with the Wimmera River

### 3.4.1 PUBLIC INVESTMENT REQUIREMENTS

Over the next five years an indicative annual public investment of \$2.4 million p.a. will be required to start implementing the Wimmera Regional Salinity Action Plan.

**TABLE 44 INDICATIVE ANNUAL PUBLIC INVESTMENT REQUIRED TO IMPLEMENT PROPOSED FIVE-YEAR PROGRAM OF ACTIVITIES**

Item	Staff (FTE)	Cost \$m
Management and Co-ordination	1.7	0.2
Implementation Support	10.6	0.8
Works and applied Research (average annual budget)		0.6
R&D		0.6
Monitoring		0.2
<b>Total Plan</b>	<b>12.3</b>	<b>2.4</b>

## 3.5 COST-BENEFIT ANALYSIS

### 3.5.1 QUANTIFIABLE COSTS

The quantifiable costs considered in this analysis included:

- Costs of implementing the 20-year works targets in each GFS classified for implementation
- Agricultural production forgone on areas revegetated with trees
- Costs associated with implementing the 20-year discharge treatment targets
- Costs of managing, providing implementation support, undertaking research and development and monitoring implementation of the plan.

A breakdown of the present value of these costs over the next 30 years is provided in the Background Paper - Economic Analysis of Salinity Threats to the Wimmera Region, Madden 2004.

### 3.5.2 QUANTIFIABLE BENEFITS

We have been able to quantify the six main potential benefits of implementing the Wimmera Regional Salinity Action Plan.

1. Agricultural Loss Avoided - We have assumed that implementing the plan will be sufficient to halt the expected 1% p.a. increase in Wimmera area affected by salinity.
2. Infrastructure Loss Avoided - infrastructure costs are currently estimated at \$18 million p.a. The analysis assumes that implementing the plan will stop these losses increasing by 0.5% p.a. into the future.
3. Perennial Pasture Productivity Gain - Adopting perennial pastures is estimated to improve gross margins by a conservative \$30/ha.
4. Native Pasture Productivity Gain - estimated to be \$5 per hectare more than the costs of implementing improved management
5. Waterway Tourism Losses Avoided - the total number of visits to waterways in the Wimmera catchment has been estimated at 340,000 visitors per annum, with a total value of over \$7.5 million. Taking a conservative approach we have estimated the impact of future deterioration of water quality as a result of salinity reducing this tourism to the area by 1% p.a.
6. Protection of Wetland Capital Value - benefits of protecting the ecological, social and productive capacity of wetlands are difficult to quantify. Recent estimates place the capital value of stock of natural capital associated with the region's wetlands at about \$140 million. We have assumed that implementing the Wimmera Regional Salinity Action Plan will prevent this value from declining by 0.5% p.a.

### 3.5.3 QUANTIFIABLE COST-BENEFIT ANALYSIS

An analysis of the quantifiable costs and benefits of implementing the salinity plan over the next 30 years is shown in Table 45. At a 4% discount rate the costs have a present value of \$56.7 million while expected benefits are worth a present value of \$68.2 million. As such, the benefits outweigh the costs and the plan has a net present value of \$11.5 million and a benefit cost ratio of 1.2.

At a discount rate of 8% (which implies a higher preference for benefits or dollars now than in the future) the net present value is reduced to 0.1 million and the benefit cost ratio is 1.0, implying the benefits of implementation just outweigh the costs involved.

While we have attempted to quantify some environmental benefits of implementing the plan it is unlikely that we have captured them all. We expect that there are other potential benefits relating to:

- Improved water quality
- Protecting the ecology and biodiversity of the Wimmera
- Reduced salinity in the Wimmera River and Lake Hindmarsh
- Biodiversity benefits of increased native vegetation in the priority GFS.
- Protecting and improving key EVCs

If these benefits could be quantified they would further improve the net present value and benefit cost ratio of implementing the plan.

Quantifiable benefits and costs of implementing this plan are summarised in Table 45.

**TABLE 45: QUANTIFIABLE BENEFITS AND COSTS OF IMPLEMENTING THE WIMMERA REGIONAL SALINITY ACTION PLAN**

<b>Costs and Benefits</b>	<b>Present Value (\$ Million)</b>	
	<b>Discount Rate 4%</b>	<b>Discount Rate 8%</b>
<b>Future Costs</b>		
Tree Establishment	5.6	3.9
Break of Slope Trees	0.6	0.4
Perennial Plant Establishment	5.2	3.5
Fencing	3.8	2.7
Improved Native Pasture Management	1.3	0.7
Discharge Pasture Establishment	0.8	0.5
Agricultural Production Forgone	15.0	7.8
Management and Coordination	2.7	2.0
Implementation Support	10.9	7.9
Research & Development	8.2	5.9
Monitoring	2.7	2.0
<b>Total Costs</b>	<b>56.7</b>	<b>37.2</b>
<b>Quantifiable Future Benefits</b>		
Agricultural Productivity Losses Avoided	4.9	2.6
Infrastructure Losses Avoided	20.5	10.7
Perennial Pasture Productivity Gain	14.4	7.4
Native Pasture Productivity Gain	1.9	1.1
Waterway Tourism Losses Avoided	15.1	8.0
Protection of Wetland Capital Value	11.4	7.5
<b>Total Known Benefits</b>	<b>68.2</b>	<b>37.3</b>
<b>Net Present Value</b>	<b>11.5</b>	<b>0.1</b>
<b>Benefit Cost Ratio</b>	<b>1.2</b>	<b>1.0</b>



**Distichlis on trial to combat salinity.**



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**AEM.**

Airborne electromagnetic (induction techniques for salinity mapping).

**agro-forestry.**

A collective name for land-use systems in which woody perennials (trees, shrubs) are grown in association with herbaceous plants (crops, pastures) and/or livestock in a spatial arrangement, a rotation, or both, and in which there are ecological and economic interactions between the tree and the non-tree components of the system.

**aquifer.**

A porous soil or rock formation, below the surface of the ground, that holds water and through which water can move to reach bores and springs.

**biodiversity.**

The variety of life forms, plants, animals and micro-organisms, the genes they contain, the ecosystems they form, and ecosystem processes.

**catchment.**

An area of land supplying water to a watercourse bounded by hills or ridges that direct the flow of water.

**cyclic salt.**

The salt derived from oceanic spray transported inland by winds and deposited by rain.

**discharge.**

Groundwater that escapes into a stream bed, lake or ocean, or through the land surface.

**discharge zone.**

Areas of catchments where groundwater emerges at low points in the landscape.

**dryland salinity.**

Saline seepages or salt scalds occurring in rain-fed (non-irrigated) areas caused by changes in land use that affect the groundwater balance throughout the landscapes. A typical situation occurs following the tree clearing from hill slopes, which reduces transpiration and allows an increase in rainfall intake beyond the root zone and a rise in water tables lower down the slope. Increased subsurface seepage dissolves salts in the soil and, with lateral flow through the landscape, moves from hill slopes to valley floors. Salty water then surfaces in patches depending on the geomorphology and topography of the site. The salt becomes concentrated by evaporation at these locations and the normal vegetation is killed.

**EC units.**

The electrical conductivity (EC) of water provides a measure of the amount of salt dissolved in the water-the higher the EC value, the more saline the water. One EC equals one micro-Siemen per centimetre measured at 25 degrees Celsius, or approximately 0.6 milligrams of salt per litre. 800 EC units is the World Health Organization recommended desirable upper limit for salinity in drinking water.

**end-of-valley target.**

A target for the quality and quantity of water at the point where a river leaves a catchment.

**evapotranspiration.**

Water returned to the atmosphere by evaporation (by the sun) and by plants emitting water vapour from their leaves.

**groundwater**

The water in the saturated pores of soil or rock below the watertable.

**Groundwater Flow System.**

A GFS describes the movement of groundwater in an area and is used as a tool to manage and treat salinity.

**ICM.**

Integrated catchment management. The integration of water and land management activities and the government agencies involved in these activities within a catchment.

**irrigation salinity.**

A form of salinity caused by increasing build-up of salts in soils used for irrigation. It results from raised watertable levels that bring soil salts into the upper levels of the soil profile, as well as repeated use of saline river water for irrigation.

**Landcare.**

Landcare is a community-based approach to fixing environmental problems and protecting the future of our natural resources. There are now more than 4250 Landcare groups across Australia. About one in every three rural landholders is a member of a Landcare group.

**landholders.**

Those who own or lease land.

**land managers.**

Those who manage land, including farmers, graziers, irrigators, cultural and environmental land holders, councils and government agencies.

**LWA.**

Land and Water Australia. LWA is an Australian Government research and development corporation within the Agriculture, Fisheries and Forestry portfolio. Established in 1990 as the Land and Water Resources Research and Development Corporation under the Primary Industries and Energy Research and Development Act 1989, LWA invests in research and development for the productive and sustainable management of Australia's land, water and vegetation resources.

**market mechanisms.**

Mechanisms that change the market forces for particular commodities to help achieve the desired natural resource management outcome.

### **NAP. National Action Plan for Salinity and Water Quality.**

Established by the Australian, state and territory governments in November 2000, the objectives of the NAP are to enable regional communities and landholders to use coordinated and targeted action to prevent, stabilise and reverse trends in dryland salinity, and to improve water quality. Under the NAP, the Commonwealth funds communities to implement accredited integrated catchment/region management plans through block funding, on a matching basis with the States and Territories. Twenty-one priority regions have been identified under the Plan. Governments have jointly committed a total of \$1.4 billion for the NAP over seven years to 2007-08.

### **NDSP. National Dryland Salinity Program**

The NDSP was established in 1993 to address the lack of opportunity for the research community to cooperate across disciplines, organisational boundaries and state borders to address the management of dryland salinity. The program's goal is to research, develop and extend practical approaches to effectively manage dryland salinity. The program, which completed a second phase in 2003, is managed by Land and Water Australia on behalf of a consortium of organisations. In 2003-04 the NDSP will focus on four key areas: policy, production, catchments and networks as part of an accelerated communication and regional consultation process.

### **NHT. Natural Heritage Trust**

The Australian Government established the NHT in May 1997 to fund environmental protection, sustainable agriculture and natural resource management. Trust funding totalling \$1.4 billion supported some 12,000 projects and related programs over six years to 2001-02. More than 400,000 Australians were involved in these projects. In the May 2001 Budget, the NHT was extended with the allocation of an additional \$1 billion for a further five years to 2006-07. Trust funds are delivered at three levels: national investments, regional investments and a local component to directly fund some community groups. Under the NHT Extension, states and territories have agreed to provide matching funding for investments at the regional level. Funding for projects is delivered under four Trust programs: Landcare, Bushcare, Rivercare and Coastcare. The 2004 Budget provided an additional \$300 million for the NHT to 2007-08, bringing total investment in the Trust to \$3.0 billion.

### **NLP. National Landcare Program**

The objective of the NLP is to increase the engagement of industry and resource users in Landcare and NRM activities. The NLP has a focus on sustainable farming and sustainable land management. NLP investments currently consist of a community support and a national component. There are 4000 Landcare groups, involving 40 per cent of the nation's farmers. In 2003, the NLP received an additional \$122 million in funding for the three years to 2005-06. The 2004 Budget extended the program by providing an additional \$80 million (\$40 million in both 2006-07 and 2007-08).

### **NLWRA. National Land and Water Resources Audit**

Established in 1997, the NLWRA is a \$30 million research program funded under the NHT, the objective of which is to facilitate improved decision making on land and water resource management issues, particularly by the Australian and state governments. Now in its second phase, June 2002-June 2007, the audit will provide data, information and assessments of Australia's land, water and biological resources to support sustainable development. A core function will be to collate natural resource information to support the monitoring and evaluation of the NAP and the NHT. Two key audit information products are the Australian Natural Resources Atlas and the Australian Natural Resources Data Library. One of the audit's principal pieces of research has been the Australian Dryland Salinity Assessment 2000.

### **public good.**

A benefit accruing to the community as a whole.

### **private good.**

A benefit accruing to an individual or individual organisations.

### **PURSL.**

Productive Use and Rehabilitation of Saline Land.

### **RDC.**

Research and Development Corporation.

### **recharge.**

Water that has drained below the root zone of any local vegetation and which is then able to drain downward to add to the underlying layer of saturated soil, or groundwater.

### **recharge area.**

An area where water enters the soil and contributes to the groundwater store. Upper slopes and areas with shallow soils are common recharge areas. Recharge is maximised where soils overlie fractured rocks, where soils are highly permeable, where vegetation is shallow-rooted or absent, and when rainfall exceeds evapotranspiration.

### **regolith.**

A general term for the entire layer of fragmental and loose, incoherent or unconsolidated rock material of whatever origin (residual or transported) and of very varied character; that nearly everywhere forms the surface of the land and overlies or covers the bedrock.

### **riparian.**

Of, inhabiting, or situated on the bank and floodplain of a river.

### **river salinity.**

River salinity is caused by saline discharges from dryland, irrigation and urban salinity, and aquifers into creeks and rivers.

### **salinisation.**

Degradation of the soil or water through the accumulation of salts. Land salinisation occurs following the accumulation of soluble salts (usually sodium chloride) at or near the soil surface, to a level that causes degradation. This usually occurs through the evaporation of groundwater that discharges through the soil surface. Water salinisation usually results from increasing salinity of run-off and groundwater.

### **salinity.**

The concentration of dissolved salts in groundwater or river water, usually expressed in EC units.



**Salinity Management Triage.**

In considering possible options to manage salinity there are three possible alternatives available:

1. Options that seek reduce the impact of current salinity issues within a "reasonable" timeframe
2. Options that seek to avoid future salinity impacts
3. Options that seek to adapt to saline environs

**salt scald.**

An area where salt crystals accumulate on the soil surface, suppressing plant growth and often leading to surface soil erosion which can expose saline subsoils.

**surface water.**

Water on the surface of the land, for example, rivers, creeks, lakes, dams and overland flows.

**urban salinity.**

Salinity that occurs as a result of urban activities.

**waterlogging.**

Saturation of soil with water; resulting from over irrigation, seepage or inadequate drainage.

**watertable.**

The upper surface of a layer of soil or rock material that is saturated with water.

This glossary has been compiled from the following source:  
House of Representatives - *Science Overcoming Salinity* - 2003





Wimmera  
Catchment Management  
Authority

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