Chapter 9

Economic guide for on farm decisions

Key points

- Hostile subsoils cost the Australian grains industry $1.3 – 1.5 billion dollars per year in potential production forgone.
- Consider carefully the cost of amelioration against any yield benefits that may be obtained.
- In some cases the best option for maximising economic return is to 'live with the problem' by managing input, crop type and crop variety.

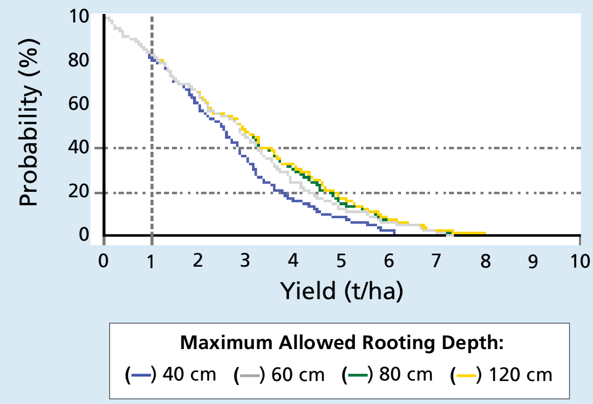

Figure 9.1: An assessment of the affect of different rooting depths on simulated grain yield of Yipti wheat growing on a Mallee clay loam at Birchip over the past 100 years.

Introduction

The economic cost to the Australian grains industry of subsoil constraints such as sodicity and transient salinity has been estimated on the basis of potential production foregone at $1.3 – 1.5 billion per year (Rengasamy 2002). The value of lost production due to boron toxicity alone has been suggested to be $620 million per year, although it was noted that this latter estimate could not be separated from the effects of sodicity (Rengasamy 2002).

The financial cost of a subsoil constraint to a farmer can be demonstrated using computer simulation. Several different scenarios were assessed using the computer simulation model Yield Prophet® for a typical Mallee clay loam soil. The approach underlying the simulation was based on the assumption that subsoil constraints limit the effective rooting depth of a crop and that the relative impact of this restricted rooting depth would vary season to season depending on both the amount and the distribution of rainfall during the season. The simulation assumed that nitrogen wasn't limiting and that the crop was sown on the 21st of May each year (regardless of soil water present). In the first scenario (see Figure 9.1) no subsoil constraint was present (ie. there were no soil restrictions on rooting depth). In the other scenarios increasing degrees of subsoil constraints were imposed by altering the maximum rooting depth. The affect of these subsoil constraints on the grain yield of wheat cultivar Yipti was simulated over the past 105 years using historical weather records for Birchip, Victoria.

For the modelling, subsoil constraints are expressed as reduced plant available water capacity of the soil (139 mm in the subsoil constraint soil, 195 mm in the no subsoil constraint soil) and a reduced rate at which plant roots can grow down the soil profile.

The impact of subsoil constraints on simulated yield were as much as 1.2 t/ha in some years and averaged 0.5 t/ha across all years with the largest impact occurring in average to good seasons ie. When most farmers have the potential to make their largest profits.

Farmers who crop on soils with subsoil constraints face a number of decisions; do nothing ('live with the problem'), attempt to ameliorate the subsoil or adjust farming practices to suit the environment (e.g. reduce inputs, or limit crop choice to tolerant crop types and varieties). There are a range of amelioration treatments available to overcome different subsoil constraints (see Chapter 8). Whilst ameliorating subsoil constraints can promise extensive gains in yields, the actual costs of implementing these treatments and the financial viability of the management strategy needs to be carefully considered. A range of factors other than subsoil constraints such as nutrient deficiency, rainfall or disease, can also limit the ability to achieve potential yields in Australian dryland cropping systems. Employing strategies to manage the limitations imposed by subsoil constraints will only result in increases in production to the point where yields are constrained by the next most limiting factor.

Amelioration Strategies and Costs

Prior to implementing a subsoil amelioration treatment, growers must ascertain the extent and likely severity of subsoil constraints. To do this, there is a need for targeted soil sampling and subsequent analysis ($100 per paddock). In addition, the use of rapid soil mapping procedures such as EM38 ($2 – $2.50 per ha) may also assist in assessing the proportion of a paddock that contains subsoil constraints. Subsoil constraints can vary markedly within a paddock and between paddocks so knowledge of the proportion of a designated paddock that is affected is critical when assessing the relative financial viability of a particular management option. This process is not cheap but the knowledge gained is essential in deciding subsequent strategies to manage the problem. Economic analyses needs to be conducted to take into account the many variables associated with applying a particular treatment. Variables that need to be considered include relative improvement in yield, proportion of paddock affected, types of crops grown, cost of ameliorant and its application including transport costs, residual effects, capital expenditure on equipment used to implement the treatment, additional fuel costs and the opportunity cost of alternative investment. The final strategy selected will in turn depend on both the capacity of the landholder to afford these costs and their particular attitudes to risk.

A sensitivity analysis of a range of amelioration strategies has been conducted (Table 9.1). The average cost of production for one hectare of wheat, assuming contract rates for sowing, fertilisers, purchase of herbicides and their application, and harvest, was $165/ha, based on 2004 input prices. The sensitivity analysis tables work on a break even price being equal to the average cost of production plus the cost of the amelioration strategy implemented.

A range of potential amelioration strategies were assessed:

1. Gypsum
2. Deep Ripping
3. Nutrient application at depth
4. Raised Beds
5. Organic Matter
6. Primer Crops & Variety Selection

1. Gypsum

High quality gypsum (7.5 t/ha) slotted at 40 cm is one practice used experimentally across south-eastern Australia. High quality gypsum has been priced at $15/t. The total cost of gypsum per ha equals $112.50 plus the operation of deep ripping $40/ha and cartage at $15/t. The total amelioration cost thus equals $265/ha. With an average production cost of $165/ha the total cost of production would be $430/ha including the gypsum application. The breakeven points for both wheat price and yield are highlighted in yellow below. If for example the current wheat price was $200 per tonne, the minimum yield required to achieve break-even point would be 2.5 tonnes/ha. The farmer then has to assess whether this yield is achievable in any particular season. Computer simulation models like Yield Prophet® can be used as a decision support tool in this process.

Table 9.1 Sensitivity Analysis - Gypsum

Yield (t/ha)	Wheat or Grain Price ($/tonne)					
	100	150	200	250	300	350
0.5	50	75	100	125	150	175
1.0	100	150	200	250	300	350
1.5	150	225	300	375	450	525
2.0	200	300	400	500	600	700
2.5	250	375	500	625	750	875
3.0	300	450	600	750	900	1050
3.5	350	525	700	875	1050	1225
4.0	400	600	800	1000	1200	1400
4.5	450	675	900	1125	1350	1575

2. Deep Ripping

The benefit of deep ripping on crop performance varies widely according to results reported in the scientific literature. Most studies indicate that deep ripping alone provides little or no long-term impact on the physical condition of clay subsoils. Recent research (Sadras *et al*, 2005) has recorded yield benefits from deep ripping on non-sodic sandy loam soils in the northern Mallee. On dispersive (sodic) soils, ripping is unlikely to have significant long-term beneficial effects unless the structure of the soil is simultaneously stabilised through amelioration with either calcium or organic matter. Recent advances in machinery, such as 'slotting' equipment to simultaneously introduce ameliorants at depth with ripping, could increase the effectiveness of this approach to managing subsoil constraints.

Total amelioration cost for deep ripping based on contract rates has been quoted at $40/ha (Sadras *et al*, 2005). With an average production cost of $165/ha the total cost of production equals $205/ha. The breakeven points for both wheat price and yield are highlighted in yellow below.

Table 9.2: Sensitivity Analysis – Deep Ripping

$350 / ha is a lot more than break even at $205/ha production cost

Yield (t/ha)	Price ($/tonne)					
	100	**150**	**200**	**250**	**300**	**350**
0.5	50	75	100	125	150	175
1	100	150	200	250	300	350
1.5	150	225	300	375	450	525
2	200	300	400	500	600	700
2.5	250	375	500	625	750	875
3	300	450	600	750	900	1050
3.5	350	525	700	875	1050	1225
4	400	600	800	1000	1200	1400
4.5	450	675	900	1125	1350	1575

3. Subsoil Nutrients Application

Nutrient deficiencies eg. phosphorus and nitrogen, are widespread throughout southern Australia. Substantial increases in crop yield have been reported by placing nutrients in the subsoil, even when seemingly adequate rates of fertilisers have been applied to the surface soil. Nutrients are usually placed 10 – 20 cm below the soil surface.

In a trial conduction at Stansbury on the Yorke Peninsula (South Australia), lupin grain was incorporated into the subsoil with deep ripping. The cost of this amelioration strategy was $450/ha (Wilhelm 2004). With an average production cost of $165/ha, the total cost of production equals $615/ha. The break even points for both wheat price and yield are highlighted in yellow below (Table 9.3).

Table 9.3 Sensitivity Analysis – Subsoil nutrient application

Yield (t/ha)	Price ($/tonne)					
	100	**150**	**200**	**250**	**300**	**350**
2	200	300	400	500	600	700
2.5	250	375	500	625	750	875
3	300	450	600	750	900	1050
3.5	350	525	700	875	1050	1225
4	400	600	800	1000	1200	1400
4.5	450	675	900	1125	1350	1575
5	500	750	1000	1250	1500	1750
5.5	550	825	1100	1375	1650	1925
6	600	900	1200	1500	1800	2100
6.5	650	975	1300	1625	1950	2275

4. Raised Beds

Research has shown that raised beds can reduce the effects of temporary waterlogging that can result from perched water tables overlaying poorly structured (sodic) clay subsoils, even in medium rainfall areas (450mm). The cost of forming raised beds including surveying, cultivation & deep ripping, bed formation & drain installation and based on a 3 year depreciation using contract rates is approximately $200/ha. With an average production cost of $165/ha the total cost of production equals $365/ha. The breakeven points for both wheat price and yield are highlighted in yellow below (Table 9.4).

Table 9.4 Sensitivity Analysis – Raised Beds

Yield (t/ha)	Price ($/tonne)					
	100	**150**	**200**	**250**	**300**	**350**
0.5	50	75	100	125	150	175
1	100	150	200	250	300	350
1.5	150	225	300	375	450	525
2	200	300	400	500	600	700
2.5	250	375	500	625	750	875
3	300	450	600	750	900	1050
3.5	350	525	700	875	1050	1225
4	400	600	800	1000	1200	1400
4.5	450	675	900	1125	1350	1575

5. Organic Matter

Organic matter can improve soil structure, resulting in enhanced infiltration of water and improvements in root growth. It has been applied as an amelioration strategy with mixed results.

Work conducted by Armstrong, *et al*. (2001) found that when a single surface application of composted pig bedding litter (derived from cereal straw at 20t fresh weight / ha) was applied to a highly sodic clay soil prone to water logging in the southern Wimmera it significantly improved dry matter production and grain yield of wheat and several subsequent crops by an average of 40%. However, in trials conducted at Birchip and Lubeck in the southern Mallee and Wimmera, commencing in 2004, organic matter was applied to the soil surface at the same rate (20t/ha) and produced no significant increase in grain yield or quality for any crop type during the first two years of the trial.

The cost of purchasing and spreading organic matter in the trials in Birchip and Lubeck was $140/ha. No transport costs have been included as they will be dependant on each individual proximity to a supply point. With an average production cost of $165/ha the total cost of production equals $305/ha (not including transport costs). The breakeven points for both wheat price and yield are highlighted in yellow below (Table 9.5).

Table 9.5 Sensitivity Analysis – Organic Matter

Yield (t/ha)	Price ($/tonne)					
	100	150	200	250	300	350
0.5	50	75	100	125	150	175
1	100	150	200	250	300	350
1.5	150	225	300	375	450	525
2	200	300	400	500	600	700
2.5	250	375	500	625	750	875
3	300	450	600	750	900	1050
3.5	350	525	700	875	1050	1225
4	400	600	800	1000	1200	1400
4.5	450	675	900	1125	1350	1575

6. Primer Crops & Variety Selection

Primer crops modify the soil and provide pathways for the roots of following crops. Possible species that may be grown as primer crops, depending on the particular subsoil constraint present, include chichory, lucerne and sulla. A key factor in the success of this strategy will be the financial return obtained during the primer crop phase (eg. grazing benefits) and the length of any residual benefit to subsequent crops. Growing a primer crop may have negative impacts on the performance of subsequent crops by removing water, nutrients etc.

The economic benefits of both primer crops and crop varieties selected will vary for each situation and each subsoil constraint. A case by case assessment should be made.

Case Study

'Glenalvon' Birchip

'Glenalvon' is a 7000ha property owned by the Barber family in the Kinnabulla district, 15 kilometres north-west of Birchip, Victoria. Purchased in the 1880's the property has over the years expanded in size and has supported five generations of the Barber family. Currently the property is managed by Lachlan Barber in partnership with his brother Andrew. Locals would describe the soil type as part of 'the Birchip Plain' (Figure 9.2).

Since Lachlan returned to the farm in 1990 the property has continued to support a mixed cropping enterprise as well as quite a substantial livestock (sheep) trading enterprise. The cropping program has consisted of predominantly cereals with canola and pulses incorporated into the rotation on more of an opportune and break-crop basis.

The long-term average annual rainfall for 'Glenalvon' is 350mm with an average Growing Season Rainfall (GSR) of 250mm.

In the mid to late 1990's Birchip experienced a few seasons of average to above average rainfall and despite employing best practice nutrition and disease management strategies, some paddocks on the property did not perform or reach what at that time Water Use Efficiency (WUE) calculations would suggest was their potential.

The perceived under-performance of these paddocks suggested to Lachlan and Andrew that something beyond their current management practices was affecting the performance of some crops in certain paddocks.

After this assessment a series of investigations took place. The first being a soil test. Lachlan and Andrew were keen to assess whether it may have been a soil characteristic responsible for poor crop performance. Results of the soil test are shown in Table 9.6.

The soil test results in Table 9.6 revealed that the paddock contained significant subsoil constraints (high boron (B), salinity and sodicity) at depths greater than 40 cm

Figure 9.2: Typical landscape of 'Glenalvon' – Quaternary aeolian and alluvial deposits (Photo: M Imhof).

Table 9.6 Chemical analysis of soil profile

Horizon	Horizon Depth	pH $CaCl_2$	EC dS/m	%ESP	NaCl %	Exchangeable Cations Ca	Mg	K	Na	Boron $CaCl_2$ mg/kg
						meq/100g				
A1	0-10	7.7	0.21	3.4		20	4.4	2.2	0.94	2.7
B21	10-25	8.4	0.63	3.5	0.09	20	4.8	2.7	1.0	8.2
B22k	25-40	8.7	1.5	32.3	0.26	11	16	2.3	14	34
B23	40-65	9.3	1.9	41.0	0.33	6.7	14	2.3	16	42
B24	65-105	8.8	1.7	43.5	0.3	5.5	11	1.7	14	33
B25	105+	9.1	1.8	41.5	0.3	5.7	11	1.6	13	

although the intensity of these constraints varied across the paddock (Figure 9.3). These soil properties are likely to severely restrict crop yields, especially that of pulses (as already observed) and including boron tolerant cultivars alone will not significantly improve yields.

Further research in the Birchip region highlighted that this issue of subsoil constraints was not isolated.

Management

As a result of these soil tests and a better understanding of the nature of the problem, Lachlan made a conscious decision to only grow boron tolerant varieties of cereals. Pulses have been almost dropped out of the rotation and canola is only used on a very opportune basis requiring a minimum of 50mm stored soil moisture and an opening rainfall occurring in April.

Recently Lachlan considered the viability of applying pig bedding litter (organic matter) as a potential ameliorant. The following calculations were made.

Extra costs per hectare

1. Cost of organic matter

   = 20t/ha at $4/t

   = $80/ha

2. Transport

   = $300/100kms for 25tonne (Travel to Birchip is 120kms)

   = $14.40/t (transport to Birchip)

   = $288/ha (travel cost/ha)

3. Spreading cost

   = $60/ha ($3/tonne – contract rate)

4. capital investment required to undertake amelioration process

   = $0 due to all operations being contracted out to professional spreader

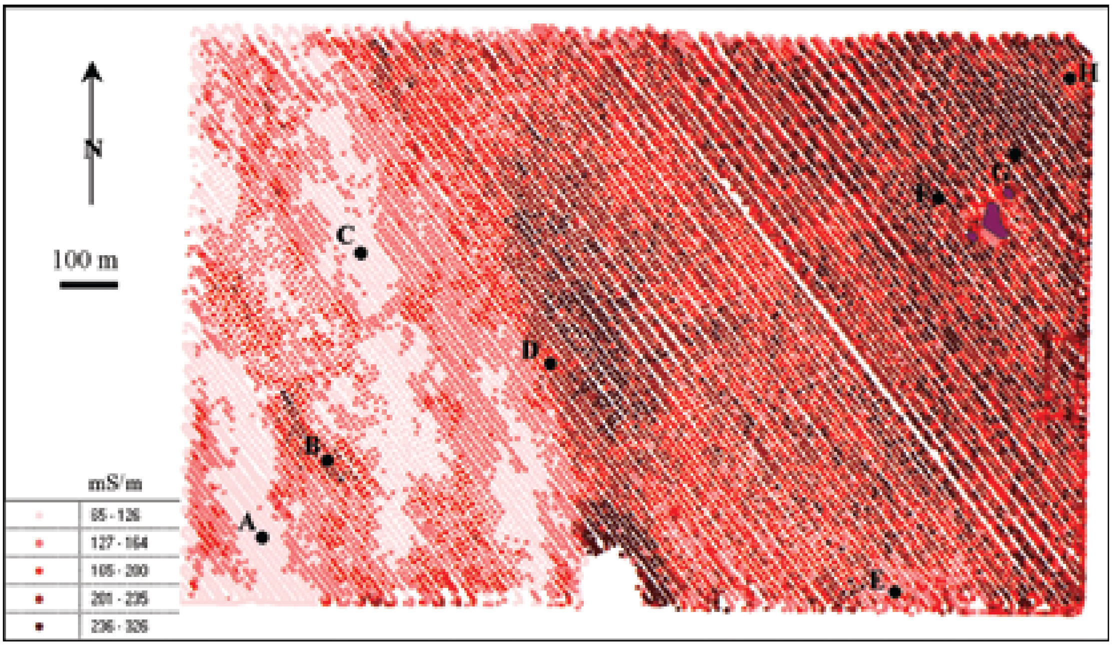

Figure 9.3: Horizontal EM 38 Survey at Barbers (Birchip). Source: J Nuttall.

5. opportunity cost of time and capital over 12 months (interest on $428/ha)
   =$21.40 (at 5%/annum)

Total extra cost $449.4/ha

Cost of growing crop $165

TOTAL EXPENDITURE = $614

Using the sensitivity analysis below Lachlan was able to work out some approximate break even points. The fact that from 2002 – 2008 average wheat yields at Birchip have only achieved 1t/ha, Lachlan now knows that a return from the application of organic matter is unlikely and is a high risk approach in low rainfall years.

Table 9.7: (repeat of above) Sensitivity Analysis – Organic Matter

Yield (t/ha)	Price ($/tonne)					
	100	**150**	**200**	**250**	**300**	**350**
0.5	50	75	100	125	150	175
1	100	150	200	250	300	350
1.5	150	225	300	375	450	525
2	200	300	400	500	600	700
2.5	250	375	500	625	750	875
3	300	450	600	750	900	1050
3.5	350	525	700	875	1050	1225
4	400	600	800	1000	1200	1400
4.5	450	675	900	1125	1350	1575

Conclusions

It appears that trying to ameliorate this subsoil for the current yield potential/likely return as increased grain yield would be a high risk option therefore the Barbers decided not to proceed. As such the decision was made to 'live with the problem'.

Research since the Barbers went through this process has revealed that it is only likely to obtain small responses to applied organic matter in 'average' seasons although there is the possibility of much larger responses in wet years.

Partial budgeting – an alternative approach

Partial budgeting is a common technique used to evaluate the cost-benefit of a particular practice change and can be readily used to assess the benefit or loss of a particular management strategy.

When assessing the economics of subsoil management strategies, it is important to reduce the options down to one or two realistic alternatives. Management strategy selection should be based on previous knowledge of the issue, soil analyses or characterisation, personal objectives for the affected land and the nature of the subsoil constraint (Makeham, 1993). A partial budget only shows the extra expenses and the extra revenue resulting from implementing the amelioration strategy, which when analysed, presents the options as either a benefit or cost.

The net profit or loss of a management strategy can be expressed as an annual percentage of the extra (or marginal) capital involved, giving a preliminary basis for comparing with other investments. Extra margin is achieved by an increased yield and/or improved grain quality achieved by implementing a particular amelioration strategy or by reducing costs. Table 9.6 provides farmers with a simple process to assess the benefit or cost of an amelioration strategy to overcome subsoil constraints.

Table 9.6 Partial Budgeting – Simple Analysis

Simple Analysis

GAINS	***COST***
Extra income - increased yield - improved grain quality - interest earned from capital released - ability to grow an alternative (higher value) crop due to amelioration - residual value in following crops due to improved soil structure (difficult to measure)	Extra costs - (including cost of gypsum, or other ameliorant) - capital investment required to undertake amelioration process - opportunity cost of time and capital
Reduced costs (if any)	*Reduced income* (if any)
TOTAL A	**TOTAL B**
Net gain measured (A-B)	Net loss (B-A)

Capital Requirements

If extra capital is involved in the amelioration process (eg purchase of a deep ripper; need for larger tractor), then extra costs include the opportunity costs of this extra capital, ie. the rate of return it could earn in another use. If capital is released then it could be that there is some scope to invest it in other ventures and earn interest on it (Makeham, 1993).

Labour

Permanent labour costs are not usually included in a partial budget unless extra permanent labour has to be employed or the opportunity cost of existing permanent labour is known (i.e. the value of the work it would otherwise be doing).

Interest rates

Interest rates will affect the cost of new capital and will also affect the opportunity cost of capital.

Residual value

Residual value of different treatments must be calculated. It is assumed that the 'first' crop after an amelioration treatment has the greatest impact on the relative economics with a sliding scale of benefit in proceeding years. Therefore growers could 'afford' to undertake more expensive treatments in areas with less risk eg. higher rainfall or higher average yields. In areas of higher risk (eg low rainfall areas), the cost of amelioration may never be recovered.

Other considerations

If amelioration allows other higher value crops to be grown (eg canola or lentil) this needs to be considered in the economic assessment.

Practical Economic Example – organic matter

Trials conducted at Birchip and Brimpaen in the southern Mallee and Wimmera of Victoria assessed a range of amelioration strategies. Practical economic examples of these treatments aimed to increase yields across a range of different crop types (canola, wheat and lentil).

Table 9.7 Partial Budgeting – Organic Matter Cost Birchip

GAINS	***COST***
Extra income - increased yield - improved grain quality - interest earned from capital released - ability to grow an alternative (higher value) crop due to amelioration - residual value in following crops due to improved soil structure (difficult to measure) (No significant increased yield or improved quality was achieved over any crop type during the first two years of the trial)	**Extra costs** Cost of organic matter = 20t/ha at $4/t = **$80/ha** Transport = $300/100kms for 25tonne (Travel to Birchip is 120kms) = $14.40/t (transport to Birchip) = **$288/ha** (travel cost/ha) Spreading cost = $60/ha ($3/tonne – contract rate) -capital investment required to undertake amelioration process = **$0** due to all operations being contracted out -opportunity cost of time and capital over 12 months (interest on $428/ha) =**$21.40** (at 5%/annum)
Reduced costs (if any)	Reduced income (if any)
TOTAL A $0	**TOTAL B = $449.4**
Net gain measured (A-B)	Net loss (B-A) - **$449.4**

Net loss of $449.4/ha

Over 100ha paddock = $42,940 total extra cost

For no return achieved the extra investment into an amelioration strategy in this particular example was not worth the investment.

Table 9.8 Partial Budgeting – Organic Matter Cost Brimpaen

GAINS	***COST***
Extra income - increased yield equals1.7t/ha - improved grain quality - interest earned from capital released - ability to grow an alternative (higher value) crop due to amelioration - residual value in following crops due to improved soil structure (difficult to measure) (No significant increased yield or improved quality was achieved over any crop type during the first two years of the trial)	**Extra costs** Cost of organic matter = 20t/ha at $4/t = **$80/ha** Transport = $300/100kms for 25tonne (Travel to Brimpaen is 10kms) = **$24/ha** (travel cost/ha) Spreading cost = **$60/ha** ($3/tonne – contract rate) - capital investment required to undertake amelioration process = **$0** due to all operations being contracted out - opportunity cost of time and capital over 12 months (interest on $164/ha) = **$8.20** (at 5%/annum)
Reduced costs (if any)	Reduced income (if any)
TOTAL A $340.00	**TOTAL B = $172.20**
Net gain measured (A-B) **$167.80**	Net loss (B-A)

Net gain of $167.80/ha assuming a wheat price of $200/tonne

Similar analyses can be carried out for other amelioration strategies.

Organic matter

The organic matter was applied to the soil surface at 20t/ha. The organic matter was sourced as pig bedding litter from QAF Meats Pty Ltd at Gre Gre Victoria. Costs used in this example are real figures obtained from QAF Meats Pty Ltd.

Summary

Economics should be the overall deciding factor as to whether an amelioration strategy is implemented or not. The final strategy selected will in turn depend on both the capacity of the landholder to afford these costs and their particular attitudes to risk.

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