Mt Marshall Land Conservation District Committee

Beacon River Catchment - Salinity Management Feasibility Study

Report On

Cost Benefit Analysis

Dec 2001

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EXECUTIVE SUMMARY

A Cost Benefit Analysis (CBA) has been prepared on five proposed engineered schemes designed to mitigate rising saline groundwater tables in the Beacon River catchment. The five engineering schemes were conceptualised based on several possible options for implementation of engineering–based solutions. Analysis of the engineering requirements and costs for each scheme to remove, transport and dispose of saline groundwater was based on a 50 year model timeframe. The CBA model adopted estimates of the areas of either salt affected or salt threatened (SAST) land after 50 years (2001-2051), under a 'do-nothing' scenario. These estimates were obtained by modeling the rates of groundwater table rise over the 50 year period, and then mapping the extents of saline groundwater encroachment laterally across the Beacon River floodway, using a topographic model of the catchment. The computer-based SAST model was checked by several landholders either living or farming along the Beacon River floodway.

From the predictive salinity forecasting models it is estimated that a further 40,000 Ha[1] of some of the most productive cropping land in the Beacon River catchment, located along the lower valley floors, could be left salt impacted or salt threatened by 2051, if intervention methods are not put in place in the near future.

Financial modelling identified two main 'cost-drivers' or model parameters that largely determine the potential economic impact of salinisation. These are:

- Lost operating profit (income) from salt affected agricultural land ($/Ha/annum).
- Replacement and/or maintenance costs for engineering structures including bores and roads ($/annum).

The financial model adopted ascribes the protection of land from salinity as a benefit. For the 50 year simulation the benefit derived from protecting land through the most comprehensive of the engineered schemes considered (Scheme 5) totalled $18,250,000[2]. This figure is deemed to equate to the net economic value lost if the 'do nothing' (no intervention) scenario, is adopted.

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[1] This equates to roughly 15% of the area of the Catchment. Currently it is estimated 1500 Ha of formerly productive cropping land has been lost to salinity.

[2] This assumes an Operating Profit of $50 per Ha/annum (BankWest statistic), a figure considered conservative by the members of the Mt Marshall LCDC whose own farming records indicate considerably higher returns of $124.5 per Ha/annum.

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/annum) applied to the financial models. Except for one of the schemes the cost for implementation of the schemes varied from about $10-$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 ($75-$124 per Ha/annum).

The capital and maintenance cost estimates for the engineering schemes adopted in the CBA were derived from the Engineering Study aspect of the overall project. It was found that staging of the engineering works, with the capital investment spread over the first fifteen years for dewatering, bore, pump and pipe infrastructure, assisted in achieving a positive benefit to cost ratio.

The CBA identified a series of ‘intangible’ factors that cannot be accurately accounted for in a financial model. These factors could be significant in assessing the overall cost-benefit ‘value’ of the proposed engineering works. They include the likelihood of depopulation of the Mt Marshall Shire, if salinity spreads unchecked. Up to eight percent of the population of the Shire of Mt Marshall could be affected in this way.

Depopulation of the catchment would threaten the viability of the education and health services, community stores, social groups and sporting clubs. Services such as haulage firms, chemical and equipment suppliers are recognised as being potentially impacted by depopulation but are not considered in the financial model.

Potential increases in environmental impacts were identified as a result of the risks of increased incidence of flooding and further loss of remnant vegetation. These factors were not assessed in the financial model, but were recognised as being protected or the damage offset by installation of groundwater control systems.

The CBA also reviewed the current status of research into ‘alternative’ non-engineering based options for groundwater management. The options considered included broad scale commercial and non-commercial tree planting, farming with deep-rooted perennials, the use of salt tolerant pasture and developments in aquaculture.

The review concluded that non-engineering options, singularly or in combination, are insufficiently developed at this stage to offer acceptable resolution to the current salinity problems in the short to medium term. However, implementation of one or more of the options, coordinated with an engineering solution may produce a better result than can be anticipated using only engineering-based methods.

Of the non-engineering options only broad scale tree planting was considered likely to provide sustainable and demonstrable effects in ‘regional’ groundwater management within the next decade. There is a potential for commercial growing of Mallee species for manufacturing of dry fuel, oil and activated carbon products. However, whether or not this option represents a commercially sustainable catchment-wide solution to controlling rising groundwater tables and land salinisation is doubtful. The cost-benefit ratio’s for such schemes are still unproven and, therefore, they could not be included in the CBA.

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 18 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-$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 a 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 trialling of engineering interventions have not been successfully completed in Western Australia. The outcomes from trialling 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 the 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:

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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

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CALM	Dr John Bartle, Dr Richard Harper, Nicole Robinson
UWA	Dr David Pannell, Dan Wildy (PhD student)
Oil Mallee Association	David McFall
Western Power	Ashley Challenor
Planfarm	Agricultural Consultants

1. Introduction

A Cost Benefit Analysis (CBA) was undertaken to assess the feasibility of five different proposed engineering schemes designed to control the rise of saline groundwater across the main drainage route or floodway in the Beacon River catchment.

The CBA incorporated available economic and infrastructure data sourced from Department of Agriculture, Mt Marshall Shire Council and LCDC, local government agencies, universities and other relevant private organisations.

Potential financial benefits derived from the proposed engineering-based schemes, referred to as Schemes 1-5 in the Engineering Options study report, were assessed on the basis of the area of arable land that could potentially be protected from continually rising water tables. Only tangible ‘economic’ benefits were considered in the CBA, as the ‘financial value’ ascribed to intangible ‘benefits’ are both difficult to quantify and include in a CBA.

The most significant resources protected through drainage and bore pumping controls were identified as being:

- Productivity of cropping land.
- Value of farm infrastructure.
- Road infrastructure.

The CBA compares the financial benefits derived in protecting the above resources, to the estimates of capital investment and replacement/maintenance costs for the implementation of the proposed engineering schemes, over a 50 year period. A review of some of the key intangible costs that could not be effectively incorporated in the financial model and a discussion of non-engineering opportunities in groundwater/salinity management are also provided.

1.1 Scope of Work

The key components of the CBA analyses were:

- To develop a financial model to test the financial viability of the five proposed engineering schemes. This would include establishing the sensitivity of the model to the primary ‘cost-drivers’ and predicting the likely payback period of the schemes under different scenarios.
- Provide a discussion on some of the more important ‘intangible’ factors that cannot be incorporated within the financial model directly, but which could influence the overall ‘value’ of the proposed groundwater and salinity management controls for the communities living in the catchment.

- To review current developments and possible applications of non-engineering based systems, which could be used to singularly or in combination with engineering based schemes, to control rising ground water tables in the catchment.

1.2 Catchment Salinisation

The CBA requires estimates of the land areas already salinised, as well as predictive estimates of the areas that could potentially become salinised in the short to medium terms, under the ‘do-nothing’ scenario. The ‘do-nothing’ scenario assumes that there is inadequate implementation of drainage or ‘alternate’ methods of controlling rising groundwater tables.

Estimates were derived by, firstly, modelling the rates of rise of groundwater tables in the catchment using existing bore monitoring data and, secondly, using a digital elevation model (DEM) to predict where and when water tables are likely to rise to within agricultural ‘safe limit’ of about 1.5 metres below ground level. Three timescales were adopted for the mapping of potential salinity impacts, namely, 0, 15, 20 and 50 years.

The results of the predictive salinity mapping are shown in Table 1.2.1, in terms of arable land lost[3]. The areas of salt impacted land lost for production are recognised as being ‘high’ productivity cropping land, primarily along the valley floor. Salt ‘impacted’ land was identified as any land where the depth to watertable is likely to be less that 1.5 metres below ground surface.

Table 1.2.1. Predicative model results for potential salinity impacts

Model Timescale (years)	Area Lost From Production (Ha)
0	1,480
15	5,200
20	19,000
50	43,200

Note: Approximately 6350 hectares of land surface in the catchment comprises salt lake complexes (playas)

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[3] The differential between Salt Impacted Land (Column 2) and Area Lost from Production (Column 3) in Table 1.1, corresponds to non-productive land on the margins of existing salt lakes and playas, or areas of remnant bushland.

1.3 Proposed Engineering Schemes

A detailed description of the proposed engineering schemes to mitigate salinity in the Beacon River catchment is provided in GHD's 'Engineering Options' report. A brief description of the schemes is provided below. Capital cost estimates for the schemes are provided in Table 1.3.1. The schemes are depicted on catchment-scale plans at the back of the report as Figures 1.3.1-1.3.5.

Scheme 1 – Pumping from Job's Lake

This scheme includes a disposal option for pumping floodwaters out of Job's Lake to a discharge site at Mollerin Lake, which is in a neighbouring catchment. Mollerin Lake is a relatively large salt lake, and the environmental impacts of disposal at this site are likely to be negligible. The inter-catchment pumping option, however, introduces a relatively high capital cost for the overall scheme as the scheme would require a dedicated pipeline.

Pumping out of Job's Lake was proposed by the Mt Marshall LCDC to reduce current lake levels in the short term. This would increase the available flood attenuation capacity in the lake and further reduce the threat of flood-induced recharge for the land upstream of Job's Lake. This would be particularly significant if a large flood event were to occur in the next 2-3 years, which could result in the complete salinisation of good agricultural land upstream of Job's Lake.

The scheme includes a central catchment drain servicing the floodway upstream of Job's Lake. which is one of the most prominent SAST sites in the catchment.

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 floodwaters from Job's Lake. The feasibility of the scheme is however reliant on a suitable option for disposal or conveyance of saline groundwater once it reaches the Shire boundary.

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

This scheme includes removal of floodwater 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 minimising environmental disturbance and there being no requirement to install permanent structures at the lake site. The proposed route of the central drainage channel is as per Scheme 2.

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

A more expensive solution than Scheme 3, given the capital cost for an outlet structure to gravity feed water in Job’s Lake to the bypass drain. The use of a more permanent structure to control water levels in the lake is also an advantage in terms of flood attenuation and management. Operating costs would be relatively cheaper, however, compared to the operating costs associated with lifting water from the lake by pumping to the bypass drain.

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

This is the most comprehensive scheme including a central catchment drain that covers over 80% of the length of the main valley floodway. In the absence of a regional drainage network this scheme is attractive from the point of view that saline water could be effectively disposed of inside the catchment, without significant cost for long distance conveyance of saline water and the attendant possibility of downstream impacts to the environment.

Scheme Overview

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 at risk of salinisation along the valley main channel. The benefit derived from this option can be considered as being equivalent to approximately 80% of the ‘cost’ or ‘financial loss’, which would be incurred under a ‘do-nothing’ scenario.

Table 1.3.1: Comparison of capital cost estimates for engineering schemes (excludes bore dewatering and piping costs)

Scheme	Cost Estimate	Comment
1	$6,950,000	Relatively expensive option to pump water 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 – has to be linked to regional arterial drain
3	$2,268,000	Central catchment drain, pump out of floodwater from 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 – has to be linked 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%.

2. Cost Benefit Analysis Model

2.1 Methodology

The general methodology adopted for undertaking the CBA is outlined below:

- **Determine the area of land protected**:- establish the area at risk of salinisation based on the modelling of rates of rise of the groundwater table and predictive salinity mapping. From this information and the engineering studies determine the area of land that would be protected by implementing Schemes 1-5, specifying the option of groundwater table dewatering using bores with pumping to a central drain.
- **Establish 'parameters' determining model**:- define the economic parameters that determine the financial model. Benefits derived from protection of economic returns from cropping land, and protecting/maintaining infrastructure at risk of being damaged from salinisation. Costs include capital and replacement/maintenance costs for drainage and pumping infrastructure.
- **Estimate parameter values**:- through review of available references and information sourced from government agencies, banks, local authorities, farming groups etc.
- **Refinement of parameter selection**:- identify the major cost-drivers to the financial model and discard parameters that are shown to have little influence on the overall outcome of the model. Those parameters which cannot be adequately defined in 'economic' terms are excluded from the model (refer to Section 3 for details).
- **Model development**:- establish method of calculation, project staging, and timeframe for simulation.
- **Sensitivity check**:- vary parameters within anticipated boundaries to determine robustness of model and range in predicted payback periods.

2.2 Input Parameters

The key input parameters identified for the CBA model are discussed below, including references to the sources of the data used and method of estimation. Appendix A presents both tabulations and graphical depictions of the major inputs to the models for each scheme.

Farm Operating Profit

Farm operating profit was found to be one of the most sensitive ‘cost-drivers’ in the CBA model. Model predictions are highly sensitive to the this value. Selection of the appropriate value for operating profit is difficult given the possible ‘range’ for this value in the model.

An operating profit of $50 per Ha/annum represents a four year average of the operating profits from the top 25% performing North East Wheatbelt farms, as reported by BankWest. The Mt Marshall LCDC also provided an estimate of $124.50 per Ha/annum operating profit (return) for the ‘best agricultural land’ located along the valley floors. This land includes the areas, which are predicted to be under threat of salinisation in the next 50 years, under the ‘do-nothing’ scenario. The $124.50 per Ha/annum figure is based on an average of individual farm assessments. The Mount Marshall LCDC considers this figure to better represent the long-term profitability of good agricultural land threatened by salinity.

Three rates of return from cropping practices were finally adopted for inclusion in the model, namely:

- $50 per Ha/annum (BankWest).
- $75 per Ha/annum (about half of the Mt Marshall LCDC estimate).
- $124.50 per Ha/annum (Mt Marshall LCDC estimate).

Both net cashflow returns and payback periods are strongly influenced by the operating profit, the sensitivity of which is depicted in the model outcomes (Figures 2.4.1-2.4.3).

Road Infrastructure

Current estimates of road maintenance and rebuilding costs for the Shire were supplied by the Council Engineer.

The Shire has a road network comprising about 1400 km’s of gravel roads and 300 km’s of sealed roads. The budget provided by the federal government for road building and maintenance in the Shire is currently $1.7 million per annum. Rebuilding of roads and maintenance due to waterlogging and salinity is estimated by the Shire as costing accounting for between 5-10% of the annual budget ($85,000-$170,000 per annum).

Adopting this estimate for expenditure, the financial analysis compared the current length of impacted roads to that estimated from the salinity risk mapping. If no groundwater controls are implemented, waterlogged and salt impacted roads are estimated to add a further $900,000 per annum to the Shires’ roads budget within the next 50 years.

On-Farm Infrastructure

The Mt Marshall LCDC supplied an inventory of on-farm infrastructure, likely to be abandoned to a ‘barren saline wasteland’ under the ‘do nothing’ scenario. The estimated 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 the 50 year period indicated that this parameter is not significant to the financial outcome predicted by the CBA. It was therefore removed from further analysis.

Bore Infrastructure

Replacement and on-going maintenance costs for bore pumps and infrastructure such as piping for the different scheme options was found to be an important ‘cost-driver’ for the CBA model. It was concluded that without these types of costs the net cashflow predictions for a model adopting $50 per Ha/annum could be in the range $5-6 million depending on the scheme. This reduces to $2.7-4.2 million when these costs are included. The payback period also lengthens from about 15-20 years to between 25-35 years as a consequence of these costs.

2.3 Assumptions

The key model assumptions are addressed below:

- A 50 year period was adopted for the model simulations. The scenarios assume that bores with solar pumps would be installed to dewater and lower the groundwater table and that discharge from the bores would be piped to a central catchment drain.
- A discount rate of 5% was applied to the benefit and cost calculations. The model did not account for inflation or taxation.
- Operating profits are assumed to remain constant over the 50 year model simulation.
- No productivity value was been ascribed to land that becomes salt affected, so that the loss when this land becomes saline is equal to the full value of the operating profit. The model assumes that the spread of salinity is linear over the 50 year simulation.
- Capital expenditure for catchment dewatering pumps and piping would be spread over 15 years and installed in Years 1, 5, 10 and 15. All other capital expenditure, including construction of the central main drain would occur 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 value of the agricultural land protected at the end of the 50 year period was not included as a benefit, only the operating profits derived to that time.

2.4 Outcomes

The outcomes of the CBA are presented in Table 2.4.1, with the cumulative cashflows presented as Figure 2.4.1 - Figure 2.4.3. Model inputs are presented in Appendix A in both tabular sheet and pie chart formats.

Table 2.4.1 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). Scheme 1, which has the highest engineering costs and lowest economic benefits fails to reach breakeven.

The benefit derived from the Scheme 5, is roughly equivalent to the 'financial loss' incurred under a 'do nothing' scenario. The Scheme 5 works are the most holistic, with 80% of the current and predicted future SAST sites most likely to be protected by this scheme.

Table 2.4.1: Financial model 50 year simulation – with operating profit equivalent to $50 per Ha/annum

		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 2.3.1 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 2.3.2 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 $7,750,000 – $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 2.3.3 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 15-20 years for Schemes 2-5. The net cashflow at 50 years increases to between $17,550,000 and $22,750,000.

Figure 2.4.1: Cost-benefit model ($50 Ha/annum operating profit)

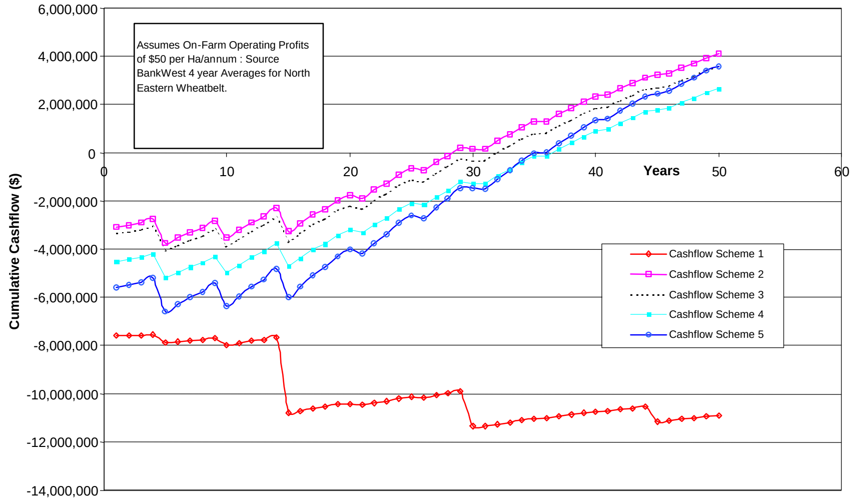


Figure 2.4.2: Cost-benefit model ($75 Ha/annum operating profit)

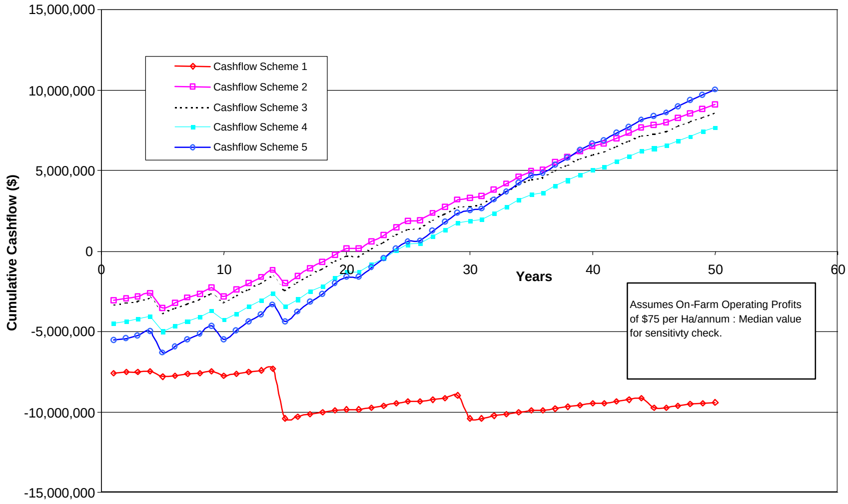
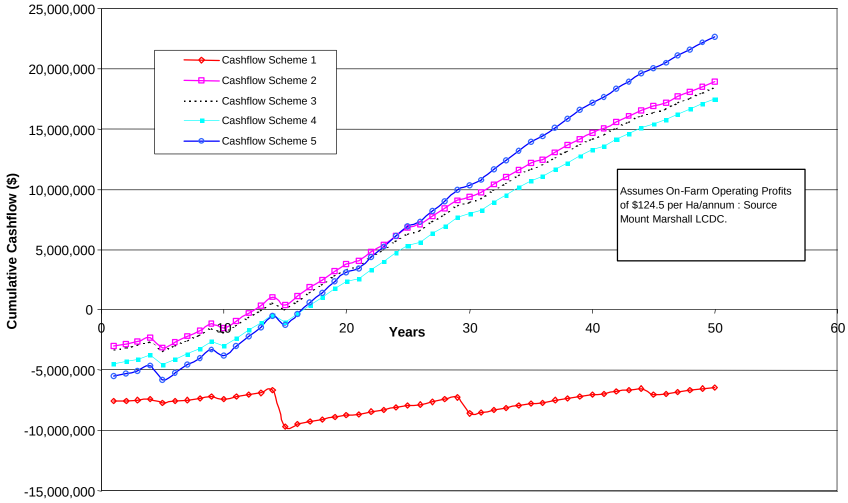


Figure 2.4.3: Cost-benefit model ($124.50 Ha/annum operating profit)



3. Intangible Benefits

3.1 Intangible Costs - Definition

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' scenario.

3.2 Social Costs

A reduction in the area of land that can be farmed profitably in the Beacon River catchment is likely to have a pronounced impact on social infrastructure and the regional community.

It has been proposed (Mt Marshall LCDC) that upwards of fourteen farms, and the families that run these farms, might be lost to the Shire of Mt Marshall as a direct result of salinisation. This is likely to equate to around 60 individuals (families of men, women and children), or 8% of the Shire population[4]. These estimates exclude the farming populace that could be lost as a result of continued and increasing economic rationalisation across the Wheatbelt into larger more economically viable farming units.

The sustainability of communities and services in the Beacon River catchment remains a 'delicate' balance between the number of people living in the catchment and the 'economics' of farming and the maintenance of services that keep them there. Relatively small reductions in the number of people are anticipated to result in adversely large negative impacts on the survival of existing communities in the catchment, and the services that support these communities. People who remain in the catchment, for example, may need to travel further to shop in Trayning, Koorda or Mukinbudin. Similarly, if pupil numbers at the primary school at Beacon and Bencubbin were to reduce, the number of teachers in the area would also reduce and the operating budgets for the schools would be adversely affected. The community fabric, as identified in organisations such as the local sporting teams, community groups and churches, would also suffer as the catchment depopulated.

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[4] Population Bencubbin Townsite 110, Bencubbin Rural 338, Beacon Town 120, Beacon Rural 194, so that the Shire population is 762, source of figures Shire of Mt Marshall.

3.3 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 majority of SAST land is some of the most productive in the district, the overall income generated by the Shire could be disproportionately negatively affected.

3.4 Recurrent Flooding

The potential for groundwater rise to reduce available soil stores in catchments and, accordingly, the area of land subject to seasonal or near-permanent waterlogging or shallow inundation by free standing water (damplands, wetlands) is recognised and under investigation by agencies such as the Water and Rivers Commission (WRC) and Department of Agriculture. Of concern is the impact this could have on the recurrence, magnitude and duration of flood events.

Research completed to date by the WRC's Surface Water Hydrology Group suggests that in South-West catchments, where the proportion of land impacted by waterlogging could double from rising groundwater tables, streamflow volumes in floods could similarly double in magnitude (pers comm John Ruprecht, 12/01/01). Control of water tables could therefore reliably be expected to reduce the magnitude[5] of flooding and the associated costs related to degradation of the environment and damage to infrastructure.

3.5 Remnant Vegetation

A review of remnant vegetation distributions in the Beacon River catchment has shown that under the 50 year 'do nothing' scenario a total of 2,674 Ha of remnant Salmon Gum/Gimlet/York Gum woodlands is likely to be lost to salt and waterlogging. This is equivalent to 14% of the catchment's remnant vegetation, and most of this remains in good condition despite instances of understorey grazing. These valley floor vegetation communities are very scarce in the Wheatbelt, with between 5-10% remaining in the entire Avon River Basin. The groundwater controls proposed should protect the majority of the surviving remnant vegetation.

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[5] Note that this relationship does not necessarily continue linearly as the areas of waterlogged soils increases by three to four times. Further work will be completed in this area in the next twelve months, sanctioned by the WRC, but these studies are limited to South-West WA and not the wider Wheatbelt area.

3.6 Lake Sites

A direct benefit is seen in the potential to protect and develop lake sites for recreational purposes and other uses. Ski Lake is an example. This site has traditionally been used for social activities including water skiing following flooding. At this and other sites lake water levels might be retained artificially high through the discharge of saline water from the pumping scheme so that they could be opened up for continual use for water skiing and other water sports as required by the locals. Opportunities also exist to harvest largely fresh runoff waters at this and other locations immediately after flooding.

4. Non-Engineering Groundwater Controls

4.1 Non-Engineering Options

This section provides a summary of the outcomes of investigations of the potential use of non-engineering or plant-based options for controlling groundwater tables rises in the catchment. The investigations comprised a review of currently available research, as well as several meetings and discussions with a number of relevant government agencies in WA.

The results of these investigations identified that low annual average rainfall is a primary constraint in establishing broad-based tree plantings that could be commercially viable. The longer term effects of salt on deeper rooted tree species is still uncertain and therefore the long-term sustainability of plantations is uncertain. If deeper rooted tree species were sustainable it would still take 1-2 decades before their effect on lowering the ‘regional’ groundwater table would be realised. Currently, species of Mallee appear to be most suited to the climatic conditions of the catchment.

Projects currently being undertaken by CALM are assessing the water use of the ‘oil mallee’ planted within a cropping system, using alley-farming techniques. Substantial promise is seen in dewatering across certain sandy soil types, with plantings as low as 10% of the recharge area (pers comm. John Bartle, CALM).

Investigations by CSIRO and Department of Agriculture point to highly localised dewatering effects under vegetation, whether they are tree plantings or crops. This effect would be even more pronounced in the silty-clayey soils typical of the valley floors of many of the Wheatbelt catchments.

Available data indicates that plant-based solutions are unlikely to effectively lower groundwater tables regionally on a commercially viable and sustainable basis. As a result the potential benefits and costs of applying non-engineering options controlling groundwater table rises within the catchment were not included in the CBA.

4.2 Background to Non-Engineering Options

The conclusion of the current study is that no ‘single’ non-engineering option would, by itself, or in combination with other non-engineering options, control rising groundwater tables to prevent ongoing salinisation of the catchment. Implementation of one or more of the options listed below, coordinated with an engineering solution may, however, produce a result better than can be anticipated using only engineering schemes.

In the medium to longer term, the scale of adoption of the non-engineering based options will depend on a number of factors. This will include the cost-benefit of sacrificing land, which could otherwise be used for cereal production, as well as comparisons of the overall cost-benefit of implementing engineering versus non-engineering options.

The options considered for the current study included:

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

The principles for adoption of the above options in land and water management are:

- Both agroforestry and use of deep rooted perennials for grazing offer the potential to reduce groundwater recharge across the catchment by increasing the volumes of water uptake beyond that of a grain crop. Through reducing the soil water store these crops can ‘locally’ lower water tables.
- Non commercial tree planting, i.e. planting for purely ‘land management’ goals seeks to reforest areas of the catchment ‘strategically’ to reduce recharge and lower water tables. The trees used are selected upon their capacity to survive in saline conditions and their ‘high’ water uptake requirement.
- Saltland pastures offer the opportunity to revegetate already salt affected land and reduce the potential for additional degradation through wind and water erosion. These pastures provide an opportunity to receive a marginal return on otherwise unproductive land.
- Aquaculture within the Wheatbelt remains at the early trial stage. The potential for commercial scale success has not yet been evaluated. The process utilises pumped saline groundwater to supply aquaculture ponds for fish, shrimp or algae production. A potential opportunity exists for the aquaculture process to partly or wholly offset the groundwater pumping and water disposal requirements, for the proposed bore dewatering schemes to lower the groundwater table.

4.3 Rainfall Limitations

The catchment has annual rainfalls of the order of 300-320 mm per annum. These low totals largely preclude a number of vegetation-based salinity management options that have been trialed in higher rainfall areas in the Southern and Western Wheatbelt. Opportunities for agroforestry and the establishment of deep-rooted perennials to control groundwater table rise are accordingly significantly reduced at this stage because of limitations in species availability.

4.4 AgroForestry - Oil Mallee Production

Economically viable agroforestry developments in the low rainfall areas of the Wheatbelt, such as the Beacon River catchment, are considered to hinge in the short-medium term on the potential for oil mallee production (pers comm John Bartle, CALM). Research efforts to this time have culminated in the construction of a demonstration scale Integrated Mallee Processing (IMP) plant at Narrogin, due for commission in December 2002 (pers comm Ashley Challenor, Western Power). The Plant will extract eucalyptus oil from the leaves, derive activated carbon from the woody material and generate electricity from the energy released in activated carbon production and from burning plant residues. The pilot plant will undergo ‘optimisation’ trials in the first half of 2003. Depending on outcomes, commercial operations could follow.

- Economic analysis of development costs and potential markets for the products suggest the process is economically viable. Current planning is to develop twelve IMP plants across the Wheatbelt, following a successful trial. Oil mallee establishment is being promoted on the following principles:
- Oil Mallees should be planted in narrow strips approximately 10 metres wide (3-4 rows) separated by 100 or more metres of crop cultivated land, so that in the order of 10% of the suitable catchment area is under mallee production.
- The Mallees, being a cash crop, are only developed on ‘good’ agricultural ground not currently subject to salinity, these areas typically being recharge sites on mid slope positions with good drainage and no waterlogging.
- The Mallees should be developed along the natural contours and provide useful sites to discharge surface flows. Surface runoff would provide water and fertiliser wash-off to the developing trees. They have been seen to perform well on WISALTS banks (pers comm Kim Brooksbank, DAgric).

- Planting costs are currently in the order of 60-64 cents per stem with planting densities of about 2600 stems per Ha anticipated. Transport costs mean that only properties within a 50 km radius of an IMP plant are considered economically viable for mallee production (pers comm Kim Brooksbank).
- Harvesting following establishment after 4 years on good soils or 5 years on lower quality sites should allow repeat harvesting of coppiced stems every 2-3 years. It is predicted that Oil Mallee farm returns could compare favourably with wheat returns, in the order of $250 per Ha/annum (Farm Forestry Toolbox[6]).

In terms of land management mallee production has several recognised benefits (information supplied by DAgric and CALM):

- Mallee root networks have been found to extend vertically to 10 metres deep and laterally as far as 25 metres in 7 year old strip plantings, more commonly referred to as alley farming. Soil water deficits have been reported across these depths and lateral extents in ‘lighter’ soil types (pers comm John Bartle, CALM).
- Harvesting of surface flows, to be collected and infiltrated along the rows of mallee’s, has the potential to reduce groundwater recharge.
- Some wind and water erosion protection is afforded by the mallee stands.
- Strip planting allows for cropping of annuals between rows of mallees.
- Mallee production has the potential to provide an economic return.

Based on information provided by Ashley Chanellor of Western Power, a number of drivers are key determining where IMP plants might be established, these are:

- Sites for the IMP plants will require existing substations and powerlines to the South West Integrated System (SWIS) grid, capable of handling output of 5 megawatts.
- The surrounding agricultural districts are required to have saline rising water tables requiring management. Local farmers will be required to plant sufficient acreages of mallee to supply feedstock to the plant, and the climatic and soils conditions for mallee in the area should provide for good growth.

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[6] Brooksbank Kim (2001), “Getting Started with Oil Mallees in the Farm Forestry Toolbox V3 – Users Guide”, a draft document supplied through the Department of Agriculture.

4.5 Deep Rooted Perennials

Currently only lucerne has been identified as being potentially viable in the low rainfall conditions of the catchment (pers comm David Tennant, DAgric), and only on heavier, moisture retaining soils. Advice from Ian McFarland of the Narrogin Office of the DAgric is that development of other species of perennials that are suited to low rainfall conditions is still at a very early stage.

The influence of deep-rooted perennials in lowering groundwater tables is considered to be limited to the immediate proximity of the plantings, so that benefits might be anticipated at a ‘paddock scale’. In heavier soils water table reduction is likely to extend to 1.5 metres and up to 2.5 metres in lighter soils under perennials. This compares to 0.9 metres under a wheat crop during the active growing season. It is considered that perennials would only be adopted at site-specific locations for short-term de-watering, and do not provide a catchment or regional scale dewatering option (pers comm David Tennant, DAgric).

4.6 Aquaculture

The research of aquaculture development within the Wheatbelt is at early trial stages with the likelihood of a commercially scaled operation some 3-5 years away (pers comm Peter Lacey, Department of Fisheries). A large number of uncertainties remain regarding its viability, key among these are:

- Issues regarding fish husbandry and potential constraints for semi to intensive fish rearing. A number of fish and crustacean species have been identified as possible aquaculture options but only a few species including rainbow trout, snapper and black bream are being trialed on farms, and these are at low stocking rates.
- The large distances to potential markets requires satellite processing centres to be developed for the product. The viability of aquaculture projects will be dependent on proximity to these processing centres.

With regards to managing the salinity problem Aquaculture offers the following potential opportunities.

- Groundwater will be ‘strategically’ harvested at a farm scale using a network of bores to feed the brackish-saline ponds used for aquaculture. The requirement for circulating ‘clean’ and oxygenated water necessitates an ongoing supply. The volumes of water required for the ponds could potentially prove significant at a landscape level in managing groundwater tables.
- It would be anticipated that for aquaculture to be a viable option in groundwater management that the operations would pay directly for the infrastructure costs in pumping and disposing of the groundwater.

- Disposal of the saline and nutrient enriched aquaculture wastewaters could be a potential environmental issue. Therefore the opportunity exists to develop and test polycultures whereby the wastewater of one process would be used as an input to another system. An example being the harvesting of brine shrimp or algae grown on the wastewater of a trout breeding operation. Final disposal would likely be via evaporation ponds.

Peter Lacey of the Department of Fisheries at Narrogin, advises that an economic analysis of the small-scale research operations currently being trialed will be prepared in early 2002. Data is not currently available to assess the economics of a regional / commercial sized operation.

4.7 Salt-Tolerant Fodder Crops

The Saltland Pastures Association Inc has reported that saltland can be developed sustainably and profitably for livestock grazing. As more cropping land is being lost to the spread of salinity, the opportunity to establish salt tolerant pasture lands, with the running of sheep, might be considered.

With the general consensus being that it is non-viable to attempt to reclaim already salt affected lands for cropping, saltland pastures offer the opportunity to develop a profit from otherwise unproductive land. The principles are to develop deep-rooted perennial fodder crops that are salt tolerant; generally species of saltbush. Once these plants are established and a net reduction in the local water tables are achieved it provides the opportunity for other pasture species to recolonise, including clovers and grasses. Studies in NSW and WA have suggested that these reclaimed pasture lands could be as, or more productive, than traditional clover/medic/grass pastures. Operating returns of up to $30 per Ha/annum could be realised.

4.8 Non Commercial Tree Planting

Any non-commercial tree planting would need to be assessed on its potential benefits in terms of controlling rising groundwater tables, its environmental and aesthetic value; as no direct economic returns are realised. Given this, broad-scale non-commercial tree plantings are not currently considered to be a viable options for controlling rising groundwater tables.

5. Conclusions

The main conclusion of the CBA is that returns on investments in engineering based salinity management schemes, with disposal inside the catchment, could be at least several of millions of dollars ‘positive’, even at the lower end ($50 per Ha/annum) of anticipated farm operating profits.

Other conclusions of significance include:

- Payback periods could vary between 20-35 years and net cashflows between $2.75-$4.25 million, depending on the actual medium to longer term operating profit figure ($50-$124 per Ha/annum).
- Cost-drivers identified to date that largely influence the outcomes of the CBA are the farm operating profit and replacement/maintenance costs for roads and abstraction bores.
- Engineering based schemes, which could include disposal to salt lake complexes outside the catchment via pipelines are highly unlikely to breakeven as they are too costly to implement and maintain.
- To date, non-engineering based interventions have not conclusively demonstrated that they represent a viable intervention option for inclusion in catchment-wide strategies for managing and controlling rising groundwater tables in predominantly agricultural catchments.
- Potential impacts under the ‘do-nothing’ scenario, which include depopulation of the catchment, closing of local businesses and services to the area, a decline in the social fabric of the communities and extensive environmental degradation, could not be included in the CBA as there is no currently agreed method of how to factor these scenario’s into a financial analysis.
- Intervention schemes need to be implemented immediately, or within the next 3-5 years, if the majority of the remaining good agricultural land is going to be protected from salinisation. Given this, the timeframes involved with researching, trailing and implementation of non-engineering based intervention schemes are such (5-20 years) that their inclusion at this stage is highly unlikely.
- It will be important for land managers in the catchment to continue to follow the outcomes of scientific research into opportunities such as the commercial growing of mallee species over the next decade. Planning for water table management should be flexible so as to accommodate new technologies, as and when their application and benefits are proven.
- The CBA approach remains a useful ‘tool’ to test the financial validity of any proposed `schemes, although the method is limited in terms of incorporating the so called ‘intangible’ benefits that are important considerations in the assessment the ‘real’ value of a proposed scheme.

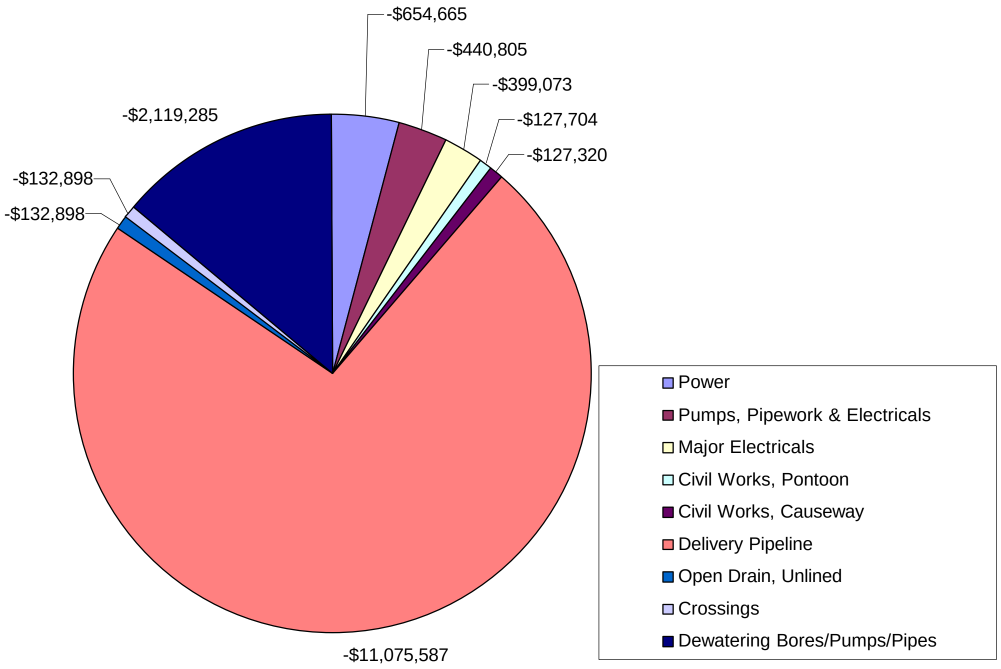
Figures

Figure 1.3.1 - Scheme 1
Figure 1.3.2 - Scheme 2
Figure 1.3.3 - Scheme 3
Figure 1.3.4 - Scheme 4
Figure 1.3.5 - Scheme 5

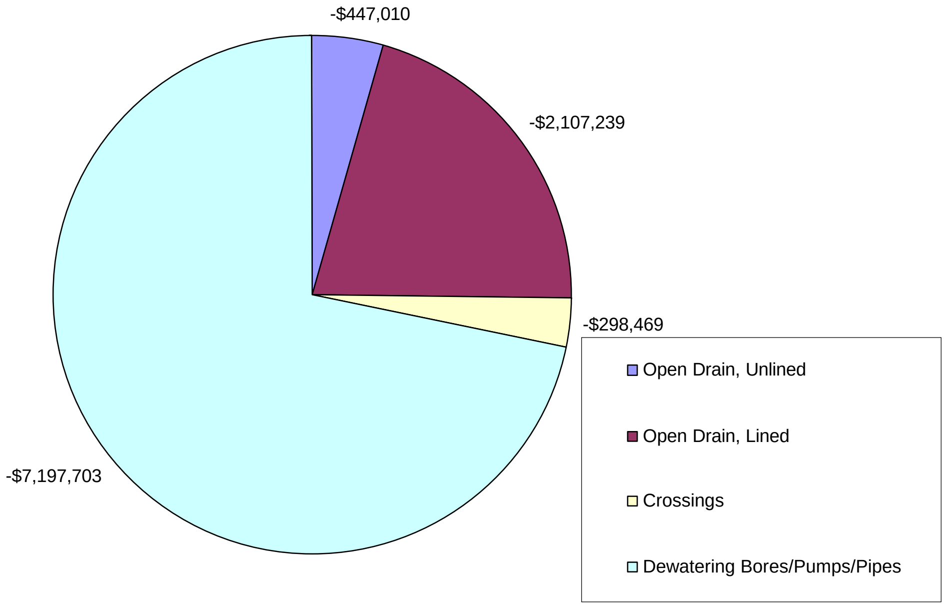
Appendix A

CBA Model Data

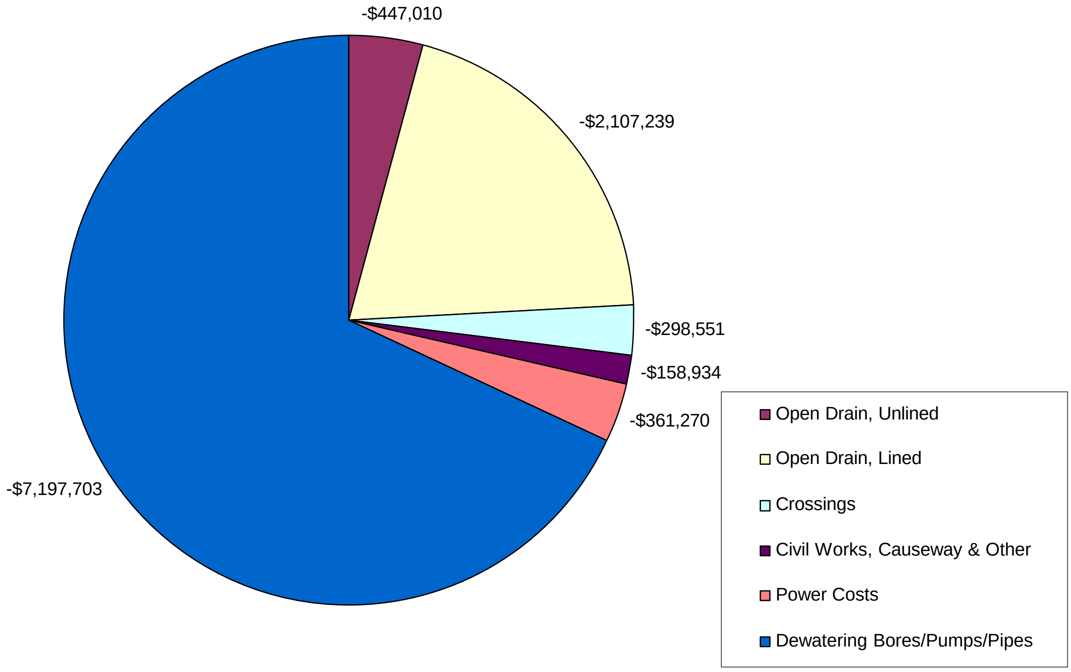
Scheme 1 Project Cost Breakdown 50 Year Simulation



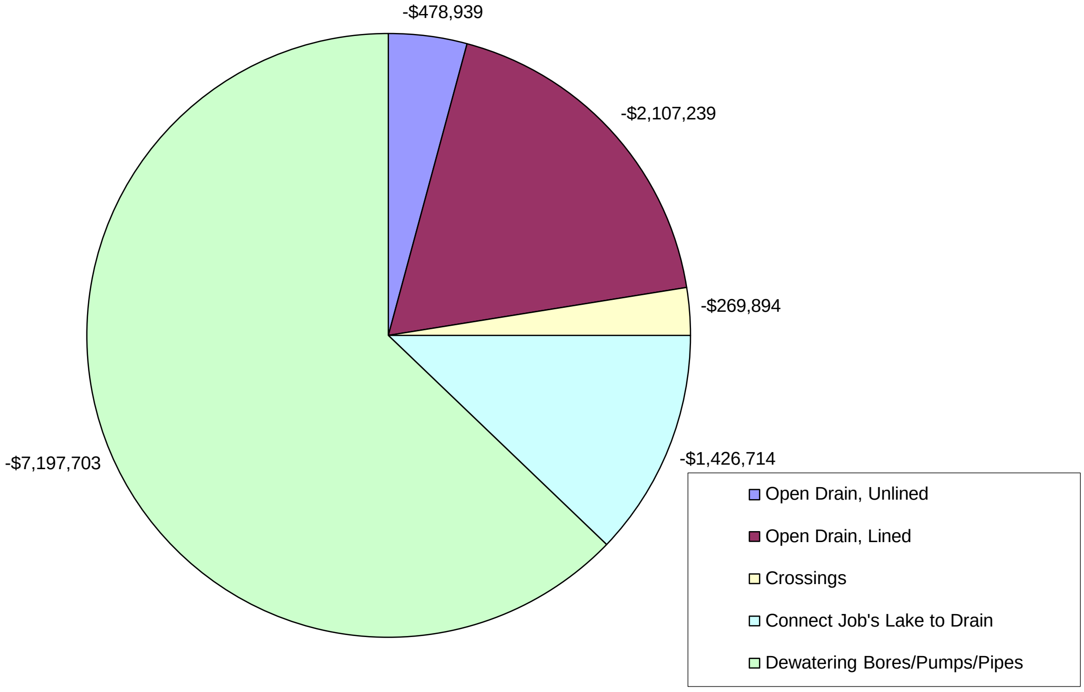
Scheme 2 Project Cost Breakdown 50 Year Simulation



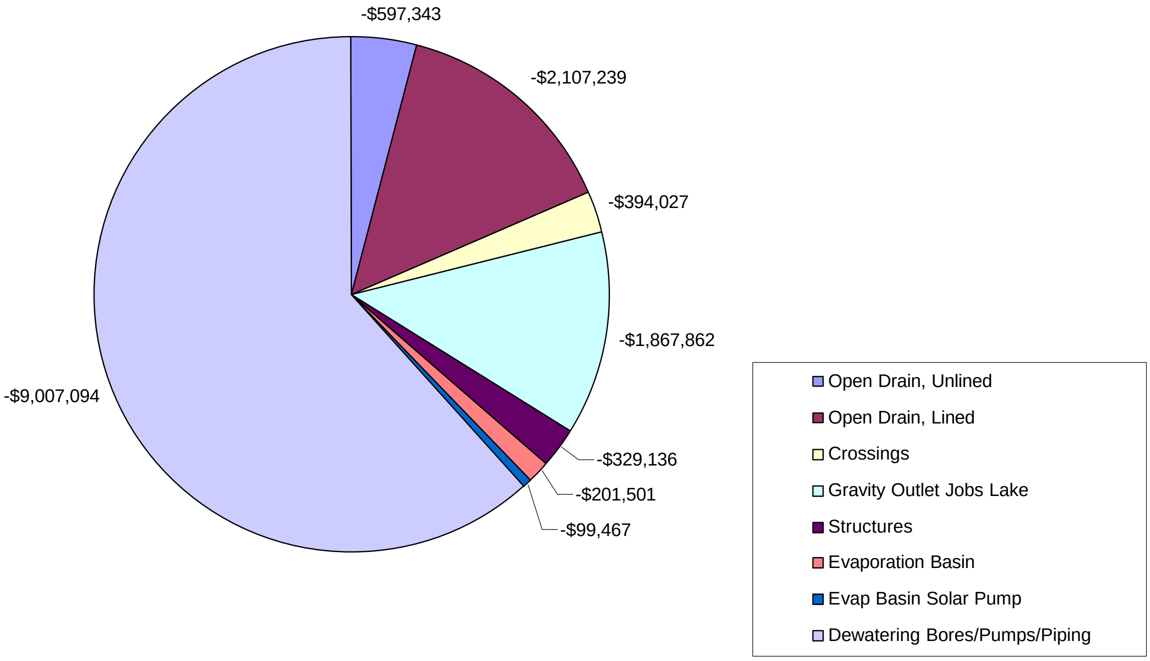
Scheme 3 Project Cost Breakdown 50 Year Simulation



Scheme 4 Project Cost Breakdown 50 Year Simulation



Scheme 5 Project Cost Breakdown 50 Year Simulation



Project:	**Beacon River Salinity**
Task:	**Engineering Scheme 1**
Details:	**Open drain with inter-basinal pumping from Job's lake, catchment dewatering using bores & solar pumps**

Item	Description	Value	Recurrence Interval	Reference	Present Value 50 yrs
1	**Power**				
	Initial	-$220,000	0	Year 0	-$ 220,000
	Ongoing Annual	-$25,000	A	Year 1 and ongoing	-$ 434,665
					-$654,665
2	**Pumps, Pipework & Electricals**				
	Capital	-$222,000	0	Year 0	-$ 222,000
	Rehabilitation	-$22,200	5	10% of Captial and Year 5^{rec}	-$ 54,232
	Replace	-$199,800	15	Year 15^{rec}	-$ 164,573
					-$440,805
3	**Major Electricals**				
	Capital	-$300,000	0	Year 0	-$ 300,000
	Rehabilitation	-$30,000	10	10% of Captial and Year 10^{rec}	-$ 36,602
	Replace	-$270,000	30	Year 30^{rec}	-$ 62,472
					-$399,073
4	**Civil Works, Pontoon**				
	Capital	-$96,000	0	Year 0	-$ 96,000
	Rehabilitation	-$9,600	10	10% of Captial and Year 10^{rec}	-$ 11,713
	Replace	-$86,400	30	Year 30^{rec}	-$ 19,991
					-$127,704
5	**Civil Works, Causeway**				
	Capital	-$120,000	0	Year 0	-$ 120,000
	Rehabilitation	-$6,000	10	5% of Captial and Year 10^{rec}	-$ 7,320
					-$127,320
6	**Delivery Pipeline**				
	Capital	-$6,060,000	0	Year 0	-$ 6,060,000
	Rehabilitation	-$60,600	10	1% of Captial and Year 10^{rec}	-$ 73,935
	Replace	-$5,999,400	15	Year 15^{rec}	-$ 4,941,652
					-$11,075,587
7	**Open Drain, Unlined**				
	Capital	-$100,000	0	Year 0	-$ 100,000
	Rehabilitation	-$10,000	5	10% of Captial and Year 5^{rec}	-$ 32,898
					-$132,898
8	**Crossings**				
	Capital	-$50,000	0	Year 0	-$ 50,000
	Rehabilitation	-$5,000	5	10% of Captial and Year 5^{rec}	-$ 15,292
	Replace	-$45,000	30	Year 30^{rec}	-$ 10,412
					-$132,898
9	**Dewatering Bores/Pumps/Pipes**				
	Capital		0	Year 0	-1,219,026
	Rehabilitation (pumps)		2.5	$200 per pump @ Year 2.5rec	-326,233
	Replace (pumps/solar panels)		20	$4500 @ Year 20rec	-539,742
	Replace (piping)		25	Year 25^{rec}	-34,284
					-$2,119,285
10	**Derived Benefit**				
	Operating Profit + Protection Roads				4,248,884
				(subtotal) Benefits	*$4,248,884*
				(subtotal) Project Costs	*-$15,150,965*
				Scheme 1 Net Cashflow @ 50yrs	*-$10,902,081*

Project:	**Beacon River Salinity**				
Task:	**Engineering Scheme 2**				
Details:	**Open drain, bypassing Job's Lake, catchment dewatering using bores & solar pumps**				
					Present Value
Item	**Description**	**Value**	**Recurrence Interval**	**Reference**	**50 yrs**
1	**Open Drain, Unlined**				
	Capital	-$336,000	0	Year 0	-$ 336,000
	Rehabilitation	-$33,600	5	10% of Capital and Year 5^{rec}	-$ 111,010
					-$447,010
2	**Open Drain, Lined**				
	Capital	-$1,188,000	0	Year 0	-$ 1,188,000
	Replace Liner	-$1,116,000	15	Year 15^{rec}	-$ 919,239
					-$2,107,239
3	**Crossings**				
	Capital	-$197,000	0		-$ 197,000
	Rehabilitation	-$19,700	5	10% of Capital and Year 5^{rec}	-$ 60,446
	Replace	-$177,300	30	Year 30^{rec}	-$ 41,023
					-$298,469
4	**Dewatering Bores/Pumps/Pipes**				
	Capital	-$1,400,000	0	Year 0	-$ 4,029,839
	Rehabilitation (pumps)		2.5	$200 per pump @ Year 2.5rec	-$ 1,270,259
	Replace (pumps/solar panels)		20	$4500 @ Year 20rec	-$ 1,784,270
	Replace (piping)	-$560,000	25	Year 25^{rec}	-$ 113,335
					-$7,197,703
5	**Derived Benefit**				
	Operating Profit + Protection Roads				$ 14,162,947
				(subtotal) Benefits	*$14,162,947*
				(subtotal) Project Costs	*-$10,048,786*
				Scheme 2 Net Cashflow @ 50yrs	*$4,114,162*

Project:	**Beacon River Salinity**				
Task:	**Engineering Scheme 3**				
Details:	**Open drain & pumped drainage of Job's Lake, catchment dewatering using bores & solar pumps**				
					Present Value
Item	**Description**	**Value**	**Recurrence Interval**	**Reference**	**50 yrs**
1	**Open Drain, Unlined**				
	Capital	-$336,000	0	Year 0	-$ 336,000
	Rehabilitation	-$33,600	5	10% Capital and Year 5^{rec}	-$ 111,010
					-$447,010
2	**Open Drain, Lined**				
	Capital	-$1,188,000	0	Year 0	-$ 1,188,000
	Replace Liner	-$1,116,000	15	Year 15^{rec}	-$ 919,239
					-$2,107,239
3	**Crossings**				
	Capital	-$197,000	0	Year 0	-$ 197,000
	Rehabilitation	-$19,700	5	10% Capital and Year 5^{rec}	-$ 60,528
	Replace	-$177,300	30	Year 30^{rec}	-$ 41,023
					-$298,551
4	**Civil Works, Causeway & Other**				
	Capital	-$150,000	0	Year 0	-$ 150,000
	Rehabilitation	-$7,500	10	5% Capital and Year 10^{rec}	-$ 8,934
					-$158,934
5	**Power Costs**				
	Initial	-$130,000	0	Year 0	-$ 130,000
	Ongoing	-$70,000	5	Year 5^{rec}	-$ 231,270
					-$361,270
6	**Dewatering Bores/Pumps/Pipes**				
	Capital	-$1,400,000	0	Year 0	-$4,029,839
	Rehabilitation (pumps)	0	2.5	$200 per pump @ Year 2.5rec	-$1,270,259
	Replace (pumps/solar panels)	0	20	$4500 @ Year 20rec	-$1,784,270
	Replace (piping)	-560,000.00	25	Year 25^{rec}	-$113,335
					-$7,197,703
7	**Derived Benefit**				
	Operating Profit + Protection Roads	$47,813	0	Incremented annually to year 50	$ 14,162,947
				(subtotal) Benefits	*$14,162,947*
				(subtotal) Project Costs	*-$10,570,085*
				Scheme 3 Net Cashflow @ 50yrs	*$3,592,862*

Project:	**Beacon River Salinity**				
Task:	**Engineering Scheme 4**				
Details:	**Open drain & gravity drainage of Job's Lake, catchment dewatering using bores & solar pumps**				
					Present Value
Item	**Description**	**Value**	**Recurrence Interval**	**Reference**	**50 yrs**
1	**Open Drain, Unlined**				
	Capital	-$360,000	0	Year 0	-$ 360,000
	Rehabilitation	-$36,000	5	10% Capital and Year 5^{rec}	-$ 118,939
					-$478,939
2	**Open Drain, Lined**				
	Capital	-$1,188,000	0	Year 0	-$ 1,188,000
	Replace Liner	-$1,116,000	15	Year 15^{rec}	-$ 919,239
					-$2,107,239
3	**Crossings**				
	Capital	-$197,000	0	Year 0	-$ 197,000
	Rehabilitation	-$19,700	5	10% Capital and Year 5^{rec}	-$ 31,871
	Replace	-$177,300	30	Year 30^{rec}	-$ 41,023
					-$269,894
4	**Connect Job's Lake to Drain**				
	Capital	-$1,404,000	0	Year 0	-$ 1,404,000
	Rehabilitation	-$14,040	5	1% Capital and Year 5^{rec}	-$ 22,714
					-$1,426,714
5	**Dewatering Bores/Pumps/Pipes**				
	Capital	-$1,400,000	0	Year 0	-$ 4,029,839
	Rehabilitation (pumps)		2.5	$200 per pump @ Year 2.5rec	-$ 1,270,259
	Replace (pumps/solar panels)		20	$4500 @ Year 20rec	-$ 1,784,270
	Replace (piping)	-$560,000	25	Year 25^{rec}	-$ 113,335
					-$7,197,703
6	**Derived Benefit**				
	Operating Profit + Protection Roads	$47,813	0	Incremented annually to year 50	$ 14,162,947
				(subtotal) Benefits	*$14,162,947*
				(subtotal) Project Costs	*-$11,480,489*
				Scheme 4 Net Cashflow @ 50yrs	*$2,682,458*

Project: Beacon River Salinity

Task: Engineering Scheme 5

Details: Open drain with lake & basin evaporation, catchment dewatering using bores & solar pumps

Item	Description	Value	Recurrence Interval	Reference	Present Value 50 yrs
1	**Open Drain, Unlined**				
	Capital	-$449,000	0	Year 0	-$ 449,000
	Rehabilitation	-$44,900	5	10% Capital and Year 5^{rec}	-$ 148,343
					-$597,343
2	**Open Drain, Lined**				
	Capital	-$1,188,000	0	Year 0	-$ 1,188,000
	Replace Liner	-$1,116,000	15	Year 15^{rec}	-$ 919,239
					$ -
					-$2,107,239
3	**Crossings**				
	Capital	-$260,000	0	Year 0	-$ 260,000
	Rehabilitation	-$26,000	5	10% Capital and Year 5^{rec}	-$ 79,885
	Replace	-$234,000	30	Year 30^{rec}	-$ 54,142
					-$394,027
4	**Gravity Outlet Jobs Lake**				
	Capital	-$1,404,000	0	Year 0	-$ 1,404,000
	Rehabilitation	-$140,400	5	10% Capital and Year 5^{rec}	-$ 463,862
	Replace			not undertaken	$ -
					-$1,867,862
5	**Structures**				
	Capital	-$300,000	0	Year 0	-$ 300,000
	Rehabilitation	-$3,000	10	5% of Captial and Year 10^{rec}	-$ 3,237
	Replace	-$297,000	50		-$ 25,900
					-$329,136
6	**Evaporation Basin**				
	Capital	-$200,000	0	Year 0	-$ 200,000
	Rehabilitation	-$2,000	20	1% of Captial and Year 10^{rec}	-$ 1,501
					-$201,501
7	**Evap Basin Solar Pump**				
	Capital	-$50,000	0	Year 0	-$ 50,000
	Rehabilitation	-$5,000	5	10% Capital and Year 5^{rec}	-$ 12,401
	Replace	-$45,000	15	Year 15^{rec}	-$ 37,066
					-$99,467
8	**Dewatering Bores/Pumps/Piping**				
	Capital	-$1,800,000	0	Year 0	-$ 5,181,222
	Rehabilitation (pumps)		2.5	$200 per pump @ Year 2.5rec	-$ 1,386,094
	Replace (pumps/solar panels)		20	$4500 @ Year 20rec	-$ 2,294,061
	Replace (piping)	-$720,000	25	Year 25^{rec}	-$ 145,717
					-$9,007,094
9	**Derived Benefit**				
	Operating Profit + Protection Roads				$ 18,209,504
				(subtotal) Benefits	*$18,209,504*
				(subtotal) Project Costs	*-$14,603,669*
				Scheme 5 Net Cashflow @ 50yrs	*$3,605,834*