# SUBMISSION TO THE SENATE INQUIRY INTO THE EXTENT AND ECONOMIC IMPACT OF SALINITY

South Australia's Upper South East Dryland Salinity and Flood Management Program
- Landholder Views -

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## SUMMARY

After being advised that a 4km drain would be dug through his property as part of the Stage 3 completion of the drainage component of the Upper South East (USE) Dryland Salinity and Flood Management Program, the author[1], motivated initially by past professional experience and interests, took a genuine interest in learning about its management and the underlying science.

On receiving contradictory information from program managers and officers, local agronomists, and scientists, he became concerned that the science of draining saline and waterlogged soils was poorly understood, and decided to test the veracity of the claims. This included seeking advice from a network of approximately 650 Australian scientists, government officers and landholders involved in research and management of dryland salinity; reviewing USE Program background papers; reading national and international scientific and related papers; and sharing ideas and knowledge with many USE landholders. The reviewing and reading continues today.

The author has now concluded that the SA State Government, supported by National Action Plan for Salinity and Water Quality funding, and an Act that gave unprecedented powers to acquire land without compensation and provided immunity against liability for actions taken by its staff, is imposing a drainage network that is uneconomic, over-designed, and causing more damage to soils and the environment than it was intended to cure. Many USE landholders who have adapted their management practices have successfully minimised the adverse effects of salinity and flooding on their properties, and are now very resentful of this intrusive and ineffective program.

## AIM

This submission has been prepared for the Senate inquiry into the extent and economic impact of salinity. It aims to summarise the experiences and observations of landholders in the Upper South East of South Australia affected by the current stage 3 implementation of the Upper South East Dryland Salinity and Flood Management Program (Program).

## THE PROBLEM

Following floods in the late 1980s, community concerns that dryland salinity was increasing resulted in the development of the Upper South East Dryland Salinity and Flood Management Plan (NRC, 1993). Dryland salinity and other problems, including declining wetland health and waterlogging in some areas, were caused or exacerbated by inappropriate land and water management practices in the region, in particular over the past 30 to 40 years.

Importantly, local changes to these inappropriate practices have also very successfully corrected many of the adverse effects of salinity and flooding at the local scale. This fact alone has been the main reason for the

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[1] The author is a semi-retired scientist and chartered engineer, who has considerable experience as a senior technical specialist and manager in government and industry. At the time he left full-time paid employment in 2000, he held a government position as a senior principal research scientist. He has over 40 years experience as a scientist and engineer, including 25 years initiating, planning, supporting, managing, and auditing major government projects, activities which continue today. He has won university and professional association awards for his work, and now owns and operates a 840 hectare grazing property with his wife in the Upper South East of South Australia.

considerable landholder reaction against the SA State Government's current simplistic deep drain solution, which has potential to cause more damage than it claims to be solving.

The root causes of many of the USE's past problems were excessive recharge of groundwater caused by the removal of native vegetation, and poor natural surface drainage. The previous balance between rainfall, water use by native vegetation, groundwater recharge and underground flows to the ocean, flooding, and surface water flows to the Coorong, had been altered by the replacement of native vegetation with lower water use crops and pastures, and uncoordinated construction of drains, weirs and stop banks.

The rate of expansion of dryland salinity in the USE monitored during the period 1988 to 1992 led to the prediction that the area would increase from affecting 37% of the region to over 60% within 30 years (Cann et al, 1992). This resulted in the further prediction that the stocking capacity, and hence gross income, of the region would decline by 41% over the same period (24, Barber A, 1993).

The comprehensive Upper South East Dryland Salinity and Flood Management Plan, published under the guise of an Environmental Impact Statement (EIS), had a number of objectives, which were to be met by an integrated strategy comprising four key components (11, NRC, 1993):

- Management of surface waters to reduce flooding impacts, which enables good quality surface water to be used in the watercourses.
- **Groundwater level and associated soil salinisation control by construction of a new regional network of groundwater and surface water drains with outlets to the ocean and Coorong.**
- Pasture improvement program utilising salt tolerant and perennial species to underpin the economic viability of the plan.
- Revegetation to increase native vegetation cover and water use in recharge areas.

The 1993 Plan, although based on a short data set now known to have been based on incorrect predictions, still remains the guide for the current program. Furthermore, the superficial and flawed belief that draining saline soils was a simple process has also remained unchallenged.

The dominant and most contentious component of the Plan was the proposed groundwater drain network, now comprising an estimated 650km of drains. When completed, the network, funded by NHT, NAP and a 25% landholder levy, will have cost an estimated $45million to construct.

After experiencing difficulties negotiating drainage alignments with some landholders during the earlier two stages of the program, the final stage of construction (410km) was facilitated by the passing of the USE Dryland Salinity and Flood Management Act 2002 (SA State Government, 2002). The Act enabled the compulsory acquisition of drainage corridors without compensation. There is evidence to indicate that MPs and MLCs were misled at the time into believing that the threat from salinity and the benefits of drainage had been grossly exaggerated, and that there was unanimous landholder support for the drainage component of the program (eg Hansard, 2002; PWC, 2003). This was probably the main reason for the high level of support the Act had during its passage through Parliament.

The Act also provided immunity to program staff and the State Government for liability for any acts or omissions taken in respect of implementing the program! Combined with an obvious lack of effective, independent and critical review of program actions, staff are thus allowed to override serious concerns of landholders, scientists, and other public servants, in the knowledge that they have little public accountability for their actions.

## THE SOLUTION?

The drain network is the main focus of this submission. In general, it was to comprise drains of depth greater than 2m. The Plan concluded that the only effective method of controlling and reversing the spread of dryland salinity was a regional network of deep drains. However, two independent reviews (Semeniuk, 1993; Coffey MPW, 1994) were unconvinced of the arguments for the drain network, which also drew considerable opposition and questioning from landholders and several government agencies (NRC, 1994b).

Despite the opposition and contrary reviews, the network proposal remained unchanged, based on arguments (9.4, 9.4.1 and 9.4.2, NRC, 1994) now known to be incorrect, and the Plan was formally published in 1994 (NRC, 1994). It is also evident that the EIS function of the Plan was deficient in a number of areas, for example, in its failure to identify any aquatic species in the region, and in hydrological predictions. Most alarming was the absence of any review or consideration of the environmental damage caused by draining saline and waterlogged soils, even though decades of national and international knowledge, experience and data on the subject existed at the time!

While the author has not seen the Department's certification on the impacts that the drainage works would have on the environment (required by Schedule 1, item 6 of the Environment Reform (Consequential Provisions) Act 1999), correspondence between the Commonwealth (Department of the Environment and Heritage) and the State Government on the subject has been seen. It is clear from the correspondence that the Commonwealth DEH was confident that the SA State Government in implementing the program would act in the best interests of the environment, and cited the existence of the (flawed) EIS as justification for not intervening. Landholder experience of the program to date has not provided them with the same degree of confidence.

At least one government submission at the time (p267, NRC, 1994b) "expressed concern that the document in many respects does not meet the standards expected of an EIS because it lacks the necessary detail to assess adequately the likely impact of many of the [drainage] options, including the preferred plan". The EIS remains in its original flawed form.

Worse still, when stages of the drainage program were being planned in 1996, 1999, and 2002, managers inexplicably failed to review (or report) data on watertables, which had been fundamental to the original case for the drain network, and which had been agreed nationally with the Commonwealth (NLWRA, 2001) would be a key measure of dryland salinity and its management.

A review of salinity audit methodologies (NLWRA, 2001) indicates that they over-estimate saline areas. Illogically, the South Australia report (Barnett, 2000) acknowledged that watertables were falling but still predicted that the area at risk of salinisation in the USE would increase by 160,000ha, from the 250,000ha reported <u>at risk</u> in 2000. An earlier assessment (Furby et al, 1998) of the USE credibly concluded that 195,000ha of the region was affected by salinity in 1997 (ie a reduction of an average 10,000ha per year since 1992). This, combined with the fact that watertables have continued to fall, would suggest that the affected area is now nearer 150,000ha, and shrinking.

Although an extensive network of observation wells had been installed in the region, and routine data logging and reporting initiated, declining watertables clearly visible by 1997 never resulted in the role of the drainage program being reviewed. Rising watertables and growing salinity turned out to be temporary phenomena, even though rainfall during the key recharge months of May to August is currently close to long-term averages (BOM, 2005a).

Furthermore, average annual rainfall has been declining in the region since the mid 1950s by up to 20mm/decade (eg BOM, 2005a; p28, BOM, 2005b), which has potential to have an enormous impact on future agricultural productivity and wetlands health. Rainfall is projected to continue decreasing at a similar rate for at least the next 50 years (Whetton, 2001). Major drainage works are the last thing the region needs now and in the future!

National and international research shows that drains deeper than about 0.5m have potential to adversely affect agricultural productivity and wetlands health, by excessively dewatering soils (including removing the critical upper fresh water layer), changing the structure and chemistry of previously saline and waterlogged sub-soils (causing soil structure to break down and the production of greenhouse gasses), depriving watercourses and wetlands of adequate fresh water, and contaminating remaining water with salts, metals, nutrients, and other chemicals. Some animal health problems in the USE have recently been linked to high concentrations of toxic elements in pastures, apparently caused by their oxidation and mobilisation arising from soil drying (pers comm Parsons, 2005).

Contamination and land degradation concerns arising from the construction of deep drains elsewhere in Australia have already resulted in a recommendation that they be fully or partially filled in (eg Smith, 2002).

Many landholders are likely to experience a long-term net loss of income arising from the high capital and maintenance costs of the drainage network, and the costs of remediating damage to their soils. This will impact directly on their farm's sustainability and ability to manage future land degradation! This fact was alluded to but not quantified in benefit:cost analyses prepared for the program (eg Barber, 1993; Wheeler et al, 2002).

A case study of the author's property shows that the financial benefits of drainage of his most saline paddocks will not exceed the costs. These paddocks have been saline for at least 18,000 years, and yet have been highly productive under salt-tolerant pastures! Another northern catchment farmer has lost 60ha of his farm to the drain corridor, and has no salinity problems, and rarely waterlogging problems. Yet another young farmer has lost a fifth of his 100ha property to the drain corridor, and also ……… has never had waterlogging nor salinity problems. Other farmers in the central and southern catchments are complaining because precious sub-soil fresh water, which lies on top of the saline groundwater, is being drained away. And yet again others, have received a $110,000 government grant to investigate "black bogs" appearing close to newly dig drains (p9, Howell, 2005).

The most freely draining coarse-structured soils in the USE are least likely to have significant, if any, salinity problems, because the capillary rise distance is very small. These soils will drain well, but should not require groundwater drainage. The soils worst affected by salinity, with greatest capillary rise distance, are the clay soils. These do not respond well to groundwater drainage, and create other management problems. Any form of deep drainage will also result in less water available to freshen wetlands and watercourses. It is difficult to see how the economic and environmental costs of deep drainage can ever be justified.

A recurring theme in background papers and analyses prepared to support the State Government's 2002 priority project NAP funding proposal was that the limited time available for studies meant that many important economic and environmental issues could not be investigated and reported in detail (eg Wheeler et al, 2002; Walker, 2002). The technical basis for the 2002 drainage proposal thus remained unchanged from the 1993 projections.

Furthermore, a review of government information shows that the Plan would probably be uneconomic at the regional scale (Wheeler et al, 2002), and unnecessary for its stated purpose, because watertables had been falling naturally in the region without drains! Having secured NAP funds for the program, staff then managed to negotiate key land salinity targets for 2010 and 2020 (NAP, 2003) that had probably been achieved before 2002, and one possibly as early as 1993, without drains!

Since the Plan's conception, program staff have clearly been preoccupied with completion of the deep drain network, and have never seriously questioned whether its original justification remained valid. Had program and other State Government staff applied equal effort to achieving the Plan's more popular and productive targets of 55% cover with perennial agricultural vegetation and 20% cover with native vegetation by 2005, the current falling trend in watertables would have been reinforced. Doubts over whether a deep drain network was needed would have been removed completely.

As part of the drain design and construction implementation process, benefit:cost analyses, and the sensitivity analysis of variable factors, have not been conducted, contrary to NRC recommendations (xiii, NRC, 1994).

A flood mitigation network of shallow surface drains feeding watercourses and wetlands, and removal of weirs and stop banks, with a shallow drain linking the land-locked watercourse termini in the north more effectively to the Coorong, would have been considerably less invasive, damaging, and expensive (in both initial capital and through-life maintenance costs), and been considerably more acceptable to and affordable for landholders.

Many landholders who have adapted their farming practices to manage and control the adverse effects of salinity and flooding are opposed to any deep drain network, and have always favoured a less invasive and costly drainage solution, in conjunction with recharge control. They recognised that uncoordinated drainage, including construction of weirs and stop banks on watercourses, and loss of deep-rooted perennial vegetation from higher ground, were the key causes of many of the dryland and wetland problems in the USE in the early 1990s.

These landholders have been achieving significant production from their saline and occasional flooded areas with salt-tolerant pastures, and have reduced salinity and waterlogging through revegetating higher ground with deep-rooted perennial pastures and native vegetation. A ground survey of the area would have shown how effective these management strategies have been.

Ongoing and thorough reviews of the fundamental data that was the initial justification for the drainage component would have shown very early that the 1993 predictions were invalid, and that the drainage network proposal should be reviewed and revised.

The benefits to be derived from the USE's current deep drain network are not worth the economic and environmental costs they are generating.

Photographs showing major points are in Attachment A. Summaries of key documents are in Attachment B, and details of references in Attachment C.

## KEY CONCLUSIONS

- Program staff appear to be motivated more by a need to spend NAP funds on drain construction before the end of 2006 than on maximising net economic and environmental (including agricultural) benefits for the region.
- Major errors and inconsistencies exist in information on dryland salinity in the USE, and which has been presented by program staff to the PWC, to MPs and MLCs in general, presumably to Commonwealth NAP managers, and to landholders.

- Many economic and environmental costs of deep drainage have been over-looked or ignored by program staff, and environmental damage is being caused as a result. Slowly degrading sub-soil structure will become evident in future years (already apparent next to new drains). This will lead to a loss in effectiveness of the drains and an increase in waterlogging.
- Groundwater tables have been generally falling since 1993, and the area affected by dryland salinity has contracted. As annual rainfall continues to decline, it will be lack of water, and not an excess, that will have the greatest adverse impact on USE agricultural productivity and wetlands health.
- The author believes that a thorough review of watertable and dryland salinity data in 2002, at the latest but ideally earlier, would have resulted in a program that placed greater emphasis on recharge and flood water management through revegetation and shallow surface drains.
- Many landholders will be out of pocket as a result of the drainage component of the program. The current program is probably uneconomic at the regional scale.

## KEY RECOMMENDATIONS

- Yet-to-be-constructed USE drains should have minimal impact on the environment; conduct and independent review of all relevant data and predictions, and give priority to environmental arguments!
- Identify remediation and maintenance requirements for existing drains, affected land and wetlands, and implement an immediate reparation program; landholders should not be expected to pay.
- Conduct an independent analysis into likely economic and environmental outcomes of the program, for farms, catchments, and the region, with the aim of identifying and subsequently addressing deficiencies and inequities.
- Conduct an independent investigation into how the program was developed, evolved, supported and implemented, with the priority aim of identifying process improvements, for immediate implementation if practicable.

15 August 2005

Attachments:

A. Photographs

B. Summary Notes and Key Extracts

C. References and Further Reading

# PHOTOGRAPHS

## NORTHERN CATCHMENT OUTLET

The photograph shows the outlet for the northern catchment drainage scheme, just before entering the Coorong. This is an enormous long structure – the drain base is about 5m wide. It was constructed over four years ago, and is now experiencing significant water erosion as a result of the program failing to stabilise its sides.

It involved the destruction of a large area of native vegetation. A little distance to the north lies the natural low lying outlet for USE surface waters.

## MONOSULFIDIC BLACK OOZE

The MBO formed in the base of a drain within two months of its construction. It comprises iron sulfides and organic matter, and is an external indicator of some of the processes occurring underground as a result of drainage. Iron sulfides are common in USE sub-soils, which form sulfuric acid when exposed to atmospheric oxygen as soil's dry. The process is associated with so-called acid-sulfate soils, which does not occur under waterlogged conditions. The drains consequently are a potential source of acid waters that could find their way to the Coorong.

USE soils contain bicarbonates and carbonates which neutralise the acid formed in soils and drain water. In so doing, carbon dioxide (a greenhouse gas) is produced. Based on CSIRO calculations, the author estimates that one million tonnes per year of carbon dioxide is being produced by the USE drainage scheme. The MBO also produces the toxic hydrogen sulfide, the stench of which is revolting during the summer months.

## WIND EROSION

Poorly stabilised drain banks have already resulted in major wind erosion, and this section of drain being desilted and repaired twice, since its construction just over a year ago.

## WATER EROSION AND SODICITY

The photograph taken 6 months after this drain was dug shows the effects of sodicity, which occurs when previously saline clays, and to a lesser extent organic matter, come into contact with fresh water. The clay rapidly loses its structure, as individual clay particles repel each other and disperse. In sub-soils, the dispersing clay particles fill the tiny pores between soil particles, and form impermeable and poorly drained layers. This results in sub-soils losing their ability to drain effectively. They then become more susceptible to waterlogging, and lose fertility.

## TURBIDITY

As a result of rain hitting and flowing sown sodic drain banks, dispersing clay particles are washed into the drain water and carry attached nutrients down-stream to wetlands, and potentially the Coorong.

The photograph was taken after a short period of heavy rain (for the USE) in August, and also illustrates how over-designed this particular section of drain is.

## SALINITY AND VEGETATION CAN COEXIST

The photograph is of a so-called saline sump in the northern catchment of the USE. It shows clearly that saline land and native vegetation can coexist. Large areas of the USE have been saline for thousands of years (the evidence for which are large surface deposits of gypsum), but have been successfully used for agriculture using salt-tolerant pastures. Unfortunately, some of the pastures are now dying close to drains as a consequence of soils drying. The sub-soils though are generally clayey in nature, and are excepted to remain saline for many years, possibly forever.

## DEATH OF NATIVE VEGETATION CAUSED BY INAPPROPRIATE MANAGEMENT PRACTICES

The photograph shows an area of dead native vegetation. This was caused by salinity, but not just because of poor recharge control (bare hill behind). Flow of water through the watercourse in which it stands was blocked by a small stop bank, to prevent inundation of a neighbouring farmer's paddock. This caused water to pond, preventing saline water from being flushed out of the root zone of the trees.

## THREATS TO REMNANT NATIVE VEGETATION AND WETLANDS

The photograph is of one of the remaining areas of pristine wetlands and vegetation in the USE, and occupies over 7,000ha.

**A DEEP DRAIN HAS BEEN PROPOSED FOR CONSTRUCTION RIGHT NEXT TO IT**

**PROGRAM STAFF CLAIM THE DRAIN WILL NOT AFFECT THE WETLANDS!**

**Attachment B**

# SUMMARY OF NOTES AND EXTRACTS OF KEY REFERENCES

## THREAT FROM DRYLAND SALINITY GROSSLY EXAGGERATED

- A review of USE observation wells by Coffey MPW in 1994 (NRC, 1994a) showed that 33 under dunes indicated that watertables were rising, 46 were static, and 3 showed falls (but only where groundwater withdrawal for irrigation was occurring).
- The draft EIS (47, NRC, 1993), quoting Mackenzie et al (1992), stated that watertables were rising at a rate of between 0.5-1.0m/year.
- In the Central Catchment in 2004, 8 out of 12 observation wells in dunes showed that watertables were falling, and 9 out of 10 observation wells on the flats showed falling trends (Cox J et al, 2005), which are the sites of potential salinity. More general reporting indicates that a majority of observation wells (estimated in excess of 90%) have shown falling or flat trends across the region since 1993 (unpublished DWLBC data, 2005).
- Cann et al (1992) reported that 250,840ha (37%) of the USE (684,320ha) was affected by dryland salinity, and calculated changes in the area affected by salinity for the period between 1988 and 1992.
- Barnett (2000) subsequently noted that such increases were "most likely the result of increased awareness and better recognition of the problem, rather than the physical expansion of salinisation", although some growth might be attributed to very wet years.
- Barber (1993) estimated that a further 175,000ha (an additional 26% totalling nearly 63% of the USE) was at risk of salinisation within 30 years if remedial action was not taken. The analyses assumed transitions from areas of lower salinity to higher salinity of between 4.5% to 12% per year, and an initial annual rate of increase of the total area of saline land of about 7,900 ha/year (117, NRC, 1993).
- These estimates were used in subsequent benefit:cost analyses (BCAs) (Barber, 1993 and Wheeler et al, 2002), and justification for a Program that gave priority to discharge management (ie a drainage network), rather than flood water and recharge management.
- Warnings from several government agencies against the Program’s recommended options and priorities were ignored (eg pp 245, 260, 268, 272, 276, 283, NRC, 1994). Many agencies advised that caution should be taken when using predictions based on a short data set (1988 - 1992), and recommended minimal drainage options with greater emphasis initially on recharge management.
- The amount of water lost by evapotranspiration is hardly discernible in the seasonal fluctuation of the watertable of the USE. The regional influence on groundwater discharge is small, amounting to about 1% of that lost over summer, and 10% of net discharge. <u>This means that local land management can have an impact</u>, because discharge is not unduly affected by recharge outside of the region (Walker et al, 1997). This has been demonstrated by many landholders, who have cured localised salinity and waterlogging by revegetation surrounding recharge sites. One could thus also conclude that <u>increased local discharge, and consequently dryland salinity, has arisen because of excessive local recharge and/or poor surface cover, eg caused by local farm management practices, such as cropping, reliance on annual pastures, and over-grazing</u>.
- Visitors to the USE will not be surprised that significant recharge of groundwater has occurred. Large areas of cleared land are covered with weedy annual grasses, in particular silver grass, and many areas are completely devoid of any vegetation. One can also see paddocks renovated with lucerne thrive well on one side of the road (high profitability, low recharge), with only samphire and silver grass on the other (low profitability, high recharge).
- Despite the availability of NHT grants for recharge project, program staff claimed in 2003 that only about 40,000ha (7%) of the USE was sown to lucerne (USEDSFMP, 2003). **The clear but incorrect message from program staff was that because of the poor uptake of lucerne, drains were needed to take away excess groundwater, which was clearly untrue!**
- According to a 1999 survey (reported in DWLBC, 2002), of 186,461ha of the USE, 72,327ha (39%) was identified as established to perennial pastures (the majority lucerne, but also including phalaris, cocksfoot, kikuyu, primrose and veldt grass). Furthermore, in 2002, 88,326 ha of lucerne had been planted according to records, which was also considered to "grossly underestimate", possibly by as

much as five-fold, the actual area planted (McEwan et al, 2002). This might provide another reason why watertables have been going down in the USE over the past decade!

- At least 60% of salt-affected land in the USE had been sown to salt-tolerant pastures (DWLBC, 2002).
- Furby et al (1998) reported that the area affected by dryland salinity was 195,000ha (29% of the region) in the period 1992 to 1997. Furby noted that "1992 was a wet year with about double the average rainfall for June and July", and that "1997 was considered more average in terms of rainfall". Furby also noted that "a qualitative assessment of the salinity map in the southern part of the catchment shows that salt-affected land is being considerably over-estimated".
- Average annual rainfall in the USE has declined by an average 10mm/decade to 20mm/decade (p28, BOM, 2005), which is equivalent to a reduction in potential stocking rates of 2 – 4 dry sheep equivalent/ha over 50 years. Annual 5-year moving average rainfall during the peak recharge months of May to August is near its long-term mean, and shows a distinct cyclic pattern of period about 9 years to peak in 1990 at about 50mm above the long-term mean. The current cycle bottomed in about 2000 at a bout 50mm below long-term mean, and is now on a rising trend with annual rainfall close to the mean.
- Whetton (2001) predicted that average annual rainfall will continue to trend downward at a similar rate for at least another 50 years. More dry spells are predicted, although the occurrence of extreme daily rainfall events could increase.
- Land classifications made in 1993 were incorrect, which exaggerated the severity of salinity in the USE:
    - Land classified as very highly to extremely saline, unproductive, and characterised by samphire and salt scalds (Cann, 1992; USE Program, 2003), has been successfully sown to very productive perennial puccinellia pastures (achieving stocking rates of 4 – 5 dry sheep equivalent (dse)/ha). These pastures are now expected to die as a result of drainage (McEwan, 2002). Program staff (Johnson, 2005) reported that on similar, but drained, land in the northern catchment sown to lucerne and clover, stocking rates are only 50% that of puccinellia! Johnson incorrectly reported that puccinellia dies when it is flooded; puccinellia can withstand long periods (in excess of 3 months) of flooding, which is one of its major attributes. Productivity on puccinellia paddocks after drainage is thus expected to decline!
    - Land classified as being highly saline, and characterised by sea barley grass and bare patches (USE Program 2003), has been successfully sown to very productive perennial lucerne and veldt grass pastures, and has been achieving stocking rates similar to non-saline land.
- The existence of gypsum over a relatively large area in the north west of the USE indicates that dryland salinity has existed there for at least 20,000 years (Keeling et al, 2001). Although still saline, this area has been successfully used for grazing after sowing with salt-tolerant pastures.
- The SA salinity audit for the region (Barnett, 2000) overestimated the area of the Upper South East (USE) affected by salinity, because groundwater in many parts is overlain with fresh water, and the sandy soils in the region have capillary rise distances less than 2m. Soils were defined as at risk of becoming saline if watertables were within 2m of the surface, or within 5m and were demonstrated to be rising (NLWRA, 2001). Furthermore, the SA salinity audit grossly exaggerated future areas at risk (a further 160,000ha in addition to the current estimated 250,000ha). Falling watertables should have indicated that the area at risk was in fact declining.
- Groundwater salinity ranges from less than 1,500 mg/L in the east and local areas in the south of the USE, to greater than 12,000 mg/L in the north (Fig 3.3, SENRCC, 2003).
- Truscott (2002) reported that only 8% of USE landholders believed they had a salinity problem, and that 55% considered that drains would only provide a partial solution.
- McEwan et al (2002) reported that native vegetation in the USE was evident over 19.4% of the region, which is close to the USEDSFMP target of 20% (20, NRC, 1993). McEwan also reported that dryland lucerne had been sown over nearly 13% (over 88,000ha) of the region, but the figure was a gross underestimation, representing possibly as little as one-fifth of the actual area planted. The area now sown to lucerne is possibly close to the pre-1978 area of 300,000ha, which was believed to have contributed significantly recharge control (56, NRC, 1993).

- The rapid uptake of lucerne (only 40,000ha in 1993) provides another reason why watertables have been falling and the area of dryland salinity has been contracting. Furthermore, the DWLBC (2002) reported that in a 1999 survey over 60% of the salt affected area in the USE had been sown to salt-tolerant pastures. Also, nearly 39% of a survey area of 186,461ha had had been established to perennial pastures (the majority being lucerne).
- Between 2002 and 2004, USE Program and DWLBC staff continued to report to MPs and landholders the 1992 predictions on dryland salinity (eg Hansard (eg 2002), USE Program (2003), DWLBC (2004))
- The DWLBC (pp2, 9, 2003a) submission to the SA Parliament's Public Works Committee (PWC) implied that the 1992 predictions ("environmental assessments" and "underlying assumptions") had been reviewed (but clearly not data on watertables and dryland salinity), which was re-stated in PWC Report 192. The DWLBC also reported that an expected outcome of the drainage component of the Program would be that land salinisation trends would be reversed (implying a belief that dryland salinity was still expanding and that watertables were rising).
- Cox (2005) reported that watertables in the USE have generally been falling since 1993.
- DWLBC (2005) first publicly acknowledged at a landholder meeting that watertables were falling, and hence the threat from dryland salinity was receding, without drains.

**A principal objective of the USE Program has thus been occurring naturally, and at no cost to landholders and tax-payers!**

The author believes that had this information been revalidated, and BCAs updated, <u>program staff would have been forced to revise Program priorities, with greater emphasis placed on recharge rather than discharge management</u>. Minimal drain designs and greater emphasis on perennial revegetation would have done more to control localised flooding, enhance wetlands health, and improve agricultural productivity, at considerably lower whole-of-life costs than the current Program.

**More efficient use of declining rainfall is becoming increasingly important to maintaining agricultural productivity in the USE. Excessive dewatering by drainage, and the resulting damage to soil structure (see later), is more likely to become the greatest threat to agricultural productivity and wetlands health in the USE.**

## BENEFITS ARISING FROM THE DRAINAGE SCHEME GROSSLY EXAGGERATED

- Barber (1993) predicted a benefit-cost ratio (BCR) of 1.56 (at 7% discount rate), for a theoretical central catchment "model farm" following drainage and the implementation of a major pasture renovation program. Peak debt would occur after 9 years, and break even after 15 years. After considering other costs, Barber concluded that "**the investment barely breaks even on financing costs (interest payments) with little or no addition [sic] remuneration to the farm business owners**".
- Barber also predicted likely catchment scale productivity improvements and BCRs for various drainage scheme options. The greatest improvements in productivity (measured as change in stocking rate) were in the range 10% to 15% (BCRs around 1.25). This is considerably less than the 57% to 100% briefed to MPs when the USE Dryland Salinity and Flood Management Act 2002 (USE Act) was debated in Parliament (eg Hansard, 2002, 2002b, 2002f).
- Minimal drainage schemes, which generated highest BCRs, resulted in productivity changes from around –15% to +10%. **Because dryland salinity is not increasing at the 1992 predicted rates, productivity increases for the minimal drainage schemes are likely to have been comparable with the more expensive options now being implemented! A thorough review of fundamental Program data and predictions would have shown this in 2002.**
- Barber (pp163 – 167, NRC, 1994) subsequently recommended against adoption of the selected drainage schemes, and **suggested more acceptable rehabilitation programs based on different pasture bases and some changes to land use**, which would improve projected net present values (NPVs) by $12 million, and save $14 million on capital costs. This advice was consistent with that given by several government agencies (pp260 – 284, NRC, 1994), but ignored.
- Wheeler et al (p13, 2002) added environmental values and costs to the central catchment "model farm" analysis, and predicted that the BCR would fall from 1.56 to 0.95 (at a 7% discount rate). Catchment

scale BCRs of around 1.25 would presumably have fallen by a similar amount (to 0.65?) when environmental values and costs were added.

- However, watertables have been falling, so net present revenues for the "model farm" are less, eg local community and wider benefits were occurring naturally, and should not have been attributed to the Program. Furthermore, Wheeler noted that the "environmental values currently included are an overestimate of the true value", because **negative environmental consequences of the drainage scheme were not fully known and accounted for**. Wheeler also noted that **if "there are more increases in capital costs of the drainage scheme, then it is likely that the project will no longer be economic". The capital cost of the Program has increased substantially!**

- The effect on the central catchment "model farm" would thus be a lowering of the BCR from 0.95, and at the catchment scale a BCR of well below 0.65. Northern catchment gross farm income from grazing is less than for central catchment properties (because of lower rainfall and soil fertility), so their BCRs are also likely to be lower.

- The Program Director reported that the "economics indicated the project based solely on drains would be marginal in terms of benefits" and that "increased water use efficiency of perennial pastures have a significant impact .... on groundwater recharge" (Johnson, 2002), but still the majority of funding ($45 million from a total of $73.3 million) has still been directed to drain construction.

- Program staff (DWLBC, 2003a) misquoted the central catchment "model farm" BCR in its submission to the PWC, by claiming that it would increase "to 1.38 if the value of wetland improvements were to be increased significantly". Wheeler et al (2002) actually stated that "**an <u>extreme test</u> of the benefits transfer rules (allowing for all of Australia to place environmental values on wetlands created by the drainage scheme) means that the BCR jumps to 1.38. The size of these environmental values is not realistic, but provides an interesting comparison to the original environmental value results**".

- Deep drains were predicted to have a zone of influence up to 6.5km on inter-dunal flats (137, NRC, 1993), and 2.5km either side of the drain (93, NRC, 1994). Program staff (DWLBC, 2003a) then claimed that a 2m deep drain would "have a drawdown effect within 1 to 2 kilometres from the drain". In fact, draw down effects are dependent upon soil type, and have been reported to extend to less than a few metres of some drains in the USE (pers comm Durkay, 2004), and rarely have a significant effect beyond 40m (Connor, 2003). Salts are likely to remain in sub-soil clays for a significant period after drainage, and thus limit pasture types that can be grown.

- Drainage also causes some soils to become less permeable (caused by sodicity). Draw down effects thus reduce over time, unless costly remediation is undertaken. Depending upon soil types, leaching of salts can be extremely slow, measured in centimetres per year (pers comm. Merry, 2004). It is likely that many drained sub-soils in the USE will thus remain saline for decades, if not forever.

- Reported stocking rates of 2 – 3 dse/ha on drained northern catchment saline land (Johnson, 2005) is 50% less than the 4 – 5 dse/ha achieved with salt- and waterlogging-tolerant pastures (puccinellia) sown on similar undrained land!

- Land that has been show-cased to demonstrate drainage benefits in the USE is unrepresentative, only representing a small fraction of the region. While productivity of this land might have improved, possibly two- or three-fold, taken across the region he benefit is small. Furthermore, the cost of changing production practices to higher yielding ones, are also likely to be high, eg from re-fencing, investment in new plant etc.

- A case study of the author's property demonstrates that the economic costs of drainage (levy, soil remediation, pasture replacement, internal drainage) to achieve an improvement in stocking rates are significantly greater than any economic benefits.

- Saline land can be highly productive if sown with salt-tolerant pastures and crops. As we have found on our property, deep drainage is killing these pastures, which we will have to replace. While we might expect an increase in productivity of about 50% along a narrow corridor adjacent to the drain, **the costs of achieving this extra productivity outweigh the benefits**. Program staff claims of two- and three-fold increases in productivity as a result of drainage are definitely not possible on the large scale they infer.

## UNDERSTATED AND IGNORED COSTS

- Remnant wetlands containing many nationally-threatened, rare and vulnerable species are already being deprived of sufficient fresh water flows, as a result of up-stream flows being cut by drains constructed as part of earlier stages of the Program (eg Fairview Drain depriving the West Avenue Range and Watercourse area). Others have been seriously damaged by down-stream construction of stop banks and weirs that hold back and pond waters, and locally raise watertables.
- Deep drainage has potential to dewater land that previously was the source of limited runoff for the watercourses and wetlands, and also contaminate water flows with saline groundwater. The West Avenue Range and Watercourse is recorded to support (Biological Survey of the WARW, 2002) 296 plant species (49 introduced), 20 mammal species (7 introduced), 108 bird species (4 introduced), 16 reptile species, and 4 frog species (one nationally threatened), plus others recorded on separate occasions. The WARW supports 27 plant species, 12 bird species, 2 mammal species, and one reptile species, that are of conservation significance. A groundwater drain has been proposed to run parallel to the WARW!
- Existing drainage works (Blackford and Fairview Drains) have already reduced flows and quality of water reaching the West Avenue Range Watercourse. Deep drains (which contain saline groundwater) are now proposed for the watercourse, including a new drain adjacent to the Parrakie Wetlands. This poses a significant water contamination threat to the watercourse and the down-stream Henry Creek, as well as producing a barrier to the east-west fresh water flows that currently supply the Parrakie Wetlands.
- Additional contamination concerns arise from the potentially high acidity of drain effluent and so-called black water. Many regions in the USE have potential acid sulfate (high concentrations of iron and sulfate) soils, which could impact on the quality of drain effluent, by releasing toxic sulfate ions and heavy metals. However, carbonate concentrations are also generally high in USE soils and groundwater, which should neutralise acidity, at least in the short-term. Increasing acidity might become a problem though when carbonate levels are low, eg during low flow periods or periods of fresh water flow. As the soluble salts (in particular carbonates) are removed from the groundwater over time, presumably this could result in an increase in acidity and release sulfates and heavy metals to down-stream areas.
- Black water is caused by the decomposition of plant material not adapted to inundation, as well as chemical interactions between iron-rich soils and water. The black sludge (monosulfidic black ooze) that accumulates in the bottom of drains can also contribute to black water. Black water is generally non-acidic, has no dissolved oxygen, and thus kills all aquatic fauna that cannot escape. Artificial drainage has greatly increased the rate and overall amount of black water exported. (Smith, 2002)
- Many economic and environmental costs (eg McEwan et al, 2002) have been over-looked or ignored by program staff, which will result in the Program becoming a source of significant recurring costs to the USE with no compensating benefits for landholders.
- Soil transmissivity data used in hydrological modelling (Armstrong et al, 1992: Cox, 2005) incorrectly assumed that soil characteristics do not change as saline water is replaced with fresher water. In fact, transmissive soils can rapidly become poorly transmissive, measured in cm/year (pers comm Merry, 2004), as sodicity symptoms appear (Fitzpatrick et al, 2003)(Strugnall, 2004a), and result in poor drainage and increased waterlogging! Modelling also incorrectly assumed homogeneous soil profiles and no soil variation across flats (Armstrong et al, 1992: Cox, 2005).
- The hydrological modelling of Armstrong et al (1992) and Cox (2005) failed to consider the impact of deep drains on wetlands.
- Declining rainfall, a trend started over 50 years ago in the USE and predicted to continue for at least another 50 years, is further reducing the frequency of significant fresh water flows necessary to export salt that is being concentrated in wetlands through evaporation. Increasing salinity has already adversely effected a number of wetlands in the USE, and is likely to prove devastating to the fauna and flora of wetlands such as Parrakie, unless action is taken to at least maintain, or preferably increase, fresh water flows to USE watercourses.
- No sensitivity analyses of variable factors in groundwater modelling and economic analyses has been reported, contrary to NRC recommendations (xiv, NRC, 1994).
- Many costs have been reported, such as those associated with remediating:

   - Water and wind erosion, caused by inadequate stabilisation of the banks of newly constructed drains. The draft EIS (12, NRC, 1993) required that "clearance of vegetation will need to be minimised and spoil banks revegetated with local native species". There is evidence of major construction works conducted over 4 years ago still not being revegetated, eg northern catchment outlet.
   - Poor aesthetics, especially because of failure of program staff to revegetate and stabilise construction works.
   - Poor weed control, including movement of weeds along drainage corridors to wetlands, including the Coorong,
   - contaminated drainage effluent (greenhouse gas producing, and a source of sulfuric acid),
   - death of wetland flora and salt-tolerant pastures, and
   - surface and sub-soil degradation.

- Sharod R et al (2000) warned that lowering of the watertable near a drain might cause some plants to die, or become less vigorous and less able to compete for space and nutrients, and to survive attacks by disease, pests or grazing animals. Subsequently, McEwan K et al (2002) reported that in Tilley Swamp, the drain is causing the watercourse to dry, which is having a deleterious effect on the health of the rare wetland community (so described in the draft EIS (NRC, 1993)) of Melaleuca brevifolia (white-flowered paperbark/teatree), and Melaleuca halmaturorum (coastal paperbark/teatree) (Milne et al, 2001). Adverse effects extend to 850m, and 1200m from the drain for Melaleuca halmaturorum, but at these distances Melaleuca brevifolia health generally improved. At other locations, Melaleuca shrublands, Gahnia filum sedgeland (vulnerable, listed in SENRCC, 2003 ) and Selliera radicans +/- Wilsonia backhousei herbland (endangered, listed in SENRCC, 2003) are being displaced by samphire or salt scalds where salinity has increased.

- At Deep Swamp, there has been a general decline in health of the entire community of both Melaleuca brevifolia and Melaleuca halmaturorum up to 850m from the drain. Extensive death of Gahnia filum sedgeland is being reported (McEwan K et al, 2002). At the Hanson-Tiver monitoring site, large-scale death of Melaleuca between 1998-2000 has been attributed to the drain (Milne T et al, 2001a).

- McEwan K et al (2002) reported that Melaleuca halmaturorum appears to respond adversely more rapidly to changes in hydrology. While annual groundwater fluctuations are found to assist in maintaining the health of Melaleuca in groundwater discharge areas, probably by leaching salts out of the root zone, death and other adverse health effects are possibly caused because their shallow roots are unable to respond rapidly enough to lowering watertables. Once the symptoms of health decline are visible, it may be too late to implement adjustments to the hydrological regime. Given that the majority of remnant vegetation occurs on the flats, large areas of native vegetation could be adversely impacted by drains, with adverse consequences also for biodiversity.

- Puccinellia is dying in newly drained soils (McEwan K et al, 2002), despite it being a salt-tolerant grass recommended for pasture renovation (NRC, 1993), and proposed in the benefit:cost analysis for the program (Barber A, 1993).

- Major drains will reduce the growing season of perennial pastures within the zone of influence (±1km) of a 2m drain, amounting to an estimated 10% annual production loss (Schrale G, 1987).

- Fitzpatrick (2003a) presented a paper in April 2003 on soil degradation caused by drainage to a forum which included program staff. The paper was a summary of a report (Fitzpatrick et al, 2003) provided and briefed to program staff (pers comm Cox, 2005).

- Saline soils are chemically altered (they become sodic), and as salts are leached, soil structure fails as microscopic particles of clay and organic matter repel each other and disperse. The dispersing particles clog soil pores, resulting in the **formation of impermeable layers, an increase in waterlogging, and a dramatic reduction in the ability of soils to leach salts.**

- Fitzpatrick et al identified 14 categories of saline soils, and developed best management practices for their rehabilitation. Fitzpatrick noted that some soils should never be drained (because they become highly acidic), some should be treated before draining (eg with gypsum, to prevent the adverse affects of sodicity occurring as salts are leached), and other soils should receive treatment after draining (eg vegetating, liming, mulching and sub-soil slotting). The advice was based on decades of experience gained draining saline soils in Australia and overseas, but was ignored by program staff.

- A review of scientific literature by program staff would have shown that drainage of saline soils has been the cause of many major problems in the past, and was reported before 1993 (eg Quirk, 1999, 1999a, 1999b).
- **The consequences of rushed drainage without pre-treatment is already resulting in some soils requiring major and costly remediation (possibly after 5 to 10 years) to correct adverse effects**. "Black bogs" and sealed sub-surface soils are symptoms of sodicity, which will result in increased waterlogging.
- Sodicity is also being observed on drain banks, which are highly unstable and erodable. Initial signs of tunnel erosion (another manifestation of sodicity) are also evident, which has potential to grow back into adjacent paddocks, expand in diameter, then collapse to form erosion gullies (Rengasamy et al, 2005).
- Dispersing clays from drain banks turn water turbid as dispersing clay particles carry nutrients down-stream, where they have potential to feed algal blooms in wetlands (Quirk, 1999).
- The Gapon relationship is the basis of statements (US (Lamond, 1992)(Buchanan, 1993), UK (Halley et al, 1992) and CSIRO (Fitzpatrick et al, 2003)) that saline-sodic soils should always be pre-treated before drainage, to ensure that sodium is replaced by calcium before the salt concentration is allowed to fall. *State Government reporting (18, Barnett, 2000) warned that if saline water is saline, much greater care must be taken with drainage.* These warnings were provided to the USE program but ignored, and farmers were not warned of the consequences of failing to follow it. In the event that pre-treatment is not possible, weirs should be installed to prevent de-watering of the soil until treatment has been applied. A number of horror stories from the irrigation industry graphically illustrate the results of ignoring this advice, eg (Quirk, 1999a)(Quirk, 1999b). When fresher water follows the use of even slightly saline water in irrigation, sodicity problems occur, resulting in a major breakdown of soil structure.
- Solutions with high sulfate content are corrosive to concrete structures. The sulfate solution penetrates the concrete, and reacts with the calcium to form calcium sulfate that precipitates within the pores. This destroys the integrity of concrete by changing it to non-cementing material (calcium sulfate) that forms crystals in voids. Type V cement has high resistance to sulfate corrosion, unlike Type I (standard Portland cement) and Type II cement. (Seelig, 2000)
- Large areas of the USE have soils with high sulfate content, which have potential to become so-called acid sulfate soils. The soils were normally waterlogged, which prevented the sulfate layers oxidising and becoming acidic. Unlike many areas in Australia, the calcereous soils and sands result in relatively high concentrations of soluble and solid bicarbonates and carbonates in the groundwater and soils in most parts of the USE, which generally neutralise any acidity formed on drainage, at least in the short term. Other chemical reactions also occur.
- As atmospheric oxygen enters previously waterlogged soil pores, the clayey soils of the Upper South East, which contain high amounts of iron and sulfides, acidify and react with soil carbonates to produce $CO_2$, a greenhouse gas. An estimated 17,500ha of trees will be needed to compensate for the greenhouse gases produced.
- Post-drainage treatment of sodic soils with gypsum proposed by program staff (Johnson, 2005) is too late, and is not recommended by national and international experts (eg Halley et al, 1992; Lamond et al, 1992; Buchanan et al, 1993; Fitzpatrick, 2003). Post-drainage remediation is more difficult and expensive to achieve. The failure of the soil's structure obstructs the transmission of soluble calcium from gypsum, which is required to displace sodium attached to soil particles, the cause of sodicity.
- A 2004 South Australian Research and Development Institute (SARDI) trial of pastures on land within 30m of a two year old drain was a failure, because the sodic soils had become impermeable and waterlogged!
- Furthermore, coarser structured soils in the USE have supported the development of a fresh water layer (lens) that lies on top of the saline groundwater. This is a source of water for irrigation and stock, and for excellent growth of summer growing pastures. These soils though are also amongst the most free draining in the USE. Drainage that removes surface water and lowers watertables in these areas could have a devastating effect on agricultural productivity, and on the availability of fresh water flows to wetlands.

- High soil pH in the USE is usually associated with sodium bicarbonate and sodium carbonate, which are relatively very soluble salts that are easily leached from sandy soils. Calcium and magnesium salts will also be present, but at much lower concentrations. (pers comm, Merry, 2004) The carbonate and bicarbonate ions are toxic. High pH also decreases trace element availability, and decomposes clays, resulting in hard pans forming in the lower top soil horizons and restrict root growth. (Fitzpatrick et al, 2003)

- Iron oxides accumulate at the top of clay sub-soils, and in drain walls, where they clog soil pores, and restrict salt leaching and effluent flow into the drain (Fitzpatrick et al, 2003 and 2004). High soil pH decomposes clays, and decrease the availability of critical nutrients for plant growth, eg P, N, Ca, Mg, Fe, Mn, Cu and Zn.

- A stinking iron monosulfidic black ooze (MBO) forms in the bottom of newly constructed drains and adjacent soils. When mixed with water, the iron monosulfide in MBO can react within minutes to completely consume dissolved oxygen (Bush, 2004). The reducing conditions in MBO (substances undergo reduction if they lose oxygen, gain hydrogen, or gain electrons) produce methane ($CH_4$), nitrous oxide ($N_2O$), and hydrogen sulfide ($H_2S$) (Fitzpatrick, 2004). $H_2S$ is believed to be formed by sulfate reducing bacteria acting on sulfates in the groundwater (O'Sullivan et al, 2005)(Sawlowicz, c. 2001). The MBO is also a source of other toxic ions (principally carbonates ($CO_3^{2-}$) and bicarbonates ($HCO_3^-$)), a scavenger of heavy metals, and if exposed to the atmosphere a source of sulfuric acid (Fitzpatrick, 2004).

- Removal of MBO during desilting will result in the rapid formation of sulfuric acid. When stirred up by rough water on windy days, in particular when the water is shallow during drier months, the $H_2S$ gas produced is toxic and noxious, and can be smelled over long distances. MBO particles can then be seen suspended in the effluent and washed down-stream (see photograph below right).

- The thin orange surface that forms on top of the MBO are iron oxyhydroxysulfates which form on oxidation of iron sulfides. They also scavenge other elements, such as arsenic and cadmium (Fitzpatrick et al, 2003a).

- Acid release can be reduced by not clearing drains. Holding water back using drop board culverts has also been shown to be effective in preventing acid groundwater seeping into drains, and hence reducing acid flows. Filling in deep drains and replacing them with shallow v-drains is, however, considered to be a more reliable and effective long-term solution. (Smith, 2002)

- Drainage effluent from these drains flows in to the Coorong. Excess nutrients in the Coorong may lead to algal blooms, and excess heavy metals may accumulate to toxic levels lethal to key food species. Metals of significance are copper and zinc (194, NRC, 1993), both of which have lowered toxicity potential in alkaline drainage waters. It is also not certain that heavy metals will remain in sediments in a shallow wind-affected lagoon. Further investigations were recommended (10.3.9, NRC, 1994). Dispersing sodic clay particles suspended in drainage flows will carry attached nutrients to down-stream wetlands and to the Coorong.

- $CO_2$ is produced when the more soluble calcium bicarbonate, $Ca(HCO_3)_2$, decomposes on drying into the relatively insoluble calcium carbonate ($CaCO_3$) (Warrence et al, 2005).

- The reducing conditions that produce MBO in the drain base produce methane ($CH_4$), nitrous oxide ($N_2O$), and hydrogen sulfide ($H_2S$) (Fitzpatrick, 2004). $CH_4$ and $N_2O$ are greenhouse gases, which have approximately 22X and 300X more global warming potential than $CO_2$ (Blasing et al, 2005)(Pew, 2005).

- Hicks (2002) estimated the long term average release of carbon from drained acid sulfate soils in North Queensland to be the equivalent of 121 tonnes of $CO_2$ per year per hectare, arising from the decomposition of organic carbon and reaction with soil carbonates. If the USE drains lower watertables up to 200m either side (Program staff claim up to 5km!), and half of the area drained in the USE has potential acid sulfate soils containing soil carbonates, then over a million tonnes per year of $CO_2$ will be produced. A planning principle of the South East Natural Resource Management Plan (17, SENRCC, 2003) requires that "future development should be either greenhouse neutral or result in a net decrease in greenhouse gas emissions". Draining saline soils thus results in a major breach of this principle, unless compensated by other means!

- A tree plantation of about 14,000ha would be needed to absorb a million tonnes a year of $CO_2$, but mature trees should be removed, and not allowed to rot or burn, which releases $CO_2$ back into the environment.  Trees are about 50% by weight in carbon, and absorb $CO_2$ through their leaves from the atmosphere by photosynthesis, which with water converts $CO_2$ into glucose and oxygen.  Mature trees grow less rapidly and thus have a lower intake of $CO_2$.

- A so-called fresh water lens (fresh water layer ) is formed on the top of saline groundwater during periods when rainfall exceeds evaporation and transpiration.  The process also leaches salts that might have accumulated in the top-soils and at the surface back down to the underlying saline groundwater.  Where top-soils are coarse structured, capillary rise distances can be as little as 10 - 15cm, or where there is good surface cover, which results in low evaporation, groundwater is unlikely to have high salinity at the surface.  However, perennial vegetation could still result in salinity concentrating in the root zone.

- Where soil conditions and vegetation are suitable, the fresh water lens does not dissipate during the summer months, and so provides an ongoing source of stored water suitable for irrigation and stock watering.  Any drainage that removes both surface water and lowers watertables will result in the lens thinning or being removed completely.  In general, the coarser structured soils that are likely to have a significant fresh water lens will be the most effectively drained!

- Drainage that removes surface water and lowers watertables could therefore have a devastating effect on agricultural productivity in these areas, and on the availability of fresh water flows to wetlands.

- A case study of the author's property shows that there is little likelihood of the current drainage component of the program producing any net benefits.  Levy charges, cost of remediating saline soils, replacing dying salt-tolerant pastures, stabilising eroding unstable soils, loss of productive land to the drain corridor, extending surface drainage via a network of smaller surface drains, and other ongoing costs, could never have been used to justify the current drain construction.

- Other landholders in the catchment will experience even greater loss, in particular those whose properties rarely experience waterlogging, and have never experienced dryland salinity.  One landholder has lost a fifth of his small property to drains, another 60ha, and others are losing fresh water drained from under some of their best pastures.

- The open-ended program has already led to landholder levies tripling over the past decade, and which now amount to a full year's net farm income for the author.  Further levies, and other economic or environmental costs arising from the drain (currently estimated to be at least another two-year's net farm income for the author), could prove devastating.  Estimates of annual drain maintenance costs are reported to have blown out from $300/km (estimated in 2003) to $600 - $800/km.

- Existing provisions provided under Section 13 of the USE Act (and DWLBC letter 1829/02 dated 9 March 2003) only allow for compensation claims for deterioration in land prices to be made between January and September 2006, well before symptoms of soil degradation caused by sodicity are likely to be evident.

## MANAGEMENT

- The only reason why the program is proceeding is because it was mandated, land for the drainage network was compulsorily acquired without compensation, because Commonwealth funding was provided to support what appears now to be a seriously flawed case, and because the State Government gave itself the power to impose a major levy on all landholders in the USE.

- Wheeler (2002) noted that as a result of complaints from landholders about the original proposed sub-schemes (two major groundwater drainage systems, and one major surface with some groundwater drainage), an independent review was conducted in 1994 by Coffey MPW (Coffey, 1994), which concluded that major surface water drainage was preferred.

- Coffey MPW argued that only surface drainage should be necessary to sustain saltland agronomy, and then only where modelling indicates that flooding could occur for a month or more with a return period of greater than 15 years.  Surface drains would thus be less of a threat to wetlands.  The arguments appearing in the draft EIS Supplement Report (NRC, 1994) inadequately, and in some cases incorrectly, represented Coffey MPW comments and recommendations.  There appeared to be selective use of statements that minimised the negative impacts of groundwater drains, eg section 9.4, 9.4.1 (incorrectly predicted that watertables would continue rising) and 9.4.2 (validation of groundwater model), now known to be incorrect, but which promoted the efficacy of groundwater drains.

- I understand that some members of the USE Program Board, which has oversight responsibilities for the Program, have expressed frustration with Board processes because they are being asked to note, and not agree or approve, key decisions taken by Program staff.
- Responsibility for managing the drainage network will be handed over to the South East Water Conservation and Drainage Board (SEWCDB) when works are complete. I have been advised that SEWCDB staff are concerned at the level of maintenance and future capital costs that the new drain network will demand. To date, some drains constructed less than a year ago have already been desilted twice and repaired as a result of wind and water erosion, caused, respectively, by the failure to revegetate and stabilise drain banks, and by sodicity, which is causing clays in disturbed sub-soils to disperse. These are new costs not envisaged during Program planning, but should have been expected.
- There are many examples of Program managers ignoring views contrary to their own. Program staff who have voiced concerns over the direction of the Program have been gagged. Concerns of staff in other departments have also been ignored. Independent reviews that have detracted from the case for a deep drain network have been dismissed. Many landholders are aware of these facts, which has seriously eroded confidence in the Program. It is clear that an independent review of the Program has been needed for years.
- Warnings from scientists that saline and waterlogged soils would be damaged by drainage were ignored by Program staff. A member of CSIRO who had taken part in the briefings confirmed this to me. Other warnings of potential damage to wetlands are being dismissed, for example, excessive dewatering of soils resulting in reduced freshwater runoff to wetlands, and potential contamination of wetlands with saline groundwater and other chemicals. Damage to soils is already being experienced (caused by sodicity), which is reducing drain effectiveness, causing turbidity of drain water, and adding more expenses to an already very expensive Program.
- Many landholders in the region have refused to pay levies to the Program, because of their dissatisfaction with its management. Some landholders have lost significant areas of land to the drainage network (in one case a fifth of a small property, and in another over a 100ha), although their properties have experienced neither salinity nor waterlogging for at least a decade.
- The National Land and Water Resources Audit (Audit) initiated a comprehensive national assessment of dryland salinity employing consistent methodologies based on a groundwater hydrogeological framework (NLWRA, 2001). The Audit noted that groundwater level and trend data are recognised as fundamental requirements in evaluating the area of saline-affected land and the rate at which it was changing. The Audit projected likely increases in dryland salinity to 2050, <u>assuming a continued rate of increase and no change to water imbalance</u> (Australian Dryland Salinity Assessment 2000, NLWRA, 2001).
- The intent was to produce individual State reports on areas <u>at risk</u> of dryland salinity, using information on groundwater levels and trends, known incidence of salinity, soil characteristics, and topography. For those States with data on groundwater levels and trends (eg South Australia), land units within 2m of surface, or within 2 to 5m and with <u>well demonstrated</u> rising watertables were classed as being at high risk of dryland salinity. The Audit noted that: "This information should not be interpreted as actual areas affected since the assessments are likely to <u>overestimate</u> areal extent particularly in dissected (hilly) landscapes. Rather they identify areas or regions within which dryland salinity occurs or could occur. Groundwater trend analysis at the scales used will only provide an overview. ..... These estimates also include some areas - mainly in the temperate zone - with persistent waterlogging from shallow watertables. Although salt is ubiquitous in landscapes in agricultural areas, it is acknowledged that not all of these waterlogged lands will become saline." (Australia's dryland salinity, NLWRA, 2001).
- Barnett (9, 2000) apparently used digital terrain models of the USE and data on watertable elevations and trends to predict areas at risk of dryland salinity. While noting that groundwater levels had fallen in southern SA in the 2 - 3 years prior to 2000, with some drier catchments experiencing falling groundwater levels since 1993 (Dryland salinity by State - South Australia, NLWRA, 2001), and that the greenhouse effect is expected to lead to lower winter rainfall when greatest potential for recharge exists (Barnett, 2000), Barnett still projected an increase in the area <u>at risk</u> of salinity in the USE without explanation. Barnett did not show or demonstrate that watertables were rising, or that salinity was increasing (as claimed by program staff (Cahalan, 2005)).
- Barnett confusingly listed the USE area <u>affected</u> by secondary salinity in 2000 as 250,500 ha (see eg Table 4 in Barnett (2000)), and later an identical area <u>at risk</u> of salinisation (see eg Table 6 in Barnett

(2000)). Large areas in the USE's north-west were incorrectly identified as affected or at risk of secondary salinity, although being saline for several thousand years (evidenced by gypsum deposits) but successfully used for agriculture.

- Barnett does not appear to have considered different soil types nor fresh water stratification of the groundwater in the assessments of land at risk of salinity (18, Barnett, 2000). Both exist in the USE. More porous, coarse textured soils have a lower capillary rise distance (<50cm), and so groundwater tables can be close to the surface without leading to dryland salinity (Seelig, 2000). Furthermore, low salinity groundwater close to the surface should reduce the potential for dryland salinity, although it could exacerbate waterlogging and adversely affect productivity during periods of high rainfall. This will have contributed further to the area of dryland salinity being <u>overestimated</u>. While noting that comprehensive coverage of aerial photography would provide a moderate to high level of confidence in the estimates, limitations are mainly related to the lack of detailed ground truthing and the complexity of dryland salinity (23, Barnett, 2000). Complexities listed include overlaps of primary (natural) and secondary (human induced) salinity, exposed subsoils that are not necessarily associated with raised groundwater levels, and seasonal changes that can cause rapid expansion or contraction of affected areas.

- On the second reading of the USE Bill, the Hon John Hill, the Minister for the Environment and Conservation, made the following comments (Hansard, 2002):

    - ".. there is no direct compensation in terms of a cash payment [for land confiscated under the terms of the Bill]. However, there is very much compensation in terms of added value to the land because, if we did not have this scheme in place, the **salinity would continue to increase** and the value of the land would decline. I have been told that, as a result of this scheme, **the productivity of the land will double**. There **will be 100 per cent increase in the productivity of land**. That is very strong compensation in an indirect form perhaps to those landowners. By and large, the majority of that money which is providing this direct benefit to those landowners is coming from the commonwealth and state funds, that is, the taxpayers of South Australia and the commonwealth are funding this scheme, and there is direct benefit to those individuals. So to say there is no compensation is a simplistic argument."

- The fundamental basis for the Program (ie watertables) was not re-validated in 2002 when the Program was review. It is even more incomprehensible that NAP managers (NAP, 2003) should approve a further $38.3 million of tax-payer's money to support Stage 3 completion with the following targets for the USE Program:

    - Resource condition targets (land salinity):

        - <u>Area of saline land to be reduced by 30%</u> within the drained area of the Upper South East by 2010 (22% achieved in 1998, so 30% probably achieved in 2000, without drains!!).

        - <u>Predicted rate of increase</u> in salinity across all other salinity affected areas in the Upper South East reduced by 50% by 2020 (probably achieved in 1993, without drains!!).

    - Management action targets (land salinity):

        - Determine the salt and water balance under perennial salt-land pasture in the Upper South East system by 2008.

        - Determine the salt and water balance under established production systems of the shallow groundwater system of the Lower South East by 2008.

        - 650km of drains completed by 2010.

        - Deep rooted perennial vegetation planted over 85,000 ha by 2007 (according to McEwan et al (2002), over 88,000 ha (considered to be a "gross underestimate) of dryland lucerne had been planted prior to Stage 3 approval, and over 131,000 ha of native vegetation was evident!!).

- NAP funding for the current USE Program was thus justified in 2003 with objectives of controlling and reversing trends in dryland salinity, which had been in natural decline since 1993!

## OTHER COMMENTS

- Of 188 public and government submissions returned, 29% supported the Plan, 36% had concerns with the Plan, and 35% had serious concerns with or opposed the Plan (NRC, 1994b). Most concerns were associated with the need for a groundwater drainage network, which had not been adequately justified. An independent review of the Plan (Semeniuk, 1993) concluded that analysis of hydrological trends and the justification for drains were unconvincing (now known to be valid criticism). A second review, including of the independent review, concluded that many aspects of hydrological data and modelling were deficient, and that "only surface drainage is necessary to sustain salt land agronomy" (Coffey MPW in Appendix 3, NRC, 1994a)!
- In 2003, Program staff sought "written acceptance of the proposed [drainage] works" in the northern catchment from affected landholders, but "lack of landowner support was highlighted by the fact that only 17 landowner agreement letters were returned from 35 sent, primarily because the depth of drain was perceived to be detrimental to agricultural production in the upper sections" (USE Program Board, 2003). Landholders in the lower sections were not consulted on drain depth. After revising the drain depth in the upper sections, construction then went ahead without seeking landowner acceptance!
- Disturbingly, northern catchment drains were designed using **subjective** assessments of run-off factors and catchment areas (USE Program, 2003)! The author has learned that drain on his property is 4 – 10X larger than it needed to be, given the catchment area and likely runoff. This has result in higher construction costs, greater footprint, and will attract greater recurring (ie maintenance and future capital costs.
- Clay sub-soils approximately 0.5m below the surface is preventing significant groundwater drawdown, obstructing leaching of salts, and will probably become sealed (and increase waterlogging) as sodic soils disperse. Sodic drain banks experience fresh water erosion, leading to undercutting, and drain water turbidity.
- Many landholders will not benefit economically from the Program, and yet are required to pay 25% of its capital cost, and presumably all future recurring costs. Under current levy-paying arrangements, less productive northern catchment properties are subsidising more productive central and southern catchment properties, and new recipients of drains in the lower levy paying districts to the east are being subsidised by northern, central and southern catchment landholders! McEwan’s (2002) recommendation to review levy arrangements to make them more equitable was ignored by the USE Program.
- The author remains convinced that landholders and taxpayers are not receiving value-for-money from the USE Program.
- Simple arithmetic shows that revegetating the northern and central catchments of the USE with 140,000ha of perennial pastures would have intercepted and transpired more water (>70GL pa) than the drainage network is designed to carry (63GL pa), at lower initial (<$35million) and through-life costs, and which would have provided an immediate and direct return to landholders (~$12million pa increase in gross margin).

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