TECHNICAL BULLETIN
NO. 220

LAND RECLAMATION IN CENTRAL AUSTRALIA

THE ECONOMIC ASPECTS

Agdex 64 $6.00 ISBN 0 7245 28717

LAND RECLAMATION IN CENTRAL AUSTRALIA

THE ECONOMIC ASPECTS

B. M. CANN
Senior Economist
Economics Branch

June 1994

SUSTAINABLE AGRICULTURE

THE DEPARTMENT OF PRIMARY INDUSTRY AND FISHERIES IS COMMITTED TO THE PRINCIPLES AND PRACTICES OF SUSTAINABLE AGRICULTURE

Definition:

Sustainable agriculture is the use of practices and systems which maintain or enhance:

- the economic viability of agricultural production;
- the natural resource base; and
- other ecosystems which are influenced by agricultural activities.

Principles:

1. Agricultural productivity is sustained or enhanced over the long term.
2. Adverse impacts on the natural resource base of agricultural and associated ecosystems are ameliorated, minimised or avoided.
3. Harmful residues resulting from the use of chemicals for agriculture are minimised.
4. The nett social benefit (in both dollar and non-dollar terms) derived from agriculture is maximised.
5. Agricultural systems are sufficiently flexible to manage risks associated with the vagaries of climate and markets.

CONTENTS

1. INTRODUCTION

This review examines the economic, management, policy, and related issues affecting the application of reclamation technologies in Central Australia. During the course of research on the profitability and potential application of reclamation technologies, it became apparent that there was a need for greater understanding of a wider range of issues than was originally contemplated. The importance of raising a wider range of issues stems from the potential of certain reclamation technologies to be one of the most profitable options for station development in Central Australia. In this role, these technologies would be more appropriately named production technologies. However, the local pastoral industry has come to see them as relating purely to reclamation so the term `reclamation technologies' is used throughout this review.

The term `reclamation technologies' as used in this review are those mechanical treatments which have application for restoring and/or increasing the productivity of rangelands for animal production. It excludes mechanical treatments aimed specifically at woody weed control as these have been examined elsewhere. It also excludes other management practices which might otherwise fall under a broad definition of reclamation (eg feral animal control and prescribed burning).

Reclamation technologies are yet to be widely implemented in Central Australia. Only pitting and ponding have been tried to any extent and only ponding has yielded a reasonable degree of success. A study has recently been undertaken by CSIRO to examine the application of pitting reclamation technology in Central Australia. Among other things this study looked at the factors which contribute to the success or failure, and has provided recommendations for future pitting efforts (M. Friedel, pers. comm.).

Reclamation techniques have been more widely applied in western New South Wales than elsewhere in Australia, particularly ponding (Cunningham, 1990) and contour furrowing (Tatnell and Beale, 1990). In the United States, a large body of experience has been built up on the use of rangeland reclamation and development technologies (Vallentine 1980). Interstate and overseas experience can provide valuable information on the appropriate use of reclamation technologies, though there is an obvious need to interpret such information for local conditions.

In recent years there has been an increasing public awareness of environmental issues. Land degradation in its many forms has received considerable attention and this trend is likely to continue. Government policies now support and promote sustainable agricultural practices. An increasing body of research is being devoted to land degradation: its causes, prevention and reversal. Continued interest in reclamation is therefore likely for some years to come.

2. ISSUES AFFECTING THE ADOPTION OF RECLAMATION TECHNOLOGIES

2.1 Past Performance and Present Perceptions of Reclamation Technologies in the Pastoral Industry

An aim of this review is establish what is the role of reclamation technologies in the future of the pastoral industry. A good guide to this role is the success of the past application of these technologies. A recent study by Margaret Freidel (CSIRO) of sites where pitting had been undertaken, concluded that an economic response was achieved on the best sites. Most sites, however, yielded far less than the best sites and had no chance of being profitable. Ponding has been less widely implemented than pitting and was not examined in the above study. Several articles have been published regarding significant areas of ponding on two properties in Central Australia and a third property is now undertaking a large program of pond building. Available evidence suggests that ponding on these properties has been a profitable exercise.

Ponds have been built on a number of other properties in the region. Many of these have been built in recent years so conclusions on their success can not yet be drawn. There are reports that attempts at ponding on a number of properties has failed due to inappropriate siting or pond design. Industry opinion seems to mirror the track record of these reclamation technologies. There seems to be little enthusiasm for pitting but a fair degree of interest in ponding.

Late in 1993 a series of schools on the construction of ponds using graders were conducted by experts from the NSW Soil Conservation Service. The schools were organised by the Centralian Land Management Association and the Conservation Commission of the NT. The lower cost of ponds built this way potentially improves their profitability relative to ponds with substantial banks. This method of pond construction has generated considerable interest but it is too early to make any judgement about their likely future success.

Reclamation technologies have also been implemented on non-pastoral land but the measures of benefits in these situations are different so no conclusions are drawn here.

2.2 Public Versus Private Costs and Benefits

An important issue for the past and future application of reclamation technologies is the difference in perception of benefits and costs between private and public interests. For example a pastoralist will be interested mainly in the dollar costs and dollar benefits of investing in reclamation works. They may also attach some value to the personal satisfaction from improving or looking after their land. From a public viewpoint there are other benefits and costs which might be considered and which may make reclamation works profitable from a public viewpoint when they are unprofitable from a private viewpoint. Many public costs and benefits are not easily valued as they are not commodities which are traded. A public benefit of reclamation works may be simply the satisfaction/warm feeling that some degraded land has been rehabilitated. It may in some cases be the value of increasing the diversity of fauna on a piece of land.

Given that there is a difference between the private and public viewpoint of benefits and costs, it can be expected that there are also differences between pastoralists and the public/government in what reclamation works should be undertaken. Pastoralists can only be expected to undertake reclamation work if the dollar benefits and their own personal satisfaction combined make the investment profitable. The public/government might be expected to undertake or subsidise reclamation in a wider range of situations but does not seem to be willing to provide substantial funds except in the form of tax incentives, and funds for research and extension.

An alternative option for government to motivate investment in reclamation is to create a regulatory environment which forces pastoralists to undertake such work. Governments in Australia have been reluctant to use such powers in the past and appear unlikely to do so in the future.

If governments are unlikely to significantly subsidize reclamation or to use regulatory force to encourage it then **the major incentive to the pastoral industry is the profit motive.** It is important then that those government departments dealing with reclamation on pastoral leases should recognize this fact. This does not appear to have been the case in some quarters of government in the past.

2.3 Assessment of the Pastoralists' Position

If pastoralists are expected to be the major client as far as future implementation of reclamation technologies are concerned then there is a need for the government departments involved to assess the situation from the pastoralists' viewpoint in order to plan how to deliver research and extension services in the most appropriate form.

Young et al (1984) stated, " As businessmen, pastoralists can be expected first to seek to survive, second to make current profits, and third to maintain productivity for long term survival." It is well known that many pastoral properties in the Alice Springs district are carrying large debts. A run of dry years over much of the district and high interest rates in the recent past have exacerbated these problems. Pastoralists in a poor financial situation are not in the position to undertake "non-essential" expenditure so are unlikely to consider large programs of reclamation unless it is likely be quite profitable with a reasonably low degree of risk.

Despite this, there is a spread in the financial situation of pastoral properties and it follows then that there is a section of the industry which is in a good enough financial condition to undertake "non-essential" expenditure such as reclamation. Those in the fortunate situation of having a high taxable income and facing high marginal tax rates will also be able to take advantage of significant tax benefits for investment in reclamation works.

Efforts to encourage industry expenditure on reclamation should target these properties. Efforts by government to demonstrate reclamation technologies, on the other hand, should be spread over the whole of the industry. The reason for this is that the results of reclamation works are long term. This strategy would give a spread over a range of land types, management styles and seasonal conditions. For those who are not currently in a financial situation to undertake reclamation works, it would also provide information for investment decisions when financial conditions improve.

Risk is an important factor for pastoralists weighing up investment in reclamation versus alternative investments. Past failures in the region, lack of familiarity with the technology and a lack of understanding of soil processes all contribute to the level of risk perceived by pastoralists. As on-property experience is developed, expenditure will no doubt be adjusted according to the confidence gained in the technology and the success or otherwise of the technologies used. No doubt past failures of pitting at least, have substantially increased the level of perceived risk of that technology in the mind of pastoralists.

Property expenditure on reclamation can be divided into two parts: the operating costs of carrying out the reclamation works; and the capital costs of any machinery or implements which might be required to undertake reclamation works. While reclamation works are still considered a risky investment any substantial capital expenditure required to undertake reclamation will be a major hurdle and those properties which already own suitable machinery and/or implements are far more likely to undertake reclamation works.

Given a situation where surplus cashflow is available for on-property investment then the pastoralist will have to allocate funds between competing uses. The share that goes to reclamation will depend on its relative profitability, riskiness, time taken to yield benefits, and general considerations about how alternative investments fit in with overall property management and development.

Encouraging pastoralists to undertake reclamation on productive soil would put dollars in their pockets and encourage further reclamation. This would improve pastoralists' familiarity with the technology and possibly lead to reclamation works in less productive situations or in situations where soils and pastures will take a long time to recover. Encouraging pastoralists to principally reclaim low productivity soils may well discourage their use of the technology in the long run.

3. TECHNOLOGY OF RECLAMATION

3.1 Definitions

Numerous methods of reclamation have been tried overseas and interstate. The potential for variation within particular methods is such that the distinction between methods can become blurred. Hence there is some scope for confusion and disagreement on terminology. For the benefit of those unfamiliar with the technology, defintions of the implements or machinery used in the technologies referred to in this review are:

• Opposed disc pitter or plough - an implement with a central ripping tyne and a disc either side of the tyne. Each disc cuts a furrow and pushes the excavated soil into a mound between the furrows. It has a seeder attached which sows seed into both sides of the mound. The implement is raised and lowered during ploughing to leave gaps in the earthworks so that runoff concentration and consequent erosion is kept to a minimum. This implement is towed by a tractor with three point linkage.

• Paech pitter - an implement with three tynes and wheels mounted eccentrically so that the tynes move into and out of the ground and form a staggered pattern. The tynes form small pits into which seed is dropped. This implement is towed by a tractor with three point linkage.

• Contour furrower - an implement which excavates a furrow and forms the soil removed into a mound next to the furrow. Usually the mound is on the downhill side of the furrow. The furrow may be excavated via a combination of tynes, disc ploughs, mouldboard ploughs, etc. Discontinuous furrows may be formed by raising and lowering the implement or a mechanism may dam the furrow at regular intervals to reduce concentration of runoff. Usually it would also sow seed into the base of the mound nearest the furrow. This implement would normally be towed by a tractor with three point linkage.

• Ponding - uses bulldozers, articulated loaders or graders to forms banks which will hold water to a designed depth and spill excess water to the pond below or to some place safe from erosion. Ponding banks may vary in height depending on the depth of water to be ponded and this may be dictated by the machinery available for bank construction. Ponding banks are recognized as long term structures.

3.2 Application of Reclamation Technologies

The main technologies applied in Australia are pitting, contour furrowing and ponding. Ponding appears to have been the most successful. This is apparent from the modest number of published works claiming its profitability though these are for a limited number of situations. Similar articles on the profitability of other methods are noticeable by their absence though Tatnell and Beale (1990) refer to the operation of a commercial service for contour furrowing which has treated over 10 000 hectares.

Pitting, in the form produced by the Paech pitter and similar implements, is no longer promoted in Central Australia though some recent research (M. Freidel, pers. comm.) suggests that the Paech pitter may have been as effective as the opposed disc plough.

Ponding has arguably been the most successful reclamation technology applied in Australia's arid rangelands. If ponding banks are properly sited, constructed and maintained then they will have a long life and feed production in the ponded area will generally improve markedly over time. Even if the banks of properly sited ponds are breached, they are readily repaired for a fraction of the establishment cost. A number of failures of ponds have reportedly occurred in Central Australia but have been largely due to poor site selection and design by pastoralists who were unaware of the principles which should be applied. Freak rainfall events can also take their toll but again the cost of repair is only a fraction of the original construction cost.

3.3 Need for an Examination of the Technology for Pitting and Contour Furrowing

Although opposed disc pitting has emerged as the main "non-ponding" reclamation technology it has generally failed to produce a profitable level of benefits. A major cause of this failure is that many of these pits have been built on inappropriate soil types. Pits are more suited to loamy and sandy-loam soils, not those with a high clay content (M. Freidel, pers. comm.). In addition, the main grass species sown (ie buffel) is not suited to clayey soil types.

On soils with a high clay content the pits made by an opposed disc plough fill in quickly thus losing their effectiveness to catch water. Even on loam to clay-loam soils the pits fill in relatively quickly. Later sections show that much of the economic benefits from reclamation works flow from their ability to harvest water. On this basis a large pit and a long pit life would enhance the profitability of any form of pitting or contour furrowing.

Another problem with opposed disc pits is that in practice it is difficult keep pits on the contour. There are even examples of pits running at right angles to the contour which have resulted from a preoccupation to keep pits parallel to each other rather than follow the contour. The shallow nature of pits means that being slightly off the contour will dramatically reduce their water holding capacity. While conducting background research on reclamation the view was expressed several times that many in the pastoral industry had discounted opposed disc ploughing as being unprofitable because of the short life of pits and the number of failures.

The Soil Conservation Service of New South Wales has been involved in considerable reclamation work in arid rangelands. They have developed implements for contour furrowing to increase the life of the earthworks and increase the volume of water trapped per metre of pit. Considering the success of this technology interstate and the failure of pits in many local situations, it is surprising that no research or demonstration work on contour furrowing has been undertaken in Central Australia.

Despite the failure of pits to provide economic returns in most Centralian applications there is potential for a suitable design of pit or furrow to be more profitable than ponds. The figures below indicate the potential advantage of pits/furrows over ponds in terms of capital cost per tonne of peak feed production:

Opposed disc pitting
- pits every 6 metres
- cost of tractor, implement and labour = $35/hr
- work speed averages 4 km/hr à work rate = 2.4 ha/hr
  ▸ machinery and labour cost = $14.60/ha
- 1 kg/ha buffel seed at $7/kg = $7/ha
  ▸ total cost is $21.60/ha or $2 160/sq km with seed
  and $16.35/ha or $1 635/sq km with own seed
  (assumed to be one quarter of the cost of purchased seed)
- average peak yield increase in an average season
  is roughly estimated at 300 - 400 kg/ha/yr
  ▸ estimated capital cost per tonne of increased feed is
  $54.00 - $72.00 (with purchased seed)
  $40.87 - $54.50 (with own seed)

Ponding (constructed by a loader or a dozer)
- cost of bank construction plus seeding of bank
  is estimated at $150 - $250/bank
- average pond size = 0.5 ha
- average increase in peak yield = 2 000 kg/ha
  ▸ estimated cost per tonne of increased feed is $150 - $250

These figures suggest that the technology, especially implement design, for pitting and contour furrowing is worth further research. The aim should be to achieve a pit/contour furrow structure that will be effective at intercepting or trapping water over a long life (say 10 years or more). This conclusion is based on the assumption that pits can produce a peak annual increase in feed production in the order of 300 - 400 kg per hectare. There is some evidence that this estimate may only be achieved on the most productive sites. On the other hand this evidence is based on productive sites where the opposed disc pits have nearly disappeared. A suitable long life structure which has the ability to harvest water may produce better yield on productive sites or the same yield on poorer sites. The ability to harvest water is identified as a key factor in the profitability of reclamation works. On sites where the soil has a high clay content, however, it is possible that no small scale structures will have a long enough life to be profitable.

During the course of researching this report it became apparent that there is a need for discussion on the niches for pitting/furrowing and ponding. This would be a useful part of the design process for a suitable contour furrowing implement. Recent information on blade ploughing suggests that it may have a role to play in reclamation. Its niche and potential problems could be included in such discussion.

3.4 Grader-built Ponding Banks

Ponds built using a grader have been utilized in New South Wales for many years to reclaim scalds. These are generally built on gently sloping land. The use of graders and the lower height of the banks makes these ponds relatively cheap to construct in terms of the cost per metre of bank or per hectare of ponded area. In NSW the current cost of constructing these ponds using a contractor is around $100 per hectare plus seed cost. This is much cheaper than the $300 - $500 per hectare estimated for loader or dozer built ponds but there are certain differences between these pond types which should be kept in mind. Firstly the more substantial loader or dozer built ponds are designed to pond water from a catchment which is six to eight times the area ponded. Grader built ponds are designed to pond nearly all of the catchment area. The latter will certainly maximize the retention of water on an area but the percentage of area ponded in smaller falls of rain will be much less than for ponds with substantial banks. Also the quantity of water infiltrated per hectare of ponded area will be greater in most situations for a loader or dozer built pond and therefore the period of plant growth and livestock weight gains will be longer. It could be concluded that grader built ponds may produce a greater quantity of feed per dollar invested but will produce less high value feed per hectare of pond than loader or dozer built ponds.

Due to their lower bank height, grader built ponds will require more frequent maintenance and are at greater risk of breaching due to cattle wearing down the bank via pads or playing in freshly disturbed soil.

The fact that grader built ponds are designed to pond the whole area of their immediate catchment means that they will be suited to a lesser number of situations than loader or dozer built ponds. However, given the current rate of pond building in Central Australia a shortage of suitable sites for either type of ponding is not likely to occur in the foreseeable future.

Given the cheaper cost per unit area and the availability of graders on some properties, no doubt grader built ponds have a future in Central Australia. It is early days yet for this type of pond so experience on how they perform under varying circumstances will need to be built up over time. It is suggested that where possible, paired trial sites of grader built ponds and loader or dozer built ponds should be constructed so that the relative merits of each. In particular, observations for each significant rainfall event on area flooded, feed produced and growth period should be collected.

3.5 Rainfall

Later sections show that the most profitable attribute of reclamation works is water harvesting. This enables production of green feed when green feed is otherwise scarce. Rainfall is obviously an important component in achieving this result.

If green feed is otherwise scarce then the rainfall events we are trying to make use of are otherwise ineffective, produce only a small amount of green feed and/or produce green feed for only a short time.

Understanding the type of rainfall events which will produce this valuable green feed should help in designing reclamation structures and siting them. Obviously quite small isolated falls of rain are of little or no use either with or without reclamation structures. Large falls, and lesser falls with follow up, can produce green feed without reclamation structures. Reclamation works then should aim to take advantage of isolated small to medium rainfall events which have high intensity and cause runoff.

This basically suggests that reclamation works should be aimed at taking advantage of storm rainfall. Rainfall patterns are summer dominant over much of the Alice Springs district with increasing summer dominance from south to north (Slatyer, 1962). Most summer rainfall is in the form of storm rainfall. Reclamation works may then be more profitable: in the north of the district than the south; and more profitable in areas along the various ranges in the district which tend to receive localised heavier or more frequent storm rainfall. This is not to say that niches for reclamation will not be developed in the future which may be more profitable in the south of the district. In a similar vein, niches may be developed for ponding which rely on stream flow rather than direct filling from storm rainfall.

A feature of droughts in the Alice Springs District is that there are often storms over large areas of the district but they are scattered and there is no follow up rain to provide widespread feed growth. Reclamation works have the ability to produce considerable feed from such storms (given reasonable size falls) and could thereby provide a means to fatten sale stock during a drought. This would provide valuable cashflow at a time when it is needed most and help to lighten grazing pressure on drought effected country.

Reclamation works may also provide added benefits from winter rainfall. Rainfall during the cooler months produces herbage which although valuable while growing, shrivels up on drying out and is susceptible to being burnt off by frosts. Reclamation works seeded with buffel grass will produce a body of lasting feed if the rain is followed by mild weather, though growth can be affected by frost. This would be particularly useful in drought conditions.

There is a need for data on runoff from local soils for a range of rainfall intensities/ durations to demonstrate the potential role of pits, contour furrows and ponds for intercepting and utilising runoff water. Historical rainfall data which details rainfall intensity and duration would be most useful in assessing the frequency of rainfall events from which reclamation works would produce valuable feed. Several references indicate that a substantial amount of data was collected in the 1960's on the infiltration characteristics of local soils. These data in conjunction with rainfall intensity data would provide some useful insights on the role of ponding and other forms of water harvesting in Central Australia.

4. ECONOMIC AND FINANCIAL ASPECTS OF RECLAMATION

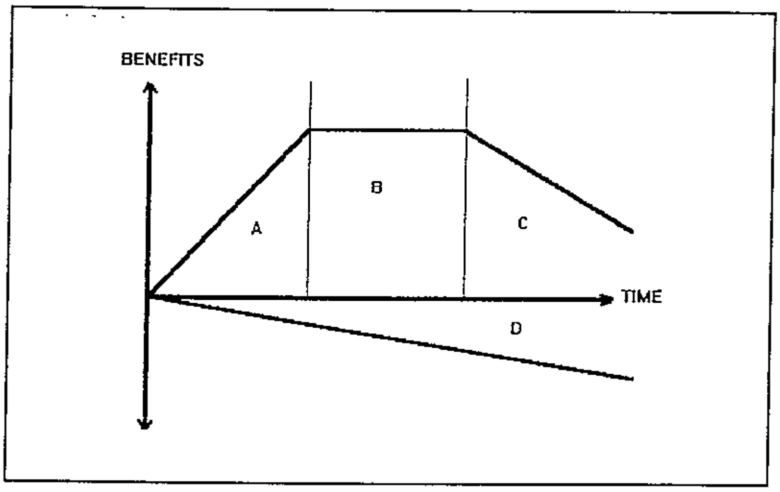
4.1 Introduction

For pastoral enterprises the main motive for undertaking reclamation works will be the profit motive. There are several economic and financial aspects to the profitability of reclamation works and these are discussed in the following sections.

4.2 Assessing the Benefits of Reclamation Works

As yet there is only limited data on which to base estimates of the likely benefits of reclamation works. While later sections examine the profitability of hypothetical examples it is worth first examining the relative importance of different components of the benefit stream derived from reclamation. This information was requested by researchers and is presented in the context of a conceptual framework for describing the potential benefits. Diagram 1 illustrates this framework. Note that the lines drawn in Diagram 1 represent an average trend in benefits. In reality there will be substantial year to year variation in benefit levels.

Diagram 1: Components of benefits from reclamation



Section A represents the lead up to achieving full grazing benefits. For the first year or possibly longer, depending on the technology, rainfall and site characteristics, there will be no grazing on the treatment area. This is the period in which grazing animals must be excluded to enable grasses to establish and set seed. Following the introduction of stock, feed production and hence grazing benefits will take some time to reach full potential. This may be due to a build up in the numbers and size of desirable plants, a build up in localized fertility or a succession of species composition from less valuable pioneer species to valuable perennial grasses.

Section B represents the period during which increased feed production resulting from the reclamation structures is at or near peak potential production. The length of this period is of obvious importance to profitability. During this period there may be an increasing or decreasing trend in feed production/benefit value. Diagram 1 suggests a smooth pattern of benefits from reclamation. In reality, the benefits will vary with seasonal factors which will cause variation in the quantity, nutritional quality and unit value of feed produced.

Section C represents the period when grazing benefits go into decline. In the case of pitting and furrowing this may be due to depressions which catch water starting to fill in thus reducing the response to a given level of rainfall. For large structures such as ponds, periodic maintenance and good management will mean that productivity should not go into long term decline.

Grazing benefits during the peak and particularly the decline may come from outside the reclamation structures or area, resulting from the introduction of a seed source of desirable grasses. In practice the transition between Sections B and C may not be easily distinguished.

Section D represents the potential loss incurred if reclamation works are not undertaken. The existence of Section D type benefits implies unsustainable management practices or a situation in which productivity will decline without intervention. Examples of such benefits include the potential loss of production from extension of rills and gullies, loss of topsoil (along with associated nutrients), decrease in soil infiltration and reduction in plant numbers, size and palatability. The pattern of losses illustrated in Diagram 1 suggests a gradual loss in grazing benefits. As with other sections there will be a strong effect from seasonal conditions. Also loss of benefits may follow a stepped pattern caused by particular weather events. For example, large falls from high intensity storms can cause considerable erosion damage on suseptible land.

4.3 Perspective on the Level and Pattern of Benefits

This section aims to put the above framework into figures **so that a perspective can be gained on the relative importance of each section.** Only a limited range of scenarios can be illustrated here. The examples used have been chosen so that the differences between scenarios are readily apparent and more easily interpreted. If low benefit levels were used then the difference between scenarios would be small and many of the IRR's would be negative. Readers will need to spend some time analysing and comparing Tables 1 - 5 to gain an appreciation of the data.

All examples are based on reclamation costing \$1000. The first example demonstrates the effect on profitability of the life of the grazing benefit and the level of peak grazing benefit. The benefit flow pattern in this example implies the existence of section B only (ie peak benefits from year 1 for a discreet number of years). The range of example peak benefit levels is \$100 - \$200 per year which is equivalent to an annual return of 10 - 20 %. These levels are higher than might be expected if feed value is of "average" value rather than if it is exploited in high value uses (see section 3.4).

Table 1: Internal rates of return for investment in reclamation for a range of benefit lives and benefit levels

Level of Peak Grazing Benefit	Benefit Life (years) 3	5	10	15	20	25	100+
				%			
$100	***	-19.40	0.00	5.56	7.75	8.78	10.00
$150	-31.34	-8.88	8.14	12.40	13.89	14.49	15.00
$200	-21.76	0.00	15.10	18.42	19.43	19.78	20.00

Note: (1) *** denotes a large negative number.

The lower benefit level (annual benefit at 10% of capital cost) requires a 10 year life just to cover costs and for any benefit life returns can not be regarded as attractive. The highest benefit level provides attractive returns for peak benefits lives of 10 years or more while the medium benefit level provides attractive returns for peak benefit lives of 15 years or more.

It should be noted that "ball park" figures for ponding generally give a peak benefit below the lowest yield scenario above, based on "average value" feed. Opposed disc pitting might produce a peak benefit marginally above the lowest yield scenario (based on "average value" feed and before allowance for the livestock capital required to take advantage of the extra feed) but in many situations the life of pits has been relatively short. This observation is based on full costs being incurred at the time of construction, average feed value, and no benefit being derived from tax deductions. Taking these factors into consideration would boost rates of return in many instances.

In real life the benefits of reclamation works are not immediate. There will be a period when the areas reclaimed must be destocked to allow sown pasture species to establish and set seed. If the soil is degraded then grazing benefits will generally increase over a period of years as soil condition improves (assuming that the reclamation is successful).

Table 2 shows the internal rates of return for a number of phase-in scenarios while Table 3 shows internal rates of return for an example 3 year phase-in scenario following periods of 0 - 3 years in which there is no grazing.

Table 2: Internal rates of return for investment in reclamation for a range of benefit lives and phase-in scenarios

Years to Reach Peak Grazing Benefit	Benefit Life (years) 3	5	10	15	20	25
	%					
0	-31.34	-8.88	8.14	12.40	13.89	14.49
2	***	-11.15	6.66	11.19	12.80	13.47
3	***	-13.48	5.33	10.14	11.87	12.61
5	***	-18.86	2.94	8.36	10.34	11.21
10	***	***	-1.04	5.78	8.24	9.34

Note: (1) Peak grazing benefit is $150 per $1 000 invested ie the intermediate peak benefit level from Table 1.
(2) Benefit is phased in linearly over the period of years stated in the left column.
(3) *** denotes a large negative number.

Table 3: Internal rates of return for investment in reclamation for a range of benefit lives and a three year phase-in period following a range of periods during which no grazing is permitted

Years of Nil Grazing Benefit	Benefit Life (years) 3	5	10	15	20	25
	%					
0	***	-13.48	5.33	10.14	11.87	12.61
1	***	-18.16	2.90	8.27	10.25	11.12
2	***	***	0.71	6.69	8.92	9.92
3	***	***	-1.40	5.30	7.79	8.91

Note: (1) Peak grazing benefit is $150 per $1 000 invested ie the intermediate peak benefit level from Table 1.
(2) Phase-in of benefits is over 3 years ie the third line in Table 2.
(3) *** denotes a large negative number.

Tables 2 and 3 show that the length of the period that grazing must be excluded and the pattern of benefits during the phase-in period are important factors in the profitability of reclamation works. Long periods of grazing withdrawal and protracted slow increases in grazing benefits (given a particular level of peak benefits) dramatically decrease the profitability of reclamation works relative to a scenario of immediate peak benefits. Alternatively, much higher peak benefits are required to offset the effect of excluding cattle for the first year or two, and the gradual build up in feed production over a number of years.

The importance of benefits in the early years of any investment is due to the effect of "discounting" or time preference for money. This stems from the use of interest rates or rates of return to capital which imply that the value of a given benefit decreases with time (ie the value of $100 in 10 years time is worth much less than $100 in 2 years time). Consequently benefits early in a project's life are worth more than the same level of benefit later in the project life.

While some reclamation methods (eg ponding) can produce an indefinite stream of benefits with proper maintenance, other reclamation technologies typically have a limited life with the level of benefits produced going into a downward trend after some period of time. Table 4 shows the effect on internal rate of return of three scenarios for the phasing out of benefits given a twenty year time horizon and an example phase-in and peak benefit scenario.

Table 4: Internal rates of return for investment in reclamation for a 20 year life and three grazing benefit phase-out scenarios

	Internal Rate of Return
Phase-out Scenario	%
No Phase-out	10.25
Phase-out over 5 years	9.24
Phase-out over 10 years	7.74

Note: (1) Peak grazing benefit is $150 per $1 000 invested ie the intermediate peak benefit level from Table 1.
(2) Phase-in of benefits is over 3 years after one year without grazing ie the second line in Table 3.
(3) Benefits are limited to a 20 year time horizon for valid comparison. A longer phase-out period therefore implies a short period of peak benefit.

The pattern of the phase-out of benefits has a significant effect on the profitability of reclamation but is less important than patterns of similar magnitude during the build up phase. The longer the benefit life the less important is the pattern of benefit phase-out due to the effect of discounting (as discussed above). It is possible that in some circumstances the phase-out period will be considerably longer than the 5 and 10 year periods examined in Table 4. An example is where reclamation results in the re-introduction of favoured pasture species to an area outside the cultivated area.

The potential losses which might occur if reclamation is not undertaken is one of the less obvious and more difficult to measure benefits. Losses might occur from loss of perennial or palatable plant species, the enlargement of scalds, the loss of top soil, the encroachment of rill or gully erosion, etc. Rough figures indicate that for opposed disc pitting, a potential peak loss of 3 adult equivalents of grazing per square kilometre is in the order of 75 - 100 per cent of the peak grazing benefit (based on pasture production from opposed disc pitting estimated at 300 - 400 kg dry weight/ha). Table 5 shows internal rates of return for a range of potential loss savings in conjunction with an example reclamation benefit scenario.

Table 5: Internal rates of return for investment in reclamation for a range of potential loss savings in conjunction with an example grazing benefit scenario

Potential Loss Savings as a Percentage of Peak Benefit	Number of years to phase in Potential Loss Savings 10	20
	%	%
0	9.24	9.24
25	11.75	10.80
50	13.88	12.17
100	17.44	14.51

Note: (1) Peak grazing benefit is $150 per $1 000 invested ie the intermediate peak benefit level from Table 1.
(2) Phase-in of benefits is over 3 years after one year without grazing ie the second line in Table 2.
(3) Phase-out of benefits is over 5 years
(4) Time horizon considered is 20 years.

Table 5 indicates the potential importance of reclamation work preventing decline in range productivity. Such benefits are greatest where range productivity via reclamation works is high but the potential for increasing productivity may be reduced accordingly. The faster the rate at which pasture production and quality decline without reclamation treatment the better the profitability.

4.4 The Importance of Increasing the Unit Value of Feed

The key to the profitable application of reclamation technologies in Central Australia, and probably other pastoral beef areas, is to construct reclamation works where they will produce feed with a high unit value and to use that feed for high value applications. Selection of sites which will yield a high level of feed production is still quite important but secondary.

Local economic studies and practical experience suggests that the value of reclamation works, in Central Australia, is in producing green feed at times when the rest of the property is short of green feed. If pits, furrows and ponds only increased the amount of feed produced on a property, and feed was produced at the same time as feed elsewhere on the property then they would produce relatively low returns to capital invested. The following example demonstrates the marginal nature of pitting and ponding based on producing feed of "average value".

Ponding:

Cost of construction and seeding = $150 - $250/bank
Area per pond = 0.5 ha
Pasture production per pond = 2 000 kg/hectare
Utilization rate = 30%
Dry feed intake per adult equivalent (AE) = 3 285 kg
Area per AE = 5.475 ha/AE
Livestock Capital per AE = $ 200/AE
Total Capital per AE = $1 841 - $2 938
Gross Margin per AE = $60
Annual Return to Capital = 2.04% - 3.25%
(at full development)

Opposed Disc Pitting with purchased seed:

Cost of pitting and seeding = $22.60/hectare
Distance between pits = 6 m
Pasture production per ha = 300 - 400 kg/ha
Utilization rate = 30%
Dry feed intake per adult equivalent (AE) = 3 285 kg
Area per AE = 27.37 - 36.50 ha/AE
Livestock Capital per AE = $200/AE
Total Capital per AE = $818 - $1 025
Gross Margin per AE = $60
Annual Return to Capital = 5.85% - 7.33%
(at peak benefit)

Opposed Disc Pitting with own seed:

Cost of pitting and seeding = $ 16.60/hectare
Distance between pits = 6 m
Pasture production per ha = 300 - 400 kg/ha
Utilization rate = 30%
Dry feed intake per adult equivalent (AE) = 3 285 kg
Area per AE = 27.33 - 36.50 ha/AE
Livestock Capital per AE = $ 200/AE
Total Capital per AE = $ 654 - $806
Gross Margin per AE = $ 60
Annual Return to Capital = 7.44% - 9.17%
(at peak benefit)

The above figures represent the upper bounds for profitability as they are the annual returns to capital at peak benefit (note that the annual returns to capital for these scenarios are below the figures used in section 4.3).

The annual return to capital at peak benefit is equal to the internal rate of return only if benefit levels peak in the first year and continue indefinitely. The period taken to reach full production reduces the internal rate of return for both pitting and ponding relative to the annual return to capital (at peak benefit). The limited life of pits and their increased risk of failure further reduces their profitability. Taking all these factors into consideration, pitting and ponding are marginal investments for cattle enterprises in Central Australia if costs are based on the full ownership cost (up front) or hire of machinery, no account is taken of tax effects and feed is based on average unit values. The effect of variation in timing and the method of calculation of machinery costs, and the effect of taxation benefits are discussed later in this report.

Assuming feed is of average value suggests that it has a similar pattern of production and similar nutrition to other feed produced on a property. In fact, the pattern of feed production and nutritional value of feed on reclamation works will often differ from that of untreated land. Pits, contour furrows and ponds collect and store runoff thus increasing the effective rainfall in their vicinity. They therefore have the ability to produce feed from isolated rainfall events and relatively light rainfall events which would otherwise have produced little or no feed.

Cattle can be fattened in such situations whereas otherwise they might have been losing weight or at best achieving only marginal weight gains. In dry times, reclamation could enable steers to be turned off as fats instead of stores. In a better run of seasons they might enable more consistent weight gains thereby enabling steers to reach Korean market or Jap Ox specifications. The following examples show the potential benefits of ponding if used for steer fattening or increasing steer growth rates.

Scenario 1: Steers fattened on ponded pasture during a dry period

Fat Steers (Alice Springs)	**400 kg liveweight @ 105c/kg = $420.00/hd**
Store Steers (Alice Springs)	**350 kg liveweight @ 85c/kg = $297.50/hd**
	Increase in livestock value = $122.50/hd
	Increase in freight and selling costs = $9.50/hd
	Gross Margin = $113.00/hd
	Interest cost $297.50/hd @ 12% p.a. for 3 months = $8.92/hd
	Net Margin = $104.08/hd
	Capital Cost of Ponding = $547/hd
	Return to Capital per Event = 19%

Note: It is assumed that a group of steers would have to be turned off in store condition without ponded pastures but could be fattened over a period of around three months. The fat steers are suitable for the US market. The store steers would be suitable for either fattening or slaughter for the US market. Steers graze for three months and have a feed intake equivalent to 1 AE.

The return per event would be reasonably attractive if it occurred every year but this scenario might apply only one year in four. The above return would have to be tempered with returns from other fattening scenarios or the returns based on average feed value (ie grazing mixed cattle year round).

Scenario 2: Steers supplemented on ponded pastures to boost growth rates so that Jap Ox specification can be reached by three years old

Jap Ox (Cloncurry) 550 kg liveweight @ 120c/kg = $660/hd (net of freight)

US Steer (Alice Springs) 400 kg liveweight @ 100c/kg = $400/hd

Increased handling costs (per year) = $20/hd turned off

Value of non-ponded feed released = $75/hd turned off

Gross Margin = $315/hd turned off

Capital Cost of Ponding = $2 737.50/hd turned off

Annual Return to Capital = 11.5% (at full development)

Note: Feed intake per head is estimated to average 1 AE over two and one half year period from weaning. One half of this feed requirement is supplied by ponded pastures. Therefore, enough ponds to supply the equivalent of 1.25 AE of feed are required for the three age groups. An estimated 1.25 AE of feed from unponded country is made available which could generate an increase in gross margin of $60/AE. The increased cost of commission (assuming an agent is used) selling as Jap Ox should be offset by the average cost of trucking cattle to Alice Springs.

This level of return is mildly attractive based on the full hire cost of machinery and no tax benefits. Again the effects of owning your own machinery, timing of machinery costs and tax deductions might increase returns to an attractive level.

In a run of average years ponds could be used to finish steers, which might otherwise have been suitable for the US trade, so that they reach Korean market specification. An example of the returns from this scenario follows:

Scenario 3: Steers finished to meet Korean market specifications

Korean Steers (Cloncurry) 440 kg liveweight @ 110c/kg = $484/hd

US Steers (Alice Springs) 400 kg liveweight @ 100c/kg = $400/hd

Increase in livestock value = $84/hd

Decrease in freight and selling costs = $4/hd

Gross Margin = $88/hd

Interest cost for three months (@ 12% p.a.) = $12/hd

Net Margin = $76/hd

Capital Cost of Ponding = $547/hd

Annual Return to Capital = 13.9%

Note: The premium for Korean specification is variable depending on demand and supply conditions at the time of sale. Steers graze for three months and have a feed intake equivalent to 1 AE.

This scenario is also mildly attractive based on full hire cost and no tax benefits. Scenario 1 could probably be considered a dry season adjunct to this scenario. An alternative to scenario 3 would be if steers are available which reach Korean specification but could be fattened to Jap Ox specification using ponded pastures.

Scenario 4: Steers fattened to Jap Ox weight which would otherwise only be suitable for Korean grassfed trade

Jap Ox (Cloncurry) 550 kg liveweight @ 120c/kg = $660/hd (net of freight)

Korean Steer (Cloncurry) 510 kg liveweight @ 110c/kg = $561/hd

Increase in livestock value = $99/hd

Net increase in freight and selling costs = $7/hd

Gross Margin = $92/hd

Interest cost for three months (@ 12% p.a.) = $16.80/hd

Net Margin = $76/hd

Capital Cost of Ponding = $684.37/hd

Annual Return to Capital = 11%

Note: Prices for Korean specification steers are variable depending on demand and supply conditions at the time of sale. Steers graze for three months and have a feed intake equivalent to 1.25 AE.

The above scenarios indicate that given the assumptions used, the use of ponding for fattening purposes is mildly attractive. During dry years ponds can provide a greater return than average or above average years. This is a bonus as the extra cashflow is particularly useful in dry years.

If allowance is made for the lower cost of machinery already owned, the timing effect of costs for your own machinery and the value of tax deductions, then there is potential for ponds to be a quite attractive investment. The effect of tax deductions and using your own (rather than hiring) equipment are discussed later. In short these considerations can mean that the profitability can be more than double the levels indicated above (on the basis of annual return to capital at full development).

The above calculations rely on a number of assumptions relating to feed production, daily feed intake by cattle, percentage of feed eaten by cattle and daily liveweight gains. These are based on very limited data. **Given the potential profitability of ponding and other forms of reclamation it is important that more data is collected on these variables.** They all affect profitability and it is possible that profitability could be considerably higher than what has been indicated above. Given ongoing resource shortages, the use of automatic identification and weighing technology would be invaluable. This technology is supposedly nearing the stage of being feasible for research purposes.

4.5 Reclamation Versus Reduced Stocking to Restore Productivity

This review is mainly concerned with discussion of reclamation technologies and related aspects. During the course of drafting this review the view was expressed that an alternative to reclamation in some cases is the reduction of stocking rate. This may refer to partial or full destocking, ranging in time period from one or two years up to a permanent reduction (in the case of partial destocking in certain circumstances). The use of this option will depend on the ability of particular sites to recover under reduced grazing pressure. It is clear however that if this option is technically feasible it is a relatively cheap option. The removal of each adult equivalent of grazing pressure is estimated to cost 60 cents per hectare per year. In contrast the cost of opposed disc ploughing is estimated at $22.60 per hectare if seed is purchased and $16.60 per hectare if own seed is available. There is conflicting opinion among research scientists about the possible use of reduced stocking rate to reclaim land.

4.6 Fencing

The need to exclude grazing during establishment and to manage grazing to ensure longevity means that fencing will be an important aspect of any reclamation program.

Most station paddocks are quite large in comparison to the potential area that might be "reclaimed" annually. This poses a requirement for fencing or some form of grazing control. The strategy adopted will depend on future plans for reclamation and other development in the treatment and adjacent areas. Most properties have smaller paddocks (eg holding paddocks and trap paddocks) that would not need extra fencing. If suitable, these could be a first priority for treatment. Stations which periodically spell paddocks could use this time as an opportunity for reclamation treatment.

The cost of fencing small areas can be quite expensive in relation to the cost of reclamation treatment. For example, take an area on which 20 ponds are built. The ponds have an average area of 0.5 hectares giving a total ponded area of 10 hectares. The average catchment area per pond is 3 hectares giving a total area to be fenced of at least 70 hectares. At an average cost of $200 per pond, the total cost of pond construction would be $4 000. Approximately 3.4 km of fencing would be required to enclose the area. At an erected cost of $2 000 per kilometre, the total cost of fencing would be $6 800. This is more than one and a half times the cost of pond construction.

Fencing costs per square kilometre fall sharply as paddock size increases so treating large areas is more economical. Where subdivision is required, fencing costs can be reduced by taking advantage of existing fence lines. If a large paddock is to be progressively treated then cheaper temporary fences might suffice (eg a two wire electric fence).

From a management and economic viewpoint it is preferable to intensively treat one area at a time than to scatter small treatment areas around a property. The exception would be for treatment aimed at preventing further erosion, which logically must be located where the trouble spots are.

5. COSTING OF MACHINERY INPUTS

Machinery costs are the largest cost component for reclamation works, in most situations. There is considerable scope for variation between properties in the machinery cost components to consider, the level of costs and their timing. Scenarios in previous sections which have been used to calculate profitability have used machinery costs based on paying the full cost of ownership and incurring the total cost at the time of construction. For many properties using this basis will under estimate the profitability of reclamation works.

5.1 Components of Machinery Costs

An understanding of the components of machinery costs is necessary to estimate overall machinery costs and to understand the potential for variation in the cost between machines, and the difference in cost between ownership and contract hire.

The straight forward costs to estimate are fuel and labour. Fuel cost can be estimated from one's own experience or from a machines' power rating combined with its workload in a particular task. Labour costs should include not only the hourly rate but also on-costs such as holiday pay, sick pay, superannuation and workers compensation. These can add around 25 per cent to the base hourly rate. If owner or family labour is used then it should be considered that this labour could have been doing some other job which may have to be completed by paid labour. The cost of repairs and maintenance can be estimated on an average hourly basis but the level and its degree of uncertainty increase with age. Depreciation is the decline in the value of a machine with time and use. It can be estimated from the difference in value between machines, of different age and hours worked, that would have a similar replacement value. Depreciation can be averaged over the whole of the expected time that machine may be kept or calculated over shorter periods (eg annually).

Opportunity cost is the cost of having capital tied up in machinery. If a business is carrying debt then the opportunity cost is the amount of interest which would be saved if the machine were sold and the proceeds used to pay off debt. If a business has surplus cash reserves then the opportunity cost is the interest which would otherwise be earned by investing proceeds from the sale. In some cases it is appropriate to ignore opportunity cost as it can already be justified and covered by existing uses for a machine. For example, a decision to build an extra 100 ponding banks will not actually increase the opportunity cost of owning a bulldozer but in a notional sense the opportunity cost can be divided by a greater number of hours use. However, this will not translate in a cashflow difference which is important from an investment viewpoint.

5.2 Hire Versus Ownership

Budgets in previous sections have used the contract hire rate for machinery and implements. Hire costs are easily identified and generally represent the upper end of the cost scale likely to be encountered. Using this figure therefore applies the 'acid test' on profitability.

Contractors have to allow a component in their rates for profit and for their input in managing the people and machinery under their control. These costs may be as much of 25 per cent of the ownership costs detailed in the previous paragraph. In addition the cost of moving hire machinery to and from a property should be added to the hourly cost of hire.

The cost of using your own machinery may be considerably cheaper than a hire machine but this is not always the case. For example, a machine of moderate value may be more expensive than a hire machine if its annual usage is low. The higher the value of a machine, the more hours per year it must work to reduce overhead costs to a level where ownership is cheaper than contract hire. Older machines which work a small number of hours per year, may be more expensive than contract hire if repairs and maintenance costs are high.

5.3 Timing of Machinery Costs

The timing of machinery costs are an important aspect of the profitability of investing in reclamation. In some situations all costs will be up front but in others certain costs will not be incurred for some time. The delayed timing of some costs improves the internal rate of return that an investment generates. While it is important to estimate the full cost of operating a machine, it is also important to recognize when the money actually leaves your bank account.

If a contractor or hire machinery is used, then machinery costs are up front. If machinery is already owned then certain costs will be up front while others will be incurred further down the track. Costs of fuel and labour are up front while the timing of repairs and maintenance costs will be spread out and occur from the time of machinery use. Except in a notional sense depreciation is not actually incurred until a machine is sold and this may be many years for a station machine. Opportunity cost is incurred on a regular basis but is independent of machinery use.

5.4 Capital Costs/Machinery Purchases

The previous few sections relate mainly to machinery costs on an hourly basis. While returns on investment based on hourly costs must be high enough to justify machinery use, any capital costs (eg machinery purchase) necessary to undertake a reclamation program must also be weighed up against the potential returns from the program as a whole (as well as any other work on and off the property). Large outlays for machinery purchase will require a large reclamation program and/or considerable other on or off-property work to justify that outlay.

6. TAX DEDUCTIONS AND THEIR EFFECT ON PROFITABILITY

Taxation deductions can have a marked effect on the profitability of reclamation but the benefits will vary greatly depending on the tax situation of the individual taxpayers involved. Scenarios in previous sections have calculated the profitability without taking tax benefits into consideration. Most pastoralists, however, will be in a situation either now or in the future to take advantage of tax concessions for reclamation work.

Expenditure on the construction of reclamation works for the purpose of preventing or repairing land degradation is 100% deductible under Section 75D of the Income Tax Assessment Act. Recommendations elsewhere in this report for reclamation on productive land would not fall under Section 75D unless the work could be classified as being for the prevention of degradation. Even without Section 75D, however, most reclamation expenditure would be deductible if the station's own machinery were used (eg via deductions for fuel, labour, depreciation, repairs and maintenance, interest on loans etc).

The importance of tax deductibility is that it is available for what is essentially (in productive applications at least) an investment. This is something akin to being able to claim a deduction for money invested in term deposits! Comparison of the returns from reclamation then should allow for the tax deductions received.

The level of benefit received from tax deductions is largely influenced by the marginal tax rate faced by the investor. Marginal tax rates for individuals are currently as high as 47%. The marginal tax rate for companies has recently been reduced to 33%. Individuals may also face marginal tax rates of 20%, 34% and 43% at present. Some pastoralists may find themselves in the situation of paying no tax due to low or negative taxable incomes so will face a zero marginal tax rate. In such situations they will receive no immediate benefits from tax deductions but would receive benefits in the future via tax averaging or provision for the carry forward of losses.

It is not possible to say precisely what the effect of tax deductions will be on the internal rate of return (IRR) for reclamation investment as it depends on the investors tax situation, the level of IRR before tax deductions, and the time lapse between expenditure and the receipt of tax benefits. As an indication though, tax deductions for an individual on the highest current marginal tax rate (47%) could nearly double the IRR. Tax deductions for a company on the proposed company tax rate (33%) could increase IRR by up to 50%.

Often primary producers look for ways to spend money at the end of the financial year because they have a 'tax problem'. This often leads to the purchase of capital items which only provide tax relief via depreciation allowances and either interest or lease payments. It appears that reclamation work could provide a more effective remedy to 'tax problems' and at the same time a profitable investment.

7. GOVERNMENT'S ROLE IN PROMOTING RECLAMATION

In the past, at least, the level of government that deals with research, development and demonstration seemed to view reclamation technologies as technical solutions to certain types of land degradation. MacLeod and Johnston (1990) stated a similar view, viz. "Community and `scientific' attitudes to rangeland restoration seem, at face value, to reflect the normative issues of what ideally should be done, rather than the positive question of what could be reasonably expected of individuals or the community acting in their own self-interest."

This review has demonstrated that reclamation technologies have significant potential in Central Australia, particularly as a profitable investment for the pastoral industry. It follows then that the relevant government departments should act to foster the use and development of these technologies to achieve the this potential. This would require some changes in direction and new initiatives on the part of the government departments involved.

CCNT, DPIF and the Department of Lands, Housing and Local Government have an interest in the application of reclamation on pastoral land. At the time of writing their still appears to be some confusion over the role of the latter department in pastoral land matters but its role in relation to the productive application of reclamation technologies is likely to be limited. The focus of CCNT is obviously in the area of conservation while the focus of DPIF is toward productivity within the bounds of sustainable resource management practices. There are obvious difficulties in achieving the potential of reclamation technology as a profitable avenue for pastoral investment when all the construction work is undertaken by a conservation oriented department, albeit that resources available are now relatively meagre. This observation is not meant as an attack on the land conservation unit of CCNT but as a reflection of the consequences of different institutional objectives. The land conservation unit is a valuable group of people, is well respected by industry and continuing good relationships between the unit and DPIF are important.

DPIF's current roles in relation to reclamation technologies are currently limited to monitoring the pasture response of certain reclamation works which have been carried out by the department's predecessors, CCNT or pastoralists, and in advisory services which includes some recent initiatives in organizing ponding schools. There is a need for DPIF to consider where reclamation technology fits within its organisation and within its research and extension programs. Some recommendations for DPIF are included in Section 8.

The fact that most pitting sites have failed to produce profitable returns must raise some questions about continued use of this technology on sites where only a marginal response is likely. No doubt CCNT need to consider non-monetary benefits in some conservation work but where reclamation works are undertaken as demonstration of the technology to the pastoral industry they should not be attempted on sites where they are unlikely to produce a profitable response.

8. RECOMMENDED STRATEGY FOR DPIF/NT GOVERNMENT

In the course of this review a number of areas were highlighted which require input by DPIF or other NT government departments. These are listed below:

• Refocus industry's thinking on the application of reclamation technologies, particularly ponding, from rehabilitation and prevention of degradation only, to include its application as a profitable investment.

• Promote an awareness in industry that the most profitable role of reclamation works is producing green feed when green feed is otherwise scarce.

• Design and trial an implement to create long life pits/furrows which are effective for water harvesting and which suit Central Australian conditions.

• Conduct research trials or collect observational data on pasture growth, utilization, feed consumption rates and cattle growth rates on ponded pasture (including ponds built by a grader).

9. SUMMARY

Reclamation technology, as the name suggests, generally applies to practices which aim at restoring productivity to land which has been degraded. This definition is somewhat narrow and restricting. Reclamation technologies, particularly ponding and possibly some sort of 'long life' pitting or contour furrowing, also have application to productive land and in these situations will generally provide higher returns. Productive areas susceptible to degradation may fit this description and be a higher priority for treatment than those already degraded. The word 'reclamation' being applied to these technologies is rather restrictive and implies connotations about the technology's use which are counter productive. In this review the term reclamation technology is used loosely to include the use of these technologies for any pastoral application in which they might be profitable.

The difference between public and private benefits and costs in relation to reclamation needs greater recognition. This would lead to a more realistic assessment of what the pastoral industry might be expected to achieve. It would also provide a clearer picture on the role of government in demonstrating and encouraging the adoption of the technology on pastoral lands.

From a public and private viewpoint there needs to be a realisation that not all degraded land can or will be reclaimed. This may be due to the technical feasibility of reclamation, limits on available resources or low benefit/cost ratios. Current government policies on sustainable agriculture and landcare tend to encourage individuals and groups to undertake activities based on the profit incentives and moral values of those individuals involved. Government support is mainly targeted at research, development and extension. If much land can not or will not be rehabilitated then it is important to have a realistic picture of what is achievable from the public viewpoint as well as the private viewpoint.

The profitability of reclamation works is marginal if the feed produced has the same value as feed produced elsewhere on a property. If reclamation is undertaken on a significant area of a property then it has the ability to reduce variation in feed supply. Evaluation of this benefit is rather complex due to the number of variables involved and lack of data on how it would affect livestock numbers and productivity. The main economic benefits from reclamation works in Central Australia appear to be derived from providing a quantity of green feed at times when it is otherwise scarce. In such episodes reclamation can provide attractive returns, particularly from short term fattening. Estimated returns for ponding are up to 19% per episode based on full up front machinery costs and no tax benefits. The benefit from reclamation works in such situations is derived from the ability of reclamation works to intercept and store runoff water from adjacent areas (ie water harvesting). Any evaluation of reclamation or reassessment of the technology should work from this premise. These characteristics would provide the ability to fatten cattle in dry times and be beneficial in mitigating the effects of drought by increasing feed production in dry years.

Tax deductions are an important variable affecting the profitability of reclamation. Profitability is substantially increased for those pastoralists who face the higher marginal tax rates of 34, 43 or 47%. At the highest marginal tax rates the returns to capital may be nearly doubled by tax deductions for reclamation costs. Aspects relating to machinery costs (eg ownership versus hire, timing of costs) are also important to profitability but are relatively complex and depend on particulars of the situation involved.

There are a number of variables relating to pasture production and grazing performance on reclamation works which require research and observation to provide a clearer picture of profitability. Suggestions for future work by DPIF have been included in this review.

If correctly applied, the use of reclamation technology in productive situations has the potential to be one of the most profitable options for station development in Central Australia.

Noble, J.C., Cunningham, G.M. and Mulham, W.E., (1984), Rehabilitation of degraded land. In 'Management of Australia's Rangelands' (Eds G.N. Harrington, A.D. Wilson and M.D.Young), pp 171-76, CSIRO, Melbourne.

Penman, P.F., (1987), An economic evaluation of water ponding. Journal of Soil Conservation New South Wales, 43(2):68-72.

Pressland, A.J. and Graham, T.W.G., (1989), Approaches to the restoration of rangelands - the Queensland experience. Australian Rangeland Journal, 11(2):101-109.

Purvis, J.R., (1986), Nurture the Land: My Philosophies of pastoral land in Central Australia. Australian Rangeland Journal, 8(2):110-117.

Ralph, W., (1989), Water-ponding reclaims inland soils. Rural Research, 144(3):9-12.

Rhodes, D.W., (1987), Vegetation response and productivity improvements under waterponding. Journal of Soil Conservation New South Wales, 43(2):62-67.

Rhodes, D.W., (1987), Waterponding banks - design, layout and construction. Journal of Soil Conservation New South Wales, 43(2):80-83.

Rhodes, D.W., (1987), Changes in soil properties during scald reclamation by waterponding. Journal of Soil Conservation New South Wales, 43(2):84-90.

Sallaway, M.M., (1978), Range improvement, regeneration and erosion control by mechanical means in the Alice Springs district, Northern Territory. In Studies of the Australian Arid Zone Part III. Water in the Rangelands, CSIRO, Melbourne, pp 220 - 226.

Sullivan, S., (1991), Costs and benefits of waterponding for scald reclamation. Northern Territory Conservation Commission, Landcare Fact Sheet No. 14.

Sullivan, S., (1992), Waterponding for scald reclamation trial - parts 1 & 2. Northern Territory Conservation Commission.

Tatnell, W.A. and Beale, G.T., (1990), Contour furrowing technology for range cultivation and reseeding. Proceedings of the Sixth Rangelands Conference, Carnarvon, pp 246-257.

Vallentine, J.F., (1980), Range Developments and Improvements. Brigham Young University Press, Utah, pp 545.

10. BIBLIOGRAPHY

Anon, (1992), Income tax deductions for landcare related activities. Commonwealth Department of Primary Industries and Fisheries, Canberra, pp 18.

Bastin, G., Rangeland reclamation on Atartinga Station, Central Australia. Australian Journal of Soil and Water Conservation, 4(2):18-25.

Butler, P., (1990), Revegetating pastoral land. Department of Agriculture South Australia Fact Sheet FS 1/90.

Cunningham, G.M., (1987), Reclamation of scalded land in western New South Wales - a review. Journal of Soil Conservation New South Wales, 43(2):52-61.

Davidson, P., (1992), Rangeland rehabilitation. Pastoral Memo, 17(4):13-5.

Ford, G., (1991), Exclosure or spelling increases the success of buffel plantings and reclamation works. Alice Springs Rural Review, 21(2/3):2-3.

Harrington, G.N., Wilson, A.D. and Young, M.D. (eds), (1984), Management of Australia's Rangelands. CSIRO, Australia, pp 354.

Johnstone, C., (1992), An economic risk analysis of waterponding. Australian Journal of Soil and Water Conservation, 5(4):44-50.

Keetch, B. and Bastin, G., (1989), Land reclamation using ponding banks. Agnote No. 381. Department of Primary Industries and Fisheries Northern Territory.

Laidlaw, E. (1992), WA pastoral family is winning revegetation battle. Australian Farm Journal, July, pp 62-4.

Lindner, R.K., (1990), Should rangeland rehabilitation be paid for from the public purse? Australian Rangeland Journal, 12(2):61-6.

Ludwig, J.A., Hodgkinson, K.C. and Macadam, R.D., (1990), Principles, problems, and priorities for restoring degraded rangelands. Australian Rangeland Journal, 12(1):30-33.

Macleod, N.D. and Johnson, B.G., (1990), Principles for assessing the benefits and costs of rangeland restoration projects. Proceedings of the Sixth Australian Rangelands Conference, Carnarvon, pp 234-43.

Matheson, B., (1992) Water erosion in pastoral districts. Fact Sheet FS 14/92. Department of Agriculture South Australia.

Matheson, B., (1992) Wind erosion in pastoral districts. Fact Sheet FS 13/92. Department of Agriculture South Australia.