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Appendix A Dryland Salinity and its Effects on Agriculture

Salinity is a widespread environmental problem in south west Victoria. There is considerable evidence that secondary (human induced) salinity has been caused by the clearing of original vegetation (i.e. trees, shrubs and native grasses) and its replacement by pastures and crops that generally use less water. This has lead to rises in watertables and increased mobility of salts present in the soil. As salts come closer to the surface in the lower parts of the landscape they inhibit plant growth not adapted to saline conditions. Saline land is then vulnerable to invasion by weed species and erosion as soil structure is destroyed. In short, salinity greatly reduces the options of what can be done on affected land.

Discharge is the process by which water seeps or flows past a given point. In a salinity context, a discharge area is one where there is upward movement of groundwater that discharges at the soil surface. The discharge water is generally saline and when combined with evaporation leads to the accumulation of salts on the ground surface. While discharge areas are normally located in the lower parts of the landscape, they can occur midslope or as springs. A diagram depicting the salinity process and the water balance equation is illustrated in Figure A.1 and equation A.1 respectively.

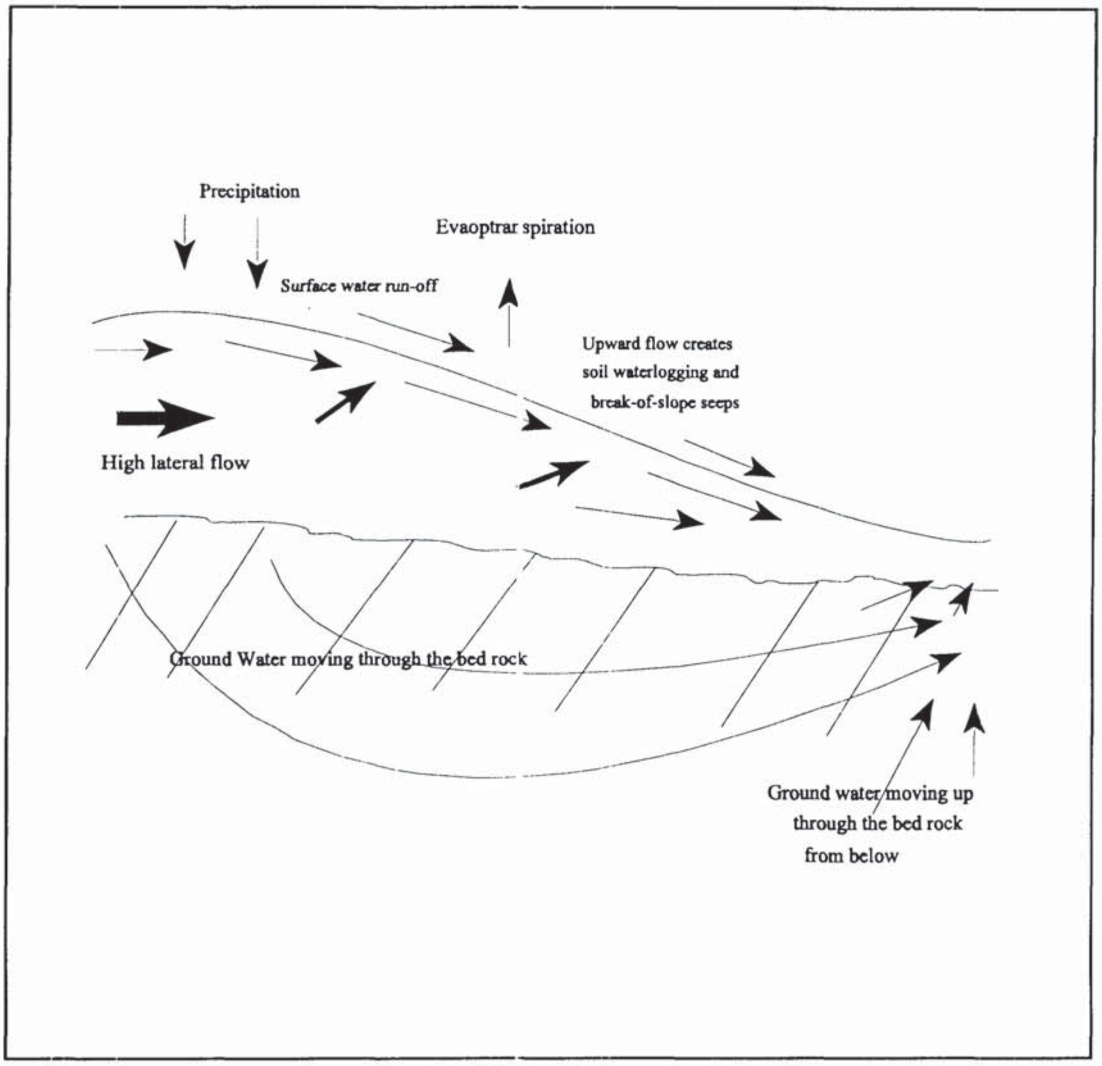

Figure A.1 Diagram illustrating the salinity process

A simplified water balance equation depicting the salinity process illustrated in Figure A.1, is given in equation A.1.

$$P + Ro = Et + RO + S + Di \qquad (A.1)$$

where: P = precipitation

Et = Evapotranspiration (from recent rainfall and shallow groundwater)

Ro = Run on / RO = Run off

S = Change in groundwater storage

Di = Deep infiltration

Appendix B: Guide to the use of Saline Water

Table A.1 Guide to the Use of Saline Water

Measurement

Salinity can be measured in a variety of ways. The most common method is the use of a conductivity meter to measure the capacity of a water sample to conduct electricity. The current passing through the water sample is proportional to its salinity. Results from this method are expressed in EC units. An EC unit is 1 microsiemen/centimetre.

Another way of measuring salinity involves evaporating the water sample and weighing the residual salt. Results from this method are expressed in milligrams/litre or parts per million (ppm).

1 mg/L unit is approximately equivalent to 1.6 EC.

EC Units	**Potential Uses**
0 - 800	• Good drinking water for humans (providing other aspects of water quality are suitable). • Generally good for irrigation though above 300 EC some care must be taken particularly with overhead sprinklers which may cause leaf scorch on some salt sensitive plants. • Suitable for all livestock.
800 - 2,500	• Can be consumed by humans, though most would prefer water in the lower half of this range if available. • When used for irrigation requires special management including suitable soils, good drainage and consideration of salt tolerance of plants. • Suitable for all livestock
2,500 - 10,000	• Not recommended for human consumption although water up to 3000 EC could be drunk if nothing else was available. • Not normally suitable for irrigation although water up to 6,000 EC can be used on very salt tolerant crop with special management techniques. • Suitable for most livestock although poultry and pigs are limited to about 6000 EC.

Over 10,000	• Not suitable for human consumption or irrigation. • Not suitable for poultry, pigs or any lactating animals but beef cattle can use water up to 17,000 EC and adult sheep on dry feed can tolerate 23,00 EC providing other aspects os water quality are suitable. • Water up to 50,000 EC (the salinity of the sea) can be used to flush toilets (if corrosion can be controlled) and to make concrete providing any reinforcement is well-covered.

Appendix C: Physical Information on the Gerengamete Catchment

Soils of the Gerangamete Area

The Barongarook and Deepdene land systems (Pitt, 1981) relate to the study region. Deeply weathered soils are often found above the Tertiary clays, and are associated with laterized remnants in the higher parts of the landscape. Ironstone in the profile is concentrated in discontinuous layers at about 1.2 meters depth (Heislers, 1997).

The southern (or upper) portion of the sub-catchment is characterized by the Barongarook Land System. Mottled yellow and red gradational soils predominate on the upper slopes and crests, with moderate to high permeability recorded. On the mid to lower slopes the clayey sub-soil becomes more defined and results in lower permeability. Soil depth exceeds 2 meters.

The Deepdene Land System in the lower catchment is characterized by mottled yellow and red duplex soils on the broad slopes, with grey gradational soils occurring along drainage lines. Permeability is regarded as only low to moderate, and soil depth exceeds 2 meters.

Soils in the Sub-Catchment

Gradational to uniform soils typically persist throughout the Gerangamete sub-catchment, with a distinct bleached A2 horizon developed on a relatively poorly permeable clayey subsoil. The predominate Northcote classifications are Gn3.04 and Uf. The equivalent Australian Soil Classification is a brown or grey Dermosol (Heislers, 1997).

The gradational soils are typified by a gradual increase in clay and pH with depth. The profile is not calcareous, but tends to be characterized by either a smooth or rough ped fabric. The A2 is large, with a rough fabric, and tends to be conspicuously bleached.

Where the bleached layer is present it extends to a depth of 40 to 70 cm before hitting more clayey subsoil. Where soils are more uniform (i.e. clay content is consistent throughout the profile) the A2 tends to disappear. Seasonal cracking may or may not occur. In low lying and waterlogged ground near the stream gauging station an alkaline Ug 5.16 was intersected (or a grey Vertosol). This is represented by uniform, finely textured soils showing seasonal cracking behaviour. Poorly drained mottled clays lay beneath (Heislers, 1997).

Regional Geology

The Gerangamete Flats area is nestled in a down faulted block (or graben) between the north-east trending Barwon and Bambra faults. The upthrown blocks to the north-west and south-east are composed of resistant sandstones of the Cretaceous Otway Group.

Within the graben 10-20 meters of partially cemented sand silts and clays of Moorabool Viaduct Formation that overlies 50-100 meters of fine grained limestone (or marl) within Gellibrand Marl. This in turn rests on early Tertiary Nirranda Group and Dilwyn Formation, the latter an important aquifer exploited for emergency and domestic water supply. Cretaceous basement rock underlies the whole area (Heislers, 1997).

Hydrogeology

Groundwater recharge does not occur uniformly across the catchment. The rate of recharge is heavily influenced by topography, the depth, permeability and moisture storage characteristics of soils, the nature of vegetation cover, and by the capacity and rate of water movement through aquifiers. For this reason, an understanding of the behaviour of groundwater systems on a large-scale is needed as the basis for the reliable long-term planning for salinity control. This requires information on how systems are recharged from the surface, the systems response to recharge events and the likely pattern of discharge in the future.

Land can be subdivided on the basis of the type of groundwater flow system - local or regional. In local systems, groundwater flows are largely governed by topography with recharge occurring on the higher ground and discharge on nearby low ground. In such areas salinity control can generally be achieved quickly, because of their size and particularly the closeness of the recharge and discharge areas. In regional flow systems, the groundwater occurs in unconfined aquifers where there is a relatively free movement of groundwater. Discharge and the associated salinisation generally occurs in low-lying depressions where the regional water table intersects the surface. It is difficult to target salinity control methods for regional groundwater systems and in addition the systems are slow to respond treatment.

With the Moorabool Viaduct Formation and/or Gellibrand Marl being comprised of fine grained sediments, aquifer permeability is considered to be low resulting in sluggish groundwater movement. Groundwater systems are predominately local in nature, with groundwater recharge being significant across the landscape as a whole. Groundwater levels, though dependent upon topography, are generally within 3-4 meters, even beneath moderately elevated crests. There is significant evidence of underlying long term rises in groundwater levels. Groundwater salinity generally varies between 2,000 and 9,000 EC, often , but not always, increasing down-slope (Heislers, 1997).

Inspection of groundwater hydrographs within the sub-catchment suggests that aquifer permeability generally decreases with depth, perhaps in line with the transition of variable and the slightly coarser Moorabool Viaduct Formation (or equivalent), to the finer silts and clays of the Gellibrand Marl. This is evidenced by the dampened seasonal fluctuations in many of the deeper piezometers, as well as relatively significant vertical gradient magnitudes (Heislers, 1997).

Appendix D Discounting

Discounting provides a method through which economic logic can be extended to consider intertemporal resource allocation (Doll and Orazem, 1984). The basic premise of discounting is that a dollar received now does not necessarily have the same value to a person as a dollar received a year from now.

Different projects have different distributions of benefits and costs and different time horizons. A reference is therefore needed to compare projects that have different values occurring at different times. Discounting is a technique that future cash flows of a project to their present worth (Kirby and Blyth, 1987). The formula for calculating the present value is represented in equation A.2.

$$PV = F/(1+i)^n \qquad \text{(A.2)}$$

Where: *PV* denotes the present value; *F* denotes future lump sum; *n* denotes years in the future; *i* denotes the discount rate.

The discount rate used is the market rate of interest or the interest earned on the next most profitable investment (i.e. its the opportunity cost of capital). Table A.2 illustrates the PV of $100 discount at various rates and project durations.

One of the concerns of conservationists is that positive discounting of the future encourages more rapid exploitation of natural resources Table A.2 shows that higher discount rates tend to mean more rapid exhaustion of an exhaustible resource. It also illustrates why investment companies are reluctant to invest in long-term projects, especially where the initial costs are largely borne in the first few years (Barbier *et al.*, 1990). .

Table A.2: Effect of discount rate and project life on PV

Years	Discount Rate (%)		
	4	7	10
1	100	100	100
10	70	54	42
15	58	39	26
25	39	20	10
35	26	10	4

Net Present Value

The net present value (NPV) of an investment is used to determine if a current expenditure should be made to earn a future income flow (Doll and Orazem, 1984). The NPV is defined as the sum difference of discounted present values of the future incomes and costs of an investment or plan (Makeham and Malcom, 1993). A project's NPV is defined in equation A.3.

$$NPV = \sum_{t=0}^{T} \frac{b_t - c_t}{(1+i)^t} \qquad (A.3)$$

(Randall, 1987, p248)

Where n = the life span of the investment.

b_t = the benefits accruing ir year t.

c_t = the benefits accruing in year t.

i = the discount rate.

T = the last year in which the project influences the productivity of its environment.

The criterion is that any project with NPV > 0 is acceptable. The optimal package of projects is that with the NPV >0. NPV cannot be used to rank projects in order of priority when capital is limited. As NPV provides no direct information about the capital requirements of projects, ranking projects according to the magnitude of NPV would be misleading (Randall, 1987).

Benefit Cost Ratio (BCR) The BCR as the name implies is simply the ratio of NPV of benefits to NPV od costs as illustrated in equation A.4.

$$\frac{B}{C} = \frac{\sum_{t=0}^{T} \frac{b_t}{(1+i)^t}}{\sum_{t=0}^{T} \frac{c_t}{(1+i)^t}} \qquad (A.4)$$

(Randall, 1987, p248)

The criterion is that projects with a $B/C \geq 1.0$ are generally accepted. For projects in a capital constrained environment, a ranking by magnitude of the B/C ratio is never strictly valid, because B/C is a ratio of average benefits to average costs (Randall, 1987).

Internal Rate of Return (IRR) The IRR is the discount rate, Å, at which NPV is zero. This is represented in formula A.5.

$$0 = \sum_{t=0}^{T} \frac{b_t - c_t}{(1+\rho)^t} \qquad (A.5)$$

(Randall, 1987, p249)

Projects with Å > r are acceptable. 'With a limited budget, the optimal package of projects is the one that has the largest Å > r for the whole package' (Randall, 1987, p249).

Appendix E Inflation

When projecting current values for costs and receipts forwards, it is assumed that the current relationships between product returns and costs remain the same in the future years as they are now (Makeham and Malcom, 1993).

The relationship between nominal and real discount rate can be expressed as follows:

$$N = r + f + rf \qquad \text{(A.6)}$$

That is

$$r = (N - f) / (1 + f) \qquad \text{(A.7)}$$

Where: N = nominal rate of interest
r = real rate of interest
f = rate of price inflation

The nominal rate (N) is the current market rate which has an allowance for the expected inflation component. The real rate on the otherhand has that inflation component removed. That is, it represents real gain over time after inflation (f) has been removed.

For example:

If $N = 14\%$ and $f = 8\%$, then r = (0.14-0.08)/(1+0.08) = 0.055 or 5.5%

Usually the discount rate is taken to be the "real" rate of interest (i.e. excluding inflation).

Appendix F Pasture Establishment and Maintenance Costing for the Gerangamete Catchm:nt

				$/ha
ESTABLISHMENT COSTS				
SEED		**kg/ha**	**$/kg**	
Phalaris		4	5.5	22
Sub clover		0	2	20
FERTILISER		**kg/ha**	**$/tonne**	
Single Super		1:0	200	30
CHEMICALS		**$/l**	**l/ha**	
Glyphosate		13 5	0.5	6.75
Glyphosate		13 5	2	27
Dicamba		18	0.2	3.6
RLEM control & wetter				5
Toad rush control		19	0.4	7.6
MACHINERY		**no. tin es**	**$/ha**	
Sowing		1	30	30
Spraying		3	10	30
LABOUR		**$/hr**	**ha/hr**	
Sowing		12	3	4
Spraying	3 times	12	12	3
TOTAL (without labour)				181.95
TOTAL (with labour)				188.95
MAINTENANCE COSTS				
FERTILISER		**kg/ha**	**$/tonne**	
Single Super		2:0	180	45
CHEMICALS		**$/l**	**l/ha**	
Paraquat/Diquat & 2,4-D				2
MACHINERY		**no. tin es**	**$/ha**	
Spraying		0 2	10	2
Spreading		1	1	1
LABOUR		**$/hr**	**ha/hr**	
Spraying		:2	4	3
Spreading		:2	12	1
TOTAL (without labour)				50
TOTAL (with labour)				54
PREVIOUS MAINTENANCE				54
INCENTIVE				60
CARRYING CAPACITY		**Cows/ha**	**$/cow**	
previous		0.:4	732	395
year 2		0.:5	732	549
year 3 to	20	0 9	732	659
ADOPTION PERIOD (YRS)		0	Family labour ($/cow)	281
AREA SOWN PER YEAR (ha)		32.:2		

Appendix G Discounted CashFlow Analysis

Current Land Use	Years										
	1	2	3	4	5	6	7	8	9	10	11
Gerangamete	$889,100	$888,133	$887,143	$886,131	$885,094	$884,033	$882,948	$881,837	$880,701	$879,538	$878,347
Total Agricultural GM	$889,100	$888,133	$887,143	$886,131	$885,094	$884,033	$882,948	$881,837	$880,701	$879,538	$878,347
Cumm Loss		$967	$1,957	$4,927	$8,933	$14,000	$20,152	$27,415	$35,814	$45,377	$56,130
GM/ha	$519	$518	$518	$517	$516	$516	$515	$514	$514	$513	$512
Current GM of Catchment	$889,100	$888,133	$887,143	$886,131	$885,094	$884,033	$882,948	$881,837	$880,701	$879,538	$878,347
NPV of Current Strategy	$13,468,904										
Catchment Management Plan (CMP)											
Gerangamete	$755,998	$753,312	$756,104	$763,772	$771,422	$779,052	$786,662	$794,251	$801,819	$809,366	$823,722
Total GM of Agriculture	$755,998	$753,312	$756,104	$763,772	$771,422	$779,052	$786,662	$794,251	$801,819	$809,366	$823,722
GM/ha	$512	$508	$507	$509	$510	$512	$514	$515	$517	$519	$527
Net benefit of Tree Program	$122,311	$117,608	$112,905	$108,202	$103,499	$98,796	$94,093	$89,390	$84,687	$79,985	$78,884
Research Costs	($50,000)										
Monitoring & Extension Costs	($10,000)	($10,000)	($10,000)	($10,000)							
Total Costs	($60,000)	($10,000)	($10,000)	($10,000)	$0	$0	$0	$0	$0	$0	$0
GM of Catchment with CMP	$818,309	$860,920	$859,009	$861,975	$874,921	$877,848	$880,755	$883,641	$886,506	$889,350	$902,606
NPV of CMP	$13,659,040										
Change with CMP											
(CMP-Current)	($70,791)	($27,213)	($28,134)	($24,156)	($10,173)	($6,185)	($2,193)	$1,804	$5,806	$9,812	$24,259
Cum (CMP-Current)	($70,791)	($98,004)	($126,139)	($150,294)	($160,467)	($166,652)	($168,845)	($167,041)	($161,235)	($151,423)	($127,164)
NPV of (CMP-Current)	$190,136										
IRR	10.27%										
BCR	1.01										

Appendix G Discounted CashFlow Analysis

12	13	14	15	16	17	18	19	20	21	22	23	24
$877,129	$875,883	$874,607	$873,302	$871,966	$870,599	$869,200	$867,769	$866,304	$864,805	$863,271	$861,701	$860,094
$877,129	$875,883	$874,607	$873,302	$871,966	$870,599	$869,200	$867,769	$866,304	$864,805	$863,271	$861,701	$860,094
$68,101	$81,319	$95,812	$111,610	$128,745	$147,246	$167,146	$188,477	$211,274	$235,570	$261,399	$288,799	$317,805
$512	$511	$510	$509	$509	$508	$507	$506	$505	$505	$504	$503	$502
$877,129	$875,883	$874,607	$873,302	$871,966	$870,599	$869,200	$867,769	$866,304	$864,805	$863,271	$861,701	$860,094
$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214
$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214	$832,214
$532	$532	$532	$532	$532	$532	$532	$532	$532	$532	$532	$532	$532
$78,884	$78,884	$78,884	$78,884	$78,884	$78,884	$78,884	$78,884	$78,884	$78,884	$78,884	$78,884	$78,884
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$911,098	$911,098	$911,098	$911,098	$911,098	$911,098	$911,098	$911,098	$911,098	$911,098	$911,098	$911,098	$911,098
$33,968	$35,215	$36,490	$37,796	$39,132	$40,499	$41,897	$43,329	$44,794	$46,293	$47,827	$49,397	$51,003
($93,196)	($57,981)	($21,491)	$16,305	$55,437	$95,936	$137,833	$181,162	$225,956	$272,249	$320,075	$369,472	$420,476

Appendix G Discounted CashFlow Analysis

25	26	27	28	29	30
$858,450	$856,768	$855,046	$853,285	$851,482	$849,637
$858,450	$856,768	$855,046	$853,285	$851,482	$849,637
$348,455	$380,787	$414,841	$450,656	$488,275	$527,738
$501	$500	$499	$498	$497	$496
$858,450	$856,768	$855,046	$853,285	$851,482	$849,637
$832,214	$832,214	$832,214	$832,214	$832,214	$832,214
$832,214	$832,214	$832,214	$832,214	$832,214	$832,214
$532	$532	$532	$532	$532	$532
$78,884	$78,884	$78,884	$78,884	$78,884	$78,884
$0	$0	$0	$0	$0	$0
$911,098	$911,098	$911,098	$911,098	$911,098	$911,098
$52,647	$54,330	$56,051	$57,813	$59,616	$61,461
$473,123	$527,452	$583,504	$641,317	$700,932	$762,393