Mt Marshall Land Conservation District Committee

Beacon River Catchment - Salinity Management Feasibility Study

Report On

Feasibility Summary

June 2002

Gutteridge Haskins & Davey Pty Ltd
ABN 3900 8488373
GHD House, 239 Adelaide Tce. Perth, WA 6004
P.O. Box Y3106, Perth WA 6832
Telephone: 61 8 9429 6666 Facsimile: 61 8 9429 6555 Email: permail@ghd.com.au

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SYNOPOSIS

THE NEED FOR THE STUDY

Since its inception in 1984 the Mt Marshall Land Conservation District Committee (LCDC) has investigated and implemented various tree planting and surface water management programmes in an attempt to control rising groundwater tables and encroaching dryland salinity in the Beacon River Catchment (BRC). In 1998 current president, John Dunne decided that 'deep drainage' and pumping would be required to lower the groundwater on his farm in the Beacon River valley 6.5 km's upstream of Job's Lake. Mr Dunne envisaged that Job's Lake could serve as a natural evaporation lake for disposal of saline groundwater.

In March 1999 cyclones Elaine and Vance dumped between 200mm and 375mm throughout the BRC over a period of 5 days. The resulting floodwaters inundated large areas of remnant vegetation and land that had previously been revegetated in an attempt to control salinity. Water levels in Job's Lake rose to around 4.5 metres in response to an inflow of about 7 million m^3 of floodwater.

For the 12 months to February 2001 farmers in the BRC recorded as much as 1000mm of rainfall, which is 3-4 times the long term annual average for the catchment of between 300-330 mm. At this stage Mr Dunne started investigating the option of draining Job's Lake, given the continual problems with water-logging, flooding and ever encroaching salinity. Mr Dunne approached GHD in August 2000 with a request for assistance to prepare a submission to WA's State Salinity Council for a whole-of catchment approach to lower the groundwater levels. An initial estimate for a scheme was about $1,4 million. The State Salinity Council offered the LCDC $100,000 to fund a Feasibility Study of the "drainage" component of the scheme.

The Beacon River Catchment is located along the north eastern fringe of Western Australia's Wheatbelt. Clearing of native vegetation, which started in the 1920's, together with periodic flooding by cyclonic activity during summer, has resulted in rising groundwater tables, reductions in available surface water storages and salinisation of some of the best agricultural land along the main drainage or floodway through the catchment.

The main drainage route along which most of the salt affected or salt threatened (SAST) sites are located is approximately 120 kilometres long and typically 2-8 kilometres wide. SAST sites are already evident along 90 kilometres of main drainage route.

GHD's study outcomes indicate that intervention and management of current and potential future SAST sites is required within the next 1-5 years to:

- Prevent the loss of upwards of $35 million/annum of agriculturally derived income.
- Preserve the investment of more than $4 million in farming infrastructure.
- Protect about 45,000 ha of good quality agricultural land.
- Protect about 2,670 ha of surviving remnant vegetation.
- Maintain the commercial viability of the towns of Beacon and Bencubbin.
- Protect the long term livelihood of about 180 families living within the catchment.
- Prevent land degradation and the resultant depopulation of the catchment.
- Prevent declines of essential services and the social fabric of the area.
- Prevent declines in fauna/flora habitats, populations and species diversity.

GHD'S PART OF THE STUDY

Submission

GHD's part in the submission phase was to determine precisely what investigations were essential to a Feasibility Study and what could reasonably be expected to be completed within a $100,000 budget limit. No funding was available for this part of the exercise.

Appointment

Through the Mt Marshall LCDC, the Feasibility Study was funded by a $100,000 grant from WA's State Salinity Council, with a further $25,000 invested by the Grains Research and Development Corporation (GRDC) for installation of groundwater monitoring piezometers, monitoring during the project, survey of the piezometers and information management.

The project was managed by the Mt Marshall LCDC overseen by a 'Reference Group', which consisted of representatives of the Department of Agriculture, Water and Rivers Commission, CSIRO, Department of Conservation and Land Management (CALM), the Avon Catchment Council, Mt Marshall Shire Council, State Salinity Council, GHD Pty Ltd and five farmers representing landholders in specific sections along the catchment.

Scope Of Work

Aspects of the study covered by GHD at various levels of detail include:

- Community consultation.
- Study risk analysis and risk management.
- Catchment flood hydrology.
- Catchment hydrogeology.
- Engineering scheme options.
- Non-engineering options.
- Impacts on conservation values.
- Scheme cost-benefit analyses.

Studies Undertaken

Field programs to install shallow monitoring piezometers and soil test pits along the main drainage route of the BRC commenced in December 2000, assisted by the Department of Agriculture. Following this a community consultation workshop, conducted on the 23 February 2001 culminated in a Risk Management Workshop held in Northam on the 15 March 2001, and subsequent preparation of a Risk Management Plan. The plan was developed to guide investigations into potential options for controlling and limiting the spread of dryland salinity in the catchment. The study considered engineering and land and water management options, within a framework of social, environmental and economic opportunities and constraints.

During the remainder of 2001 various technical studies were undertaken. These covered aspects such as catchment flood hydrology, catchment hydrogeology, the assessment of the potential for salinity to impact on conservation land values, as well as proposed engineering and non-engineering scheme options, conceptual designs and cost-benefit analyses. The feasibility of the proposed schemes were carefully assessed against the available technical, economic, environmental, social and political information made available through the various project investigations and studies.

Investigations into suitability and cost-effectiveness of adopting non-engineering intervention schemes to control rising groundwater tables included agroforestry, non-commercial tree planting, farming with perennials using various crop rotations, saltland pastures and aquaculture. The studies concluded that available research does not provide sufficient evidence to warrant broad scale adoption of these options, at this stage. The main constraints are the relatively long lead-in times (1-10years), financial risks and uncertainties of the effectiveness of these options to make them attractive.

Investigations of engineering options included phased implementations of a central catchment drain combined with abstraction bores, with options for disposal at salt-lake sites both inside (Job's, Askew's and McDermott lakes) and outside the catchment (Lake Moore, Mollerin Lake and Lake Wallambin).

Cost-benefit ratios and payback return periods for five different engineering schemes were shown to be sensitive to the agricultural operative profits figure ($50-$124.50 per ha) applied to the financial models. Except for one of the schemes the cost for implementation of the schemes varied from about $10,00-$14,5 million, resulting in derived benefits of between $14,25 -$18,25 million, calculated to the nearest quarter million dollars. Net cashflows, were calculated to be between $2,75 - $4,25 million. The payback periods for engineering works could be reduced from about 30-35 years for most of the schemes to about 20-25 years with higher operating profits.

GHD's study outcomes clearly demonstrate the feasibility of implementing engineering interventions to control and manage dryland salinity in the catchment within the timeframes (1-5 years) considered available for implementations to be successful. Delays in implementation would result in ever increasing declines in the 'rates of return' and therefore the economic feasibility of investments into management of dryland salinity in the catchment.

GHD's study outcomes further indicate that, if left too long, interventions, irrespective of whether they would comprise stand alone engineering schemes or integrated schemes comprising combinations of engineering and non-engineering options, would simply no longer be economically feasible. This would make the case of 'investment' by government or private organisations and farmers less attractive and accordingly, highly unlikely.

Recommendations

Given the potential feasibility of engineering schemes and the urgency for immediate interventions to prevent the Beacon River Catchment from sliding into a situation of continuous and near-irreversible social, economic and environmental decline, GHD recommends that pilot engineering scheme be implemented at one of several already heavily impacted sites. Trialling should include an integrated scheme, combining both a central catchment drain, abstraction bores and disposal at one of the larger salt-lake complexes.

To-date large scale trialing of engineering interventions have not been successfully completed in Western Australia. The outcomes from trialing engineering interventions in the Beacon River Catchment could therefore potentially have far-reaching implications in the race to find socially, politically, economically and environmentally acceptable solutions to the salinity problem.

Piloting a predominantly engineering-based solution to the salinity problems in Beacon River Catchment could provide opportunities to further both the practical and scientific investigations of the performance, management, maintenance and sustainability of catchment-wide drainage schemes, together with the social, economic and political dynamics associated with implementation, derived benefits, ownership and the mutual co-operation between government and private organisations in dealing with the salinity problems.

Reports

The reports produced during the course of the study underwent several sets of revisions as new information became available, or as feedback was received from the study Reference Group members. A list of report references is given below, including the dates for the initial versions of the reports, as a guide to the chronological order in which the studies were completed.

1. Risk Assessment Workshop (GHD document number 6110745, dated April 2001).
2. Flood Estimation in the Beacon River Catchment (GHD document number 27049, dated July 2001).
3. Phase I Groundwater Modelling Assessment of the Beacon River Catchment (GHD document number 29000, dated July 2001).
4. Groundwater Analyses Undertaken In Support Of The Cost-Benefit Analysis (GHD document 2940, dated November 2001).
5. Engineering Options (GHD document number 30370, dated November 2001).
6. Environmental Assessment of Vegetation (GHD document number 31139, dated October 2001).
7. Cost-Benefit Analysis (GHD document number 31128, dated December 2001).
8. Feasibility Summary (GHD document number 31137, dated December 2001).

Electronic Copies Of GHD's Reports

Hard copies of GHD's reports will not generally be made available due to the relatively high cost of reproduction of the reports. Electronic copies of the reports can however be downloaded from GHD's website (www.ghd.com.au/beacon). Registration may be required for downloading. Copies will also be made available through the Mt Marshall LCDC website (www.beaconriver.com).

Any queries or additional details can be obtained from:

GHD Pty Ltd

Robey John Chipps

Email rchipps@ghd.com.au

Facsimile 61 8 9429 6555

Telephone: 61 8 9429 6666

Mt Marshall LCDC

Mr John Dunne

Email parakeelya@wn.com.au

Fascimile 08 96861005

Telephone 08 96861045

ACKNOWLEDGEMENTS

Numerous individuals, from government agencies and private organizations, directly or indirectly involved with the project, provided valuable support and feedback for the project. Their contributions through attendance at the community consultation and risk management workshops, project meetings, Reference Group meetings, or through their telephonic, email and facsimile communications with project staff is much appreciated. It is much to our regret that we cannot list all the people who had a 'part' in the project.

Members of the Reference Group setup by the Mt Marshall LCDC for the study are:

Mt Marshall LCDC	John Dunne, Chairman Reference Group and President Mt Marshall LCDC
State Salinity Council	Rod Safstrom MSc BSc
Avon Catchment Council	Barbara Morrell Chairperson Avon Catchment Council
Dept of Agriculture	Dr Richard George Ned Crossley, Allan Johns, Brian Beetson, Rosemary Nott
Water & Rivers Commission	Mohammed Bari, John Ruprecht, Martin Revell
CALM	Paul Roberts, Mike Fitzgerald
CSIRO	Tom Hatton, Riasat Ali
Mt Marshall Shire Council	Ian Landsmeer, Shire President
GHD Pty Ltd	Ian Weaver, Robey Chipps
Farmer	Chris Kirby, Secretary Mt Marshall LCDC
Farmer	Helen Shemeld, Vice-Pres MMLCDC
Farmer	Tony Sachse
Farmer	Ian Evans

1. Introduction

1.1 Introduction

The 'Beacon River Catchment - Salinity Management Feasibility Study' was envisaged to be a broad scale catchment assessment of the potential cost-benefit of undertaking groundwater management controls to reduce the spread of dryland salinity within the catchment. Undertaking a cost-benefit analysis would require consideration of numerous options and possibilities, and potential constraints that could affect or dictate the selection, design, scale, operation, cost, maintenance, management and long-term sustainability of any proposed intervention schemes.

It was envisaged that GHD would mainly focus on the technical feasibility of any proposed interventions, but would also consider, through various forums facilitated by the Mt Marshall LCDC, some of the more important social, political, economic and environmental factors to be considered in the design and assessment of the schemes.

It was further envisaged that, although GHD would consider the non-technical factors and include them in the process where possible, GHD's opinions and contributions to the project would not in anyway be prescriptive. GHD's reports would hopefully provide, through the Mt Marshall LCDC as client, the basis to further the process, which will result in the implementation of a scheme/s to better manage dryland salinity in the Beacon River Catchment.

1.2 Catchment Setting

Runoff from flooding tends to be concentrated in one or more of the larger freshwater and salt lake complexes (playas) located along the main channel valley. Des's Lake, a freshwater lake, is located in the north east. The main salt lakes are Job's Lake near Beacon, Askew's Lake which is about 6 kilometres downstream of Job's Lake, and the McDermott Lakes complex located near Bencubbin.

Clearing of land has resulted in increased recharge to the catchment aquifers, mainly along the main channel valley. Flooding associated with cyclonic activities has accelerated the rate of rise of groundwater tables along the main channel valley. Rapid degradation of land from water-logging and/or salinisation has resulted in approximately 124 km^2 (4.6 % of the area of the catchment) of good agricultural land being salt-affected or salt-threatened. At currently predicted rates of rise for the water table, this is expected to increase to about 453 km^2 (45,300 ha or 16.9 % of the area of the catchment) in 50 years time (2052).

The State Salinity Council and Grains Research and Development Corporation considered the LCDC proposal for the Feasibility Study important for a number of reasons. The Feasibility Study has shown that:

- The catchment is an important producer of mainly cereal crops, primarily wheat and barley. Production value for crops and stock was approximately $40 million in 1992/1993 fiscal year with over 90% of this income derived from cropping. The protection of about 45,300 ha of good cropping land over the next 50 years, 2,670 ha of surviving remnant vegetation, the commercial viability of both the Beacon and Bencubbin towns and associated facilities and services, and the potential livelihood of upwards of 18 families is dependent on the successful intervention and management of dryland salinity in the short to medium term (5-25 years).
- The dryland salinity situation in the Beacon River Catchment is one of the worst in the Swan-Avon River Basin. Collaborative mapping of salinity risk in the South West by several government agencies shows that the Beacon River Catchment falls in the zone designated as “highest salinity risk” in the State. Physiographic and hydrological characteristics of the catchment are highly conducive to dryland salinity processes. The study of these processes therefore affords a unique opportunity for knowledge transfer to other catchments with similar physiographic and hydrolological characteristics and dryland salinity risk-status.
- The catchment may provide a unique opportunity to undertake and evaluate holistic catchment-based approaches to dryland salinity management in the future. Trialing of engineering schemes and non-engineering intervention options could be used to evaluate the applicability and effectiveness of these techniques in low soil and aquifer permeability environments, particularly the opportunities for combined drain and bore abstraction schemes.
- If catchment-based intervention schemes were to be implemented in the future, the suitability of current legal, environmental and institutional controls and mechanisms relating to catchment-based management of dryland salinity, could be tested.

A summary of the outcomes of the individual reports completed as part of the Feasibility Study are provided in the following sections.

2. Risk Assessment and Management

2.1 Introduction

The objective of using risk assessment and management approaches as part of the Feasibility Study was to identify the potential risks affecting the outcomes of the project, to assess the potential impacts of those risks, and to develop a prioritised strategy for managing risk for the benefit of the community.

2.2 Methodology

The methodology used was to conduct two workshops, a Community Participation Workshop and a Risk Management Workshop. The perceived risks associated with various issues were identified, listed, categorised and ranked. Issues raised that were within GHD's scope of work were addressed during the course of the project. Issues outside the GHD scope of work are to be addressed by the Mt Marshall LCDC on an on-going basis.

2.3 Workshops

A Community Consultation Workshop was held at Beacon on 23 February 2001. Following on from the workshop, a second Risk Management Workshop was conducted at Northam on 15 March 2001. This workshop brought together technical experts and community representatives to evalute the risks identified at the Community Consultation Workshop, and the need for management and action plans to mitigate the risks.

The Risk Management Workshop followed applicable guidance provided by Australian Standard AS/NZS 4360:1999 – Risk Management.

Participants at both workshops included various interested and affected parties (e.g. local farmers, indigenous people, Shire Council representatives, academics), and representatives from relevant government agencies (e.g. D.Agric, CALM, WRC, CSIRO).

Workshop participants were also invited to consider additional issues and provide post-workshop feedback and comments. Community members who could not attend the workshops and wished to contribute their ideas to the Feasibility Study were invited to contact the Mt Marshall LCDC, or any other community spokespeople identified at the Community Consultation Workshop.

Management and Action Plans were developed from the outcomes of both the workshops. These were circulated to participants for comment. Several responses were received and included in finalisation of the management and action plans. The plans were restricted generally to matters that could be resolved or actioned within the scope of the feasibility study.

2.4 Study Outcomes

The outcomes of the Community Consultation Workshop were first grouped into categories (social, technical, political etc) and then assessed within each category to provide an indication of relative risk. The following table summarises the identified and evaluated risks into seven broad categories as described.

Table 2.4.1 - Accumulated votes for key risk categories

Votes	Issue
59	Downstream effects - legal implications, damage to remnants, increased salt loads in middle & lower catchment
41	Engineering issues - leakage from drain, soil stability, ability to handle large flows, proper design, handling surface water
35	Gaining agreement – type of system used, allowing drain to pass through, maintaining community unity, information availability
21	Economic impacts - cost of construction, effects on land value
20	Do Nothing Scenario - Costs of not taking any remedial action
16	Maintenance – identifying responsibilities and costs
6	Lake Mc Dermott - effects on capacity

All these issues were addressed in considerable detail during the course of the project. Under Category A it should be noted that only one of the five remedial schemes now proposed includes the option for linking to an arterial drainage network with drain discharge to downstream catchments. This option was only included as an option in the event that regional drainage between catchments is realised in the near-future.

The list of issues raised at the Risk Management Workshop is quite extensive. The list included items which were similar or outside the project scope. A summary of most of the major and medium ranked issues is presented in Table 2.4.2, together with a brief description of how they were addressed during the course of the project.

The majority of concerns focussed on issues pertaining to the location, design, costs, benefits, performance, protection and management of engineering-based remedial schemes involving mainly drainage.

Issues related to avenues of future funding and ownership, management and responsibilities for remedial schemes are outside GHD's scope of work for the Feasibility Study.

Table 2.4.2: Summary of issues raised at the risk management workshop

Issue/Risk	Main Action
Risk and consequences of flooding in previously unaffected areas	Removal, conveyance, storage and disposal of flood-water and saline drain-water was optimised in most of the proposed engineering-based remedial schemes to reduce this risk. Options investigated include removal of existing lake-water and potential drain-water to salt lake complexes outside the catchment (if required).
Sufficient details in design options to determine cost implications	Various engineering schemes designed and costed to this level.
Impacts of management options on cost-benefit analysis	Impacts and cost-benefit analyses for five different engineering-based remedial schemes were assessed as part of the Feasibility Study.
Salt loading in 'regional' arterial drainage.	Detailed assessments of salt loadings in regional arterial drainage did not form part of the project brief. Preliminary estimates were made for a central catchment drain. Arterial drainage was not the only disposal option considered. Inter-catchment pumping and internal catchment evaporation options were also investigated.
Engineering options should consider minimising land utilisation and disruptions	Location of the central catchment drain moved inside the 1:100 year flood line. Proposed routing is through mostly degraded and salt-affected land located towards the central sections of the main catchment valley.
Knowledge gaps to ensure efficient designs are implemented	Review of current designs, inspections of drains in the field and detailed 3-dimensional modelling of performance of proposed drain designs was undertaken.
Channel design to safety requirements and incorporate barrier effects	Scheme design included consideration of geotechnical and people safety and included flood protection of drains, progressive/staged decanting of water in the drains to suitable disposal sites.
Mitigation of undesireable biological elements	Inclusion of traps to collect silt and plant debris.
Piped options in porous soils	Engineering schemes address this issue mainly downstream of Job's Lake.
Potential impact of groundwater levels	Included in development of predictive land salinisation models and maps.

Issue/Risk	Main Action
Insect breeding sites in design of channels and ponds	Channel designs don't allow for stagnant water accumulations. No ponds are envisaged in the design of disposal options, except in the traps to collect silt and plant debris.
Soil types and potential for drainage	Soil types and their influence on inflows to drains and drain discharges were modelled and evaluated in detail.
Risks of extreme weather conditions	Drain design considered extreme weather conditions and included protective berms and compartmentalisation to mitigate some of the risks associated with flooding
Cost efficiency in cost/benefit assessment of each remedial option	Costs for each option were evaluated and compared with the do-nothing option to achieve this.
Address hydraulic performances of discharge sites	The hydraulic performance of the discharge outlet at Job's Lake was assessed, as well as the performance of the proposed inlet and outlet structures at the Lake McDermott complex.

3. Flood Study

3.1 Introduction

The main objective of the flood study was the assessment of the magnitudes, levels and extents of flood events in order to appropriately site, design and engineer proposed remedial schemes. Besides trying to assess the potential impacts of flooding on farming and infrastructure, the requirement was also to define the extent of the 1:100 year flood, in the event that drainage design necessitated that a drain be sited outside the 1:100 year flood line. Catchment yield analysis did not form part of the study.

3.2 Methodology

The methodology used included the following:

- Estimations of peak flows for the 2-100 year Average Recurrence Interval (ARI) flood events.
- Flood modelling to determine the levels and extents of the 1:100 flood event.
- Calibration of the Flood Model using available photographic and anecdotal evidence. No streamflow gauging data is currently available for the catchment.
- Preparation of Flood Maps using available contour data.

3.3 Study Outcomes

The broad flood plains and limited channel slopes tend to slow and restrict the discharge of flood waters in the Beacon River catchment. The ridges north and south of Askew's Lake and storage at Job's Lake, effectively divides the Beacon River Catchment into three distinct catchments. Modelling of floods up to 1:100 year indicates that no surface flows occur between these water-bodies for floods up to this magnitude. The Askew's Lake Catchment can be considered to be independent of the Job's Lake Catchment to the north and the McDermott Lakes Catchment to the south.

Table 3.3.1 provides a summary of the analyses of peak flow estimates for each major catchment. Table 3.3.2 provides the estimates of runoff volumes reporting to the lake-bodies and rough estimates of the area the lakes would occupy following these flood events.

The results of the flood study proved valuable given that flood-induced recharge is the most significant control on rising groundwater tables. Defining the 1:100 year flood lines through flood mapping also therefore defined the extent of potential flood-recharge zone to groundwater and by implication, the areas that are at risk of becoming salt-affected in the short-term if further flooding takes place in the catchment

Table 3.3.1: Estimate of peak flows for ARI flood events

ARI (years)	Job's Lake (m^3/sec)	Askew's Lake (m^3/sec)	McDermott Lakes (m^3/sec)
2	13	2	9
5	27	4	20
10	50	7	36
20	87	12	63
50	164	23	120
100	256	43	228

Table 3.3.2: Estimates of the flood surface area at each major lake site for different ARI flood events

	Job's Lake		Askew's Lake		McDermott Lakes	
ARI (years)	Runoff (ML)	Area (km^2)	Runoff (ML)	Area (km^2)	Runoff (ML)	Area (km^2)
10	990	1	240	0.1	1,610	2
20	10,800	4	470	0.2	5,380	4.5
50	22,700	10	1,090	0.5	6,580	5.5
100	42,400	20	2,140	1.2	6,860	6.0

The estimates provided in Table 3.3.2 are possible maximums assuming uniform flooding across the lake catchments. This is not always the case. For example, the 1999 flooding in the catchment resulted in approximately 6-8 million m^3 entering Job's Lake. This event was deemed by the Mt Marshall LCDC to be at least a 1:50 to 1:100 ARI event.

Rough estimates of the annual runoff yield for each of the main catchments is given in Table 3.3.3. The total yield for the Beacon River Catchment is about 7,000,000 m^3 per annum, which equates roughly to the annual evaporative capacity of the McDermott Lakes complex. Hence, under average rainfall conditions, there are few surface expressions of runoff in the catchment.

Table 3.3.3: Estimated annual catchment yield

Catchment	Area (km^2)	Yield (millions m^3)
Jobs	1,440	3.7
Askews	66	0.2
Lake McDermott	785	2.0
Shire Boundary	2,670	6.9

4. Groundwater Balance Modelling

4.1 Introduction

The primary objective of the groundwater balance study was to obtain estimates for the groundwater fluxes (flows at certain points or sections of the catchment aquifers) at different locations along the main valley floodway. Other objectives included obtaining preliminary indications of the:

- sensitivity of water table responses to small changes in infiltration recharge under average rainfall conditions;
- likely pumping rates for bores given local hydrogeological conditions; and
- rate of inflow, discharge volumes and extent of dewatering catchment zone for an open-cut drain.

4.2 Methodology

Following a review of available groundwater information for the catchment, computer-based analyses of the catchment digital terrain (DTM) model were undertaken to map both smaller and larger surface water catchments. These provided indications of the potential boundaries between, and relative importance of, the surface water catchments as recharge zones to groundwater systems.

Potential infiltration recharge zones were further delineated by:

- Mapping changes in topographic slope.
- Identifying areas which could potentially generate significant runoff during flood events.
- Identifying flat areas in the landscape with the potential to accumulate the flood runoff
- Defining the extents of infiltration recharge zones around the major lake sites.

The outcomes from the digital catchment analysis were integrated into a simple two-layered 3-dimensional numeric Modflow-based groundwater model. The model was used to simulate flow and water table fluctuations in the shallow alluvial and deeper sedimentary aquifers for different recharge scenario's. Water table data for March 2001 was used in the model, together with estimates of aquifer parameters obtained from Department of Agriculture research conducted in the catchment.

Estimates of groundwater fluxes at sixteen cross-sections in the catchment were also estimated using the model.

4.3 Study Outcomes

The results of computer simulations of catchment topography, slope and surface water catchments are given in Figures 4.3.1-4.3.3. Interpretation of the major topographic features of the catchment is given in Figure 4.3.4.

Water levels throughout the catchment are sensitive to slight increases (<10%) in the nett recharge rates, due principally to aquifer geometry and the low permeabilities–low storage characteristics of the aquifers. Groundwater fluxes in the shallow alluvial and deeper sedimentary aquifers along the main channel route and under average rainfall conditions, are generally low. Fluxes are typically less than 100 m^3/day, depending on the location in the catchment.

The modelling predicted optimum bore abstraction rates in the range 20-25 m^3/day. Preliminary model results indicated that the maximum flow rate after two years in a 20 km long, 2 m wide groundwater interception drain would be of the order of 3000 m^3/day (34.7 l/s). Average rates for drain inflows and discharges were assessed later in the project (refer Section 5.3).

Overall the outcome from the groundwater budget was to show the vulnerability of the majority of the main channel route (good farm land) to mainly flood-induced recharge effects and rapid salinisation of farm land from rising water tables.

5. Groundwater Studies

5.1 Introduction

A number of groundwater studies were undertaken, principally with the objective of providing pertinent data for the Cost-Benefit Analysis (CBA). These included:

- The installation of over 50 shallow monitoring bores along the main valley floodway from below the McDermott Lake's complex in the south to slightly downstream of Des's Lake in the north east.
- Survey of the monitoring bores, including a number of bores that were installed and have been periodically monitored since the since the mid 1980's.
- Assessment of the history of the ground water levels and the rates of rise of groundwater tables in different parts of the catchment using available historic and bore monitoring data.
- Identification and mapping of current and potential future sites, which could become salt-impacted.
- Predictions of possible variations in drain inflow rates, drain discharge volumes and drain catchment zones for a range of representative material properties for catchment soils and weathered rock horizons.
- Predicting the radius of influence of bores used to dewater areas of shallow saline groundwater.

5.2 Methodology

The selection of suitable sites for establishing bore monitoring facilities was undertaken by GHD using available topographic, geological, surfacewater and ground water information. Final selection of sites in the field, supervision of installation of the monitoring facilities and production of bore logs was undertaken by DAgric.

Survey of bore monitoring sites was undertaken by an independent contractor appointed by the Mt Marshall LCDC.

Assessment of the rates of rise of the groundwater tables in the catchment included graphing and statistical analysis of bore monitoring data and comparison of the results with the soils/lithological information in close proximity to the sites. DAgric bore logs for the newly installed monitoring bores proved most useful for this purpose.

Three different methodologies and map products were produced. The first involved using depth to groundwater table information to predict the extent and level of the water tables in the future. Landsat and SPOT satellite imagery for the catchment were used to assist with interpretations of degraded and/or salt-affected land along the main valley floodway. Where possible the extents of the larger salt-lake bodies and river channels were mapped from the satellite imagery.

The second process involved using available digital elevation model (DEM) data and calculated rates of rise for the water tables to predict where and when the water tables would impact on the near-surface and soils of the catchment. A depth of 1.5 metres below ground level (mbgl) was used as the threshold after which agricultural production would be adversely affected by rising groundwater tables.

The third method involved supplying the Mt Marshall LCDC with a copy of modelled land salinisation maps. These maps were reviewed by a number of farmers in the catchment and modified according to their knowledge of local conditions.

Three-dimensional numeric modelling approaches were used to evaluate variations in drain and bore yields and catchment zones for a range of soil/weathered aquifer permeability conditions, typical of the local conditions at Beacon.

5.3 Study Outcomes

The more relevant outcomes from the groundwater studies, which were required as CBA inputs, are depicted in the following figures, or listed below:

- Figure 5.3.1 depicts the locations of both the historic and newly installed catchment monitoring bores.
- Figure 5.3.2 depicts the land salinisation map developed by the farmers in the catchment.
- Figure 5.3.3 depicts the land salinisation map generated using the topographic-water table rise method.
- Conservative estimates indicate that drain inflows could be 50m^3/day/km (18,250 m^3/km/yr) of drain, while drain catchment zones (minimum 500 mm drawdown) could extend up to 400m either side of the drain after 1-2 years of drainage.
- Assuming average pumping rates of between 20-25 m^3/day, an average radius of influence of 250 m was adopted, indicating that 3-4 bores would be required per km^2 for to control rising water tables.

Applying the above outcomes to the catchment as a whole indicated that:

- 453 km^2 of saline land was predicted to become salt-affected within 50 years if no interventions are implemented.
- 90 km^2 of salt-threatened land could be drained and protected using only a central catchment drain.
- 363 km^2 of land under threat of salinity could be protected using shallow (<5 m deep) bores or lateral drains.
- For every 1 kilometre of central catchment drain, 16 bores would be required, on average, to protect 4 km^2 of salt-threatened land on either side of the drain.

Applying the outcomes to the individual engineering schemes proposed in Section 6 indicates that:

Scheme 1

- 21 km of drain would be required to protect land under immediate threat of salinisation.
- 336 bores would be required to protect 84 km^2 of salt-threatened land in the next 50 years.
- 168 km of piping would be required to discharge saline bore-water to the central drain over the next 50 years.

Schemes 2,3,4

- 70 km of drain would be required to protect land under immediate threat of salinisation.
- 1220 bores would be required to protect 280 km^2 of salt-threatened land in the next 50 years.
- 560 km of piping would be required to discharge saline bore-water to the central catchment drain over the next 50 years.

Scheme 5

- 90 km of drain would be required to protect land under immediate threat of salinisation.
- 1440 bores would be required to protect 360 km^2 of salt-threatened land over the next 50 years.
- 720 km of piping would be required to discharge saline bore-water to the central catchment drain over the next 50 years.

6. Engineering Options

6.1 Introduction

At the start of the project it was envisaged that bores and link-drains to the central catchment drain could be used to remove saline water to lower the ground water tables in salt-affected areas. Drain-water and bore-water would be disposed of in a large catchment drain, located outside the 1:100 year flood plain, the main function would be to convey saline water to the southern boundary of the Mt Marshall Shire, i.e. the Trayning Shire boundary. At this point the Mt Marshall catchment drain would link to a regional arterial drain network. Disposal of saline water would be downstream at suitable sites, possibly including the Indian Ocean via the Avon and Swan rivers.

Later in the project preliminary analysis of current depth to water table along the main channel route indicated four priority areas currently affected by rising groundwater tables and salinisation. This information provided the basis for the proposed routing of a central catchment drain along the main valley floodway. Areas with groundwater tables of less than 2.0 mbgl were identified and open drains for both drainage and conveyance of saline water were proposed for these sites. The use of lined and/or piped drains was investigated for areas with deeper groundwater tables. On the basis of the mapping of salt-affected areas the final scope of work for the engineering component of the project included:

- the assessment of the proposed central catchment drain along the Beacon River valley (main drainage route);
- the concept design of schemes to transfer water out of the Beacon River Catchment;
- the concept design of natural and engineered evaporation basins to dispose of the drainage from the central catchment drain; and
- the preparation of preliminary cost estimates of the proposed works.

6.2 Methodology

An intensive review and feedback process over several months, involving the Reference Group and others, resulted in the selection of five conceptual engineering schemes for detailed design and costing.

The design of the drain was undertaken following a field visit to the Wongan Hills-Ballidu District to review firsthand some of the operational aspects of current drainage schemes.

The design of the drain considered numerous issues including routing, drain flows, geotechnical stability, operation, maintenance, protection, environmental impacts and cost.

The design covered aspects such as stability of the side slopes, the use of liners in areas with porous soils, the use of spoil banks to protect the drain from flood events, revegetation of the drain and spoil banks, the use of cross-over structures to facilitate access, the use of fencing to protect the drain corridor, silt traps for collecting silt and debris, compartmentalisation for management during flooding and inclusion of structures to release water at disposal sites.

Job's Lake provides a relatively large, natural collection and storage site high up in the catchment. The use of the lake-site to mitigate the potential for downstream flooding was considered and designs for pumping or releasing floodwaters from Job's Lake were included in the engineering designs.

The issue of disposal of saline water both within and outside the catchment posed a number of challenges because of potential legal, social and political constraints. In the final analysis the option to dispose of saline water using the major salt-lake complexes inside the catchment was agreed to and proved to be the most feasible option, in the absence of a regional drainage network.

Disposal at salt-lake complexes outside the catchment that were considered included Mollerin Lake, Lake Moore and Lake Wallambin. Disposal at these sites is relatively expensive, compared to disposal at salt-lake complexes inside the catchment. Suitable salt-lake complexes inside the catchment for disposal of saline-water include Job's Lake, Askew's Lake and the McDermott Lakes complex. The use of smaller salt-lake complexes or areas, which will become water-logged and/or salinised in the near-future, if no interventions are implemented, were considered as possible "last resort" options.

6.3 Study Outcomes

Figures 6.3.1-6.3.5 depict conceptual plan layouts at regional scale for each proposed scheme. A summary of the anticipated capital cost for each scheme is given at the bottom of each Figure. A comparison of costs for each scheme (excluding bore/abstraction costs) is given in Table 6.3.1 below.

Table 6.3.1: Comparison of the capital cost estimates for engineering schemes (excludes bore and piping costs)

Scheme	Cost Estimate	Comment
1	$6,950,000	Expensive option to pump waters from Job's Lake to Mollerin Lake. Limited central catchment drain serving only the Job's Lake catchment
2	$1,724,000	Central catchment drain with no disposal inside the catchment – link to arterial drain?
3	$2,268,000	Central catchment drain, pump out of floodwater in Job's Lake with no disposal inside the catchment – link to arterial drain?
4	$3,128,000	Central catchment drain, gravity release of water from Job's Lake, with no disposal of water inside the catchment – link to arterial drain?
5	$3,821,000	Central catchment drain, release of floodwaters from Job's Lake, with disposal inside the catchment

*Cost estimates for the five Schemes include a 20% allowance for contingency and engineering and should be considered to be accurate to +/- 25%.

Scheme 1 – Pumping from Job's Lake

This is a scheme where the option to pump waters from Job's Lake to Mollerin Lake introduces very high capital costs. The concept of a restricted central catchment drain servicing the currently 'at risk' Job's Lake catchment presents a viable pilot project, under Scheme 1, if the inter-catchment pumping option is discarded. This scheme serves to reduce the potential threat of flood induced recharge effects on valuable agricultural land above Job's Lake, in the event of a 1 in 10 year ARI or larger flood event in the near future (less than 5 years).

Scheme 2 – Gravity Drainage, Bypassing Job's Lake

This scheme could be viewed as " a start" or "extension" to a regional arterial drain network for disposal of saline water downstream of the Mt Marshall Shire boundary. This scheme is the cheapest option reviewed for implementation of a central catchment drain, as it does not include removal of brackish/saline lake water from Job's Lake.

Scheme 3 – Open Drain and Pumped Drainage of Job's Lake

This scheme includes removal of brackish/saline water from Job's Lake by pumping the water into a drain that bypasses the lake. It is a relatively expensive option but attractive from the point of view of minimal environmental disturbance and no installation of permanent structures at the lake site.

Scheme 4 – Open Drain and Gravity Drainage of Job's Lake

A more expensive solution than Scheme 3, using an outlet structure to gravity feed the water in Job's Lake into the bypass drain.

Scheme 5 – Open Drain with Salt-Lake and Basin Evaporation

This is the most comprehensive and holistic scheme and covers over 80% of the length of the main valley floodway. It is attractive from the point of view that saline water could be effectively disposed of inside the catchment, without significant cost or impacts to the environment.

Discussion of Schemes 1-5

Since the flood in March 1999, water levels in Job's Lake have dropped about 1.5m in response to evaporative and seepage effects. The lake is expected to gradually dry out in the next 5-10 years in the absence of any further flooding. This may provide a window of opportunity to drain upstream sections of the catchment directly to Job's Lake.

In the interim the proposed drain to Job's Lake under Scheme 1 could be extended around the perimeter of the lake to Askew's Lake for disposal of drain water. The analysis of potential drain discharges and available storages at both salt-lake sites indicates that this option is feasible and low risk.

Scheme 2 is the cheapest option of the five schemes, but has the disadvantage of being dependent on an arterial drainage scheme downstream of the catchment. Schemes 3-4 are similarly disadvantaged. Scheme 5 is the only option which deals with saline drainage disposal within the catchment.

Situations/Schemes Not Considered For Analysis

The “best-case” scenario for implementation of engineering schemes would be that there is no flooding of the catchment within the next 5-10 years. This would allow:

- Job’s Lake to partially dry out;
- installation of a central catchment drain over 80% of the length of the main valley floodway, and
- proportioned and managed releases of drain-water and bore-water at Job’s Lake, Askew’s Lake and McDermott Lakes complex, as and when required.

An order of cost estimate for an engineering scheme in this situation would be $2,000,000.

Analysis of the evaporative capacities of the combined drain and salt-lake complexes indicates a significant evaporative excess and therefore low risk for disposal using natural lakes. The analysis also shows that not all the available lake evaporative area would need to be utilised during average rainfall periods. During flooding, and depending on the magnitude of the floods, using all the available lakes to evaporate flood waters as quickly as possible would provide the most expedient approach and means to dispose of excess water, in the absence of a regional drainage network.

7. Environmental Assessment

7.1 Introduction

A preliminary environmental assessment of the vegetation of the Beacon River Catchment was carried out during October 2001, following the early spring emergence of flora. The main aim of the assessment was to investigate the potential impacts of uncontrolled salinisation ("do-nothing" scenario), and also implementation of engineering schemes ("intervention" scenario's), on surviving remnant vegetation in the catchment. This includes both remnants on private land, and vegetation within catchment reserves.

7.2 Methodology

The review required a desktop review of available information to identify the predominant vegetation systems and associations, significant flora and threatened ecological communities. Information from CALM and the Mt Marshall Herbarium was reviewed, together with information obtained during discussions with various ecologists.

This was followed by a two day field visit to investigate key sites where salinity is currently causing significant impacts on vegetation (remnant bushlots, reserves and lake margins), as well as existing salt lakes currently being considered for disposal of saline water from drainage and/or pumping.

An assessment of the extent (hectares) of remnant vegetation that could be impacted under the "do-nothing" or the "intervention" scenarios was also undertaken. Initially GHD applied standard vegetation classification techniques to available SPOT satellite imagery to obtain estimates of the vegetation cover in the catchment. These estimates were later superseded based on information sourced from more accurate vegetation maps provided by the DAgric.

7.3 Study Outcomes

Figure 7.3.1 depicts the location of surviving native vegetation in relation to the predicted extents of land salinisation over the next 50 years, under the "do-nothing" scenario. Estimates of the hectares and percentage of vegetation that could be affected in the next 50 years are given in Table 7.3.1.

Table 7.3.1: Areas of remnant vegetation predicted to be impacted by salinisation under a "do-nothing" option

Time Period	Hectares (cumulative)	% of Total Remnant Vegetation
1 year	703	3.8
15 years	967	5.2
20 years	1,796	9.6
50 years	2,674	14.3

The models predict that approximately 2,670 hectares of vegetation could be impacted under the "do-nothing" option within 50 years. This represents about 14.3% of the surviving native vegetation in the catchment. Recent estimates indicate that about 7.3% of the catchment is covered by remnant vegetation.

More importantly, the vegetation type that is likely to be impacted is predominately the valley floor woodlands, which have been selectively cleared in the wheatbelt due to their occurrence on high quality agricultural soils.

An assessment of the potential impacts on conservation values from the proposed intervention schemes is summarised below:

- No conservation-listed plant species are predicted to be directly threatened by the 'do-nothing' option or any of the proposed drainage schemes in the near to medium term future.
- No Threatened Ecological Communities are at risk from any options.
- One CALM-managed flora reserve is potentially at risk within a predicted 50 year time-frame if the 'do-nothing' option is taken. No reserves are at risk from any proposed drainage schemes.
- Significant amounts of remnant woodlands are at risk from the 'do-nothing' option.

Threatened plant species may occur in the McDermott Lakes or Job's Lake vegetation but comprehensive surveys to confirm this did not form part of the current study.

Considerable amounts of remnant woodlands on private property and lake margin vegetation are currently being lost to rising groundwater with little chance of any improvement or natural regeneration without intervention. Predictions for the 15 and 20 year horizons indicate that some large woodland blocks throughout the catchment are at risk, particularly north of Job's Lake and north of the McDermott Lakes.

On balance, considerably more vegetation is at risk from a 'do-nothing' option than from any proposed drainage scheme in the Beacon River Catchment. No additional damage would be anticipated to remaining vegetation from discharge of drainage waters to Job's, Askew's and the McDermott Lakes, based on the rates of dewatering outlined in Section 5.3.

8. Cost-Benefit Analysis

8.1 Introduction

A Cost Benefit Analysis has been completed on the Beacon River Catchment using available economic and infrastructure data sourced from Department of Agriculture, Local Authorities and the Mount Marshall LCDC.

The benefits derived from the proposed engineered drainage Schemes 1-5 have been assessed on the basis of the areas of land protected from water table rise[1]. Only tangible 'economic' benefits were considered in the analysis and the resources protected through drainage control were identified as being:

- Productivity of cropping land.
- Value of farm infrastructure otherwise left isolated in saline ground.
- Road infrastructure.

Scheme 1 being a partial catchment solution achieves the lowest benefit in terms of area of land protected. Scheme 5 is the most holistic, protecting up to 80% of the land area along the valley main channel. The benefit derived from this option can be considered as being equivalent to approximately 80% of the 'damage costs' avoided under a 'do-nothing' scenario.

The engineering costs defined within the Engineering Report, presented here in Section 6, were adopted for the CBA**.** These engineering costs have been benchmarked against the benefits described above.

8.2 Methodology

The key input parameters selected for the model are defined below, including references to the sources of the data and method of estimation.

Operating Profit ($/Ha)

Defined as being the farm income less operating costs less depreciation (10% machinery value). An operating profit of $50 per Ha has been derived based on four year average operating profits from top 25% performing NE Wheatbelt farms, reported by BankWest.

In addition the Mt Marshall LCDC provided an operating profit for the best land in the valley floors, representing the soil types threatened in the 50 year prediction scenario. The averaged figure was considerably higher than the BankWest value at $124.5 per Ha. The Mount Marshall LCDC considers this figure to better represent the long term profitability threatened by the potential loss of much of the best land in the valley floors. This figure has also been simulated using the model.

[1] The areas impacted by salinity as a result of water table rise were defined from the Salt Risk Mapping undertaken in the groundwater modelling studies, see Section 5.

Road Infrastructure

Road maintenance and rebuilding costs for the Shire of Mt Marshall were supplied by the Shire Engineer. If no groundwater controls are implemented waterlogged and salt impacted roads are estimated to add a further $900,000 to the Shire Roads budget on an annual basis within the next fifty years. This analysis compared the current length of impacted roads to that estimated based on the salinity risk mapping.

Replacement Cost of On-Farm Infrastructure

The Mt Marshall LCDC supplied an inventory of on-farm infrastructure, likely to be abandoned to a ‘barren saline wasteland’ under a ‘do nothing’ scenario. The current replacement cost of this infrastructure, including houses, general-purpose sheds, silo pads etc was put at $4.2 million. Discounting the value of this infrastructure over a fifty year model it was found that this parameter is not significant to the outcome of the CBA and was removed from the analysis.

Model Assumptions

The key model assumptions are addressed below:

- A discount rate of 5% has been applied across the benefits and costs calculation. The model does not account for inflation or taxation.
- Operating profits are assumed to remain constant over the 50 year model simulation.
- No productivity value has been ascribed to land that becomes salt affected, so that the loss associated is equal to the full value of the operating profit.
- Capital expenditure for catchment de-watering pumps and piping is spread over 15 years and installed in yrs 1, 5, 10 and 15. All other capital expenditure occurs in year 1.
- Replacement or refurbishment costs have been included for the catchment de-watering pumps and piping and engineering structures where deemed necessary as well as maintenance costs for managing accumulated salt build-up at evaporation sites.
- The benefit derived in maintaining the agricultural value of the land at the end of the 50 year simulation has not been accounted for in the reported results.
- No consideration has been given to operating profits accruing from land currently impacted by salinity, which might be restored to some level of productivity.

8.3 Study Outcomes

The outcomes of the CBA are presented in Table 8.3.1, with the cumulative cashflows presented as Figure 8.3.1 - Figure 8.3.3. Table 8.3.1 presents only the results of the $50 per Ha operating profit scenario. It shows that each of Schemes 2-5 achieve a positive return, even at these relatively low profit margins. Schemes 2-4 protect the same area of land so the derived benefit is the same, the only differential between the schemes being the engineering and replacement/maintenance costs.

After 50 years it is shown that each of Schemes 2, 3 and 5 return a relatively narrow range in net cashflow ($2.750,000 – $4,000,000 million). Scheme 1, which has the highest engineering costs and lowest economic benefits fails to reach breakeven.

Table 8.3.1: Financial model 50 year simulation – with operating profit equivalent to $50 per Ha

		OPTION Of CENTRAL DRAIN – WITH PUMPING & PIPED DRAINAGE		
Scheme	Total Area Protected (Ha)	COST	BENEFIT	NET CASHFLOW
Scheme 1	10,080	-$15,250,000	$4,250,000	-$11,000,000
Scheme 2	33,600	-$10,000,000	$14,250,000	$4,000,000
Scheme 3	33,600	-$10,500,000	$14,250,000	$3,500,000
Scheme 4	33,600	-$11,500,000	$14,250,000	$2,750,000
Scheme 5	43,200	-$14,500,000	$18,250,000	$3,500,000

* Modelled results have been rounded to nearest $250,000

Figure 8.3.1 shows the cumulative cashflow with the returns at 50 years equal to the net cashflow as presented above. The Schemes 2 and 3 are shown to breakeven at around 30 years, with Schemes 4 and 5 slightly later at 35 years. Schemes 2-4 are the same curve slightly offset as a result of the different engineering costs. Scheme 5 returns would overtake the other schemes if the model timeframe were extended, as the benefits of the additional land protected start to take effect.

The model for the $75 per hectare per annum return is depicted in Figure 8.3.2 and probably represents the median case in terms of the possible range in operating profits. Estimates of cumulative cashflow returns at 50 years is between $7,750,00 – $10,000,000.

The influence of staging in the installation of catchment de-watering pump and pipe infrastructure is seen in years 1, 5, 10 and 15 as inflections in the cashflow. Figure 8.3.3 shows that in adopting the higher operating profits of $124.5 per Ha, derived by the Mt Marshall LCDC, the payback period for the engineering works is reduced by between 20-25 years for Schemes 2-5. The net cashflow at 50 years increases to between $17,550,000 and $22,750,000.

8.4 Un-Quantified Benefits

A number of intangible ‘benefits’ are at risk through the increase in salinisation of the Beacon River Catchment. Intangible benefits are recognised as benefits preserved through implementation of the groundwater controls to which an economic value cannot be reliably attributed. A brief qualitative summary of these benefits is provided below, comparing the current status to that predicted under the 50 year ‘do-nothing’ benchmark.

Social Costs - Reduction in the area of effective farming land in the Beacon-Bencubbin area is likely to have a pronounced impact on social infrastructure and the Mt Marshall district. Up to 60 individuals (families of men, women and children) are predicted to leave the district, or 8% of the total population.

Aligned Service Industries - Indirectly a range of suppliers, most notably haulage firms, agricultural, chemical, and machinery suppliers will be impacted by a loss of productivity from the region. As it is recognised that the best land will be impacted by salinity the overall income generated by the district is likely to be disproportionately affected.

Recurrent Flooding - The potential for groundwater rise to increase the magnitude of flooding has been identified within West Australian catchments. Control of water tables therefore can be reliably expected to reduce the magnitude of flooding and therefore the associated damage costs.

Protection of Remnants - Review of remnant vegetation has shown that under the 50 year ‘do nothing’ scenario a total of 2,670 Ha of remnant Salmon Gum/Gimlet/York Gum woodlands is likely to be lost to salt and waterlogging. These remnants could be largely conserved under Schemes 2-5.

Recreational – The potential to protect and develop sites for recreational purposes exists such as at the Ski Lake. This site has traditionally been used for social activities including skiing following flooding. Maintaining water in the lake by disposal of saline water could potentially open the site for continual use, as and when required by the locals.

8.5 Non Engineering Options

The CBA report provided a discussion of non-engineering groundwater control options, specifically for implementation within the ‘low’ rainfall Beacon Catchment.

The options considered within the investigation were:

- Commercial Agroforestry -via Oil Mallee production.
- Non-Commercial tree planting.
- Use of deep-rooted perennials / crop rotation.
- Saltland Pastures.
- Aquaculture

The results of these investigations identified only broad scale tree plantings as likely to provide sustainable and demonstrable benefits in 'regional' groundwater management within the period of the next decade. Furthermore only a single tree group, various species of mallee, are currently identified as being applicable under Beacon Catchment conditions. It was considered that insufficient data was available with which to reasonably predict where tree plantings can be used within the catchment and for what derived benefit in groundwater control; as a result no non-engineering options were considered within the framework of the CBA.

9. Conclusions and Recommendations

9.1 Conclusions

General conclusions:

- Approximately 124 km^2 (12,400 ha or 4.6% of the area of the catchment) of the most productive agricultural land in the Beacon River Catchment is currently salt-affected, or under immediate threat of salinisation.
- Approximately 453 km^2 (45,300 ha or 16.9% of the area of the catchment) of good agricultural land could become salt-affected within 50 years if no interventions are undertaken in the catchment.
- Given the potential lead-times for implementation of various types of intervention schemes, it would appear that engineering solutions are the only currently feasible solution for controlling and managing the spread of dryland salinity in the catchment.
- Non-engineering agricultural-based schemes involving options such as agro-forestry and farming perennials, although potentially useful as groundwater recharge abatement techniques, have longer lead-in times for implementation, and there is still considerable uncertainty as to their effectiveness both in the short-term and long-term.
- Improved water management at farm-scale and catchment scale, including the installation of contour, diversion and flood bunds, has the potential to significantly reduce the volumes of water accumulating in areas affected or threatened by shallow groundwater tables.
- Improved flood and flood-risk management using pump-out and transfer schemes to less affected salt-lake complexes downstream or to salt-lake complexes outside the catchment is an option, but relatively expensive to implement.

Specific Conclusions

- Engineering schemes involving bores/drains with disposal inside the catchment at the larger salt-lake complexes appear to be the most feasible option in the short-term, and possibly longer-term, for controlling the spread of dryland salinity.
- Trialing an engineering scheme either above Job's Lake or the McDermott Lakes complex is possibly the most prudent option at present to evaluate the proposed designs and efficiencies of these types of schemes.
- The most cost-effective approach to trialing would be a phased implementation of drains and bores with direct discharge of drain–water and bore-water directly to an existing salt-lake complex (i.e. no-pump out schemes in the first phase of trialing).

9.2 Recommendations

The main recommendations resulting from the outcomes of the various technical studies are:

- The feasibility of implementing any number of possible engineering schemes, including those evaluated by GHD, should be tested by undertaking a trial scheme across a section of already highly degraded land located along the main valley floodway. Trialing should include an integrated scheme, combining both a central drain and abstraction bores. Disposal should be to one of the larger salt-lake sites.
- Trialing should be used to test and verify, inter alia, the routing, design / construction, performance, operation, management, maintenance and environmental impacts that a larger catchment-wide scheme might have, if it where to be implemented.
- Trialing a pilot scheme should also be used to test the level of support (financially and otherwise) that local communities in different parts of the catchment would be prepared to invest in a catchment-wide scheme.
- Given the current and predicted scale of the salinity problem in the Beacon River Catchment as identified from this study, it would seem imperative that the Mt Marshall LCDC should actively seek funds from government or other sources, to implement a trial engineering scheme.
- The LCDC should seek to maintain and develop links with researchers in the application of non-engineering agricultural-based methods of recharge abatement. Limited trialing of these methods should be considered, under the direction of recognised professionals or government agencies.
- In the absence of a Catchment Management Authority (CMA) for the Beacon River Catchment with statutory powers, the formation of an umbrella organisation, consisting of representatives of the Shire, Local Authorities, the LCDC and other interested parties should be a priority, recognising that the proposed schemes require to have broad bi-partisan acceptance across the community.