Chap 1 The Issues

The three key issues in the Goulburn Broken dryland are:

- *area of land affected by high water tables,*
- *stream salt loads, and*
- *stream salinities.*

High water tables will affect large areas of the Goulburn and Broken plain, with the Broken plain worst affected. Across the dryland, over the next 100 years, up to 135,000 hectares of land will be affected by dryland salinity. It is expected that the greater part of this will remain in the landscape.

High stream salinities are an ephemeral problem in the catchment, with a few streams of high EC, usually late in summer.

A major task in the next three years is to identify the natural and built assets at risk from the threatening process of dryland salinity and the probable impact on asset values given the projected increases in dryland salinity and the resilience of the assets.

In the Goulburn system mean EC is expected to increase by 24 EC units if nothing is done to manage the problem. In the Broken the expected increase is 133 EC, a doubling of current levels. There is limited capacity to manage these EC levels using dilution flows. The primary task, then, is to prevent the salt reaching the streams, either by lowering recharge rates or intercepting salt before it reaches the streams.

The dominance of regional groundwater flow systems in the Broken Plain means it will be very difficult to counter the expected increases in dryland salinity and stream salt loads in this area. Managing salt in the landscape will become an important part of land management in the future in this area.

Most gains in reducing salt loads will be made in areas such as the south west Goulburn and Broken Highlands where there is a predominance of local and intermediate groundwater flow systems.

The management of dryland salinity influences and is influenced by other key natural resource issues. These include water quality, soil acidity, water supply, native vegetation and biodiversity, and pest plants and animals. The integration of planning and work activities will be improved over the next three years to ensure that multiple benefits are realised and key assets across the catchment are protected and, where possible, improved.

Dryland salinity in the Goulburn Broken Catchment

The salinity problem can be defined in three ways:

1. The area of land affected by high watertables and groundwater discharge, or land salinised as a result of salt accumulating in the surface layers of the soil. This is mostly a concern to the affected landholders and the catchment community. High water tables are where groundwater is within 2 metres of the soils surface.
2. Stream salinity, or the concentration of salt in waterways and water resources. Stream salinity is of principal concern to the catchment community, as it directly affects their use and enjoyment of the water resource. Stream salinity is measured by EC units, a measure of the electrical conductivity of the water which increases as the sal t content increases.
3. Salt loads, or the total amount of salt exported from the catchment. Salt loads are more relevant to downstream communities and water resource users, because of implications for the condition of the River Murray. Salt loads are measured in tonnes of salt passing a given point over a given time-usually days or years.

High Watertables and Dryland Salinisation

The original Goulburn Broken Dryland Salinity Management Plan predicted that the area of salt affected land in the Dryland would increase from an estimated 3,500 ha in 1989, to 38,000 ha over a 30 to 50 year timeframe. The broader impacts of high watertables and waterlogging were not identified.

It is now estimated that more than 6,000 km^2 will be affected by high water tables in the Goulburn Broken catchment by the year 2100. Slightly more than 80% of this will occur on the Riverine Plains. High water tables will lead to waterlogging, salinisation of low parts of the landscape, and increased salt accession to streams.

The major problem will be in the Broken and Goulburn Plains, with at least 20% and up to 40% of the area potentially affected by water logging. This will reduce agricultural productivity and limit production options, further reducing the viability of farms. Increased waterlogging will also lead to higher maintenance costs on roads and drainage, and affect buildings and infrastructure around towns, including Yarrawonga, Violet Town, Benalla and Euroa.

High water tables and waterlogging will affect native vegetation and biodiversity values across the lower-lying areas of the Plains. In particular, the hydrological regimes of wetlands will be altered, with a consequent changes in their function and values.

Much work is still required to determine which parts of the landscape affected by high watertables will eventually become salinised. A conservative estimate would see between 15,000 and 20,000 hectares of land highly salinised, equivalent to 7.5% of the arable cropping and grazing country in the Riverine Plains area being rendered unsuitable for any form of conventional production.

Saline groundwater will cause accelerated depreciation of infrastructure, including roads, bridges and culverts as well as buildings. Townships in the Plains area, including Yarrawonga, Violet Town, Euroa and Benalla are already at threat. Remnant vegetation on the riverine plains has a high intrinsic value because it is already highly depleted. The maintenance of existing stands of native vegetation are a high priority for the environmental value they serve. Much of this remaining vegetation is along watercourses and floodplains where the risk of salinisation is greatest.

The condition of the Murray River and the supply of water to Adelaide is measured at Morgan in South Australia. At present salt loads from the GB catchment are around 260,000 tonnes a year which is responsible for an increase of 24 EC in the Murray River at Morgan. This is up from the original estimate in 1989 of 186,000 tonnes and 15 EC.

Impacts of Salinity on Assets in the Goulburn Broken Dryland

Natural assets

Soils

The structure and function of soils is severely altered by waterlogging and high salt content. Both conditions can induce physical and chemical changes to the soil.

Water logging is currently a seasonal problem across large areas of the Riverine Plains, particularly in cropping country. With the projected expansion of high watertable areas across the Plains, water-logging will become more prevalent. This will affect soil structure and aeration, and reduce agricultural productivity. Water-logging will also lead to compaction, reduce trafficability, and increase surface runoff.

Once soils can no longer be flushed of excess salts, their productive capacity is severely reduced and they are rendered useless for conventional production activities. More than 15,000 hectares of land is likely to be severely salt affected. This has the potential to greatly increase soil erosion, and salt and water run off to streams. Saline throughflow and interflow in dispersive soils will increase gully and tunnel erosion, and destabilise stream banks, leading to increase sediment loads and siltation in waterways.

Waterways

It is projected that an additional 165,000 tonnes of salt per year will be mobilised in the catchment. Much of this increased salt load will reach the region’s waterways, either directly by groundwater baseflow into streams, or through surface wash-off. Many seasonal streams will flow for longer periods as they become dominated by saline groundwater, with likely severe impacts on aquatic biodiversity. Groundwater seepage will increase the risk of destabilisation of stream banks, leading to increased sediment loads and siltation.

The waterways at greatest risk are those on the Riverine Plains, and those flowing through the Plains-Upland interface along the foot of the Strathbogie Ranges. These are the areas where the risk of dryland salinity is highest and where most salt will be mobilised in the future. Many of the streams in this zone already suffer from seasonally high salinities. More work is required to fully understand the impacts of increased salinities and shifts in timing of flows on aquatic ecosystems and stream condition.

Many of the waterways in the upper-mid catchment that flow in local and intermediate groundwater flow systems are unlikely to degrade severely. However, there is some potential for reduction in runoff (dilution flows) to streams through extensive revegetation in these zones.

Biodiversity

The magnitude and potential extent of the salinity problem in the Goulburn Broken Dryland threatens to have a major impact on the biodiversity of the more seriously affected areas of the catchment, leading to a reduction in the complexity, diversity and functions of ecosystems.

Much of the remnant vegetation across the Riverine Plains is of severely depleted vegetation types. Remnant vegetation on the lower-lying parts of the landscape, on the floodplains, in wetlands, and along waterways, is particularly at risk from rising watertables. This will affect stream condition and further accelerate the degradation of aquatic habitats. Further loss of vegetation and biodiversity in the Plains zone will degrade the capacity of natural ecosystem to support essential landscape functions.

In the upland areas where dryland salinity is more localised, biodiversity impacts will be less severe.

Economic assets

All investors in the catchment and its infrastructure are likely to be affected by changes wrought by salinity. The rise in dryland salinity will force more resources to be channelled into maintenance costs for buildings, roads, bridges and utility services. In the more seriously affected areas, it will force wholesale change in land use or lead to highly degraded environment with flow on impacts to other natural assets and infrastructure. Areas of the Riverine Plains are likely to be most affected, including the towns of Euroa, Violet Town, Yarrawonga and Benalla.

The efficiency of investment in the catchment will be reduced as funds are diverted from otherwise more productive options to compensate for accelerated depreciation of infrastructure.

There will be as yet unrealised benefits as the emerging problems brings about innovative solutions and alternative land uses that would otherwise not be considered or justified. These include salt harvesting and saline aquaculture. There will also be benefits from alternative forestry and farming systems adapted to changed soil conditions and focussed on more effective use of ground and surface water.

Social assets

Regional communities are currently under enormous pressure from global and national forces. These include continued decline in terms of trade, changing employment patterns, migration of young people to urban centres, enhanced lifestyle expectations, and a steady reduction in Government and business services to regional areas (affecting schooling, banking and the quality of service delivery by utilities).

Natural resource degradation has a marginal impact within this broader context. It adds to the pressures facing rural communities, particularly where it:

- reduces the opportunities for enterprises to continue to improve production;
- adds to the costs of production or service delivery;
- diminishes service availability as population diminishes; or
- forces unwanted change in land use and lifestyle, either directly by reducing enjoyment of lifestyle or landscape, or indirectly through changed community standards for ‘accepted’ land management practices.

Dryland salinity will increase the costs of maintaining infrastructure and service delivery to regional communities. It will exacerbate the current problem of the declining condition of road networks and associated infrastructure. By reducing productivity in some areas, it will reinforce the need for off-farm employment, and further reduce the viability of medium- to smaller-sized farms, adding to family pressures. The threat of dryland salinity is likely to affect land values in some areas. It will lead to increased rates and charges by local government required to recoup the additional costs of infrastructure maintenance. The rate burden on the urban population will increase. Such increases in costs will have a ripple effect on the provision of other services, as resources are increasingly allocated to maintain the status quo.

Stream salinity and salt loads

For the purposes of salinity management, the Goulburn Broken Dryland can be sub-divided into five sub regions.

Goulburn River catchment:

1. Goulburn Highlands - from the headwaters upstream of Lake Eildon to Trawool
2. South West Goulburn - from Trawool to the Goulburn Weir
3. Goulburn Plains - from Goulburn Weir to the River Murray

Broken River catchment:

4. Broken Highlands - from the headwaters upstream of Lake Nillahcootie to Casey's Weir
5. Broken Plain - from Casey's Weir to the Goulburn River at Shepparton.

Goulburn Highlands

The Goulburn Highlands above Lake Eildon remains mostly forested. The major tributaries downstream of Eildon are the Rubicon, Acheron, Yea and Murrindindi Rivers and the King Parrot Creek. It is an area of high runoff and moderate salt generation rates. On average, each hectare generates 14 tonne/km^2 of salt and current stream salt loads are 114,000 tonne/yr.

South West Goulburn

The South West Goulburn includes the reach from Trawool to the Goulburn Weir at Nagambie. The main tributaries in this section are Dabyminga, Sugarloaf, Sunday, Gardiners, Mollison and Whiteheads Creeks.

The area is predominantly cleared (80%) with thin granitic soils and high salt stores. Salt generation rates are very high (31 tonne/km^2) and around 1/3rd of the salt in the Goulburn Broken system originates in this sub region. Current stream salt loads are 92,000 tonne/yr.

Goulburn Plains

At present, the Goulburn Plains contributes only low to moderate salt loads into the Goulburn River. Salt load generation rates are around 11 tonne/km^2 and current stream salt loads are 19,000 tonne/yr. This reach includes the influences of events at the interface between the Strathbogie Ranges and the Goulburn Plains. The main tributaries are Hughes, Creightons, Castle, Seven and Honeysuckle Creeks. Projections suggest the area is likely to generate very high saltloads from rising watertables, particularly at the interface between the Plains and the Strathbogie Ranges. The Goulburn Plains includes the Heartlands study area.

Broken Plains

The Broken Plains currently generates comparatively little salt to the Goulburn-Broken system. Salt generation rates are 7 tonne/km^2 and the current stream salt load averages out at 22,000 tonne/yr. It produces, at present, the lowest amount of salt per square kilometre in the whole catchment. This area was identified in the work by SKM (DNRE 1999) as the sub region likely to generate most of the increased salt loads over the next 100 years, as watertables rise to within 2 metres of the surface over between 20 and 40 per cent of the area.

Broken Highlands

The Broken Highlands remain moderately afforested. This, and the comparatively low flows, mean that the area is not a major source of salt. Over the next 50-100 years there will be increased salinisation in valley floor and break of slope locations in some landscapes. The average salt generation rate is 11 tonne/km^2 and the average stream salt load is 13,000 tonne/yr.

Table 1 Flow and salt load data, saltload generation rates, and impact on EC at Morgan, for Goulburn and Broken catchments and sub regions

Sub Region	Area of catchment	Area cleared	Mean Flow	Total stream saltload	Mean salinity in catchment	Salt load generation rates	EC impact at Morgan

	km^2	%	ML/yr	(tonne/yr)[1]	EC	Tonne/km^2	EC units[2]
Goulburn Highlands	8,388	50	3,298,452	114,043	72	14.0	10.15
South West Goulburn	2,975	80	445,302	91,704	430	31.0	8.48
Goulburn Plain	1,798	87	265,877	18,933	149	11.0	3.02
Broken Plains	3,036	92	241,868	21,104	169	7.0	2.60
Broken Highlands	1,798	66	248,457	13,232	98	11.0	3.19
Total Goulburn	13,161	62	4,009,631	224,680	117	17.43	18.44
Total Broken	4,834	82	490,325	35,336	133	8.49	4.18
TOTAL	**17,995**	**67**	**4,499,956**	**259,016**	**90**	**15.03**	**22.62**

[1] Data from GBD Catchment Salt and Water Balance study (SKM 1996)
[2] Estimated from relationship used in Ultimate Salt load study (SKM 1999)

Trends

An analysis of trends in stream salinities and salt loads provides the background information on which the appropriateness of end of valley and within valley targets can be analysed. The South West Goulburn, Goulburn Highlands and Broken Highlands are dominated by local and intermediate groundwater flow systems, and so it would be expected that they would have reached hydrologic equilibrium, or be very near to in the case of the slower-responding intermediate systems. In contrast, the Goulburn and Broken Plains are dominated by regional groundwater flow systems, and it may be many decades before hydrologic equilibrium is reached.

Goulburn Catchment

Above Eildon

Salt loads at Eildon are around 20 tonnes/day at 45-50 EC. There is no clear trend in the data as might be expected for heavily afforested catchments. Even the dry period from 1995 has not shown up in the trends.

There is limited data on tributaries in this section of the river. What data is there shows high variability with high salinities and low flows.

Eildon to Trawool

Salt loads past this section are 250-300 tonnes/day at 60-75 EC. There is little variation in the salinity and residual salinities of around 10 EC indicate the base flow contribution by tributaries. Flows from Eildon make up between 10 and 100% of the flows at Trawool and the salinity regime reflects this. The highest salinities correspond to periods of low release (winter) when salinities in tributaries are lower because of the effect of dilution.

Trawool to Murchison

This reach has shown a decrease in loads since 1990, down by 80 tonnes/day to 200 tonnes/day or 50 EC in that time. There is a complex area with diversions at Goulburn Weir and inputs from the South West Goulburn. Flow regimes at Trawool are up to 40 times greater than at Murchison, largely because of the diversions at Goulburn weir. The complexity means that the loads and concentrations are poorly correlated and are highly variable. Around to 6-25% of loads originate as base flow or from the tributaries of the South West Goulburn. The proportion increases as loads at Murchison decrease which supports the view that tributaries at higher reaches have the greater effect on stream EC.

Murchison to McKoys

This reach receives flows from the Strathbogie ranges and the Goulburn plains. It also passes through the Shepparton Irrigation Region (SIR) with the consequent impact of drainage returns. Estimated mean load increase from between 200-280 tonnes/day at Murchison to 540-400 tonnes/dayay at McKoys. The data shows a downward trend, probably commencing around 1989.

Tributaries

The gauging stations are not well placed to describe processes in this reach of the river. All come under the influence of other processes further back from the main stem. The figures indicate that this area is not a major contributor of salt to the Goulburn at present. In the future the dryland part of this area will be strongly influenced by outbreaks of salinity in the Plain-upland interface

Broken Catchment

Mean stream salinity increases along the river from Moorngag to Rice's weir by about 20 EC. The decrease in EC between Katamatite and Rice's weir is caused by irrigation drainage returns.

Salt loads increase along the length of the system. The high salt loads at Gowangardie are likely to result from the local influence of irrigation. The situation at Katamatite arises when water is diverted from higher up in the system and returned in irrigation drainage below Katamatite

Moorngag to Casey'

The smoothed salinity trend at Moorngag has stayed constant since 1983 following a decline in the preceding six years. At Casey's weir the salinity has increased since 1990.

There has been an increase in the salinity difference between Moorngag and Casey's of 10 EC from the mid 1970's to 80 EC in the late 1980's. Analysis shows that the salt load at Moorngag is not a good predictor of the salt load at Casey's weir.

Casey's Weir to Katamatite

While salinity at Casey's weir has been increasing the trend at Katamatite is stable. Since the late 1980's these has been a decrease in salinity from Casey's weir to Katamatite. Diversions between the two stations means there is little correlation between the loads or stream salinities. The flow at Casey's is greater that that at Katamatite for long periods of time

Katamatite to Rice's Weir

There is little difference between the salinities in this reach of the system although the time series analysis shows that there can be very large differences, with salinity in the upstream section frequently higher than that lower down.

Mean flow at Rice's Weir is significantly higher than mean flow at Katamatite, the result of drainage returns from the irrigation region. This leads to salt loads at Rice's Weir being much higher than at Katamatite.

Projections

The potential extent of the dryland salinity problem is described in the report "Prediction of the Ultimate Salt Load from Victorian Dryland Catchments to the Murray River (DNRE, 1999), otherwise referred to as the Ultimate Salt Loads study. The projected increase in area affected by dryland salinity and impact on stream saltloads from this study can be considered a worst case scenario.

The total area of high water tables in the catchment is anticipated to increase from 1,170 km^2 at present to 6,600 km^2 by the year 2100.

There are two areas of primary concern - the Riverine Plains and the Plains-Upland interface along the foot of the Strathbogie Ranges. The area of the Riverine Plains with high water tables is predicted to expand from 0 to 2,800 km^2. The area of high water tables in the Plains-Upland interface is projected to increase from around 130km^2 to 350 km^2 (Figure 1).

Across the dryland, 135,000 ha will be severely salt affected. A further 500,000 ha will be moderately to severely affected. This increase in dryland salinity will result in an additional 160,000 tonnes of salt being mobilised to the land surface (MDB Audit, 1999). Much of this salt will be retained in the landscape.

The salt that does reach the streams will cause:

- an increase in stream salinity in the Goulburn River at the Goulburn Weir by 20 EC (up from 120 EC currently to 140 EC by 2100),

- a doubling in the Broken River at Casey's Weir (up from 130 EC currently to 270 EC by 2100), and
- an increase in the Murray River of 100 EC (up from 130 EC currently to 230 EC by 2100).

The management of these projected changes in the condition of the catchment will be the focus of the Goulburn Broken Dryland Salinity Management Plan for the foreseeable future.

It has to be recognised at the outset that there is little that can be done to manage the development of discharge on the Riverine Plains area. The very large area involved, and the slow response time of the regional groundwater flow systems, mediate against any effective action to control watertable rise other than engineering options. Such measures can only be justified to either protect high value assets or as part of a Basin-wide strategy of salt interception works. Work in this area needs to concentrate on living with salt and developing profitable farming systems that complement a vastly altered landscape.

The management of stream salt loads will need to focus on the South West Goulburn and the Plains-Upland interface, and to a lesser extent the Broken Highlands.

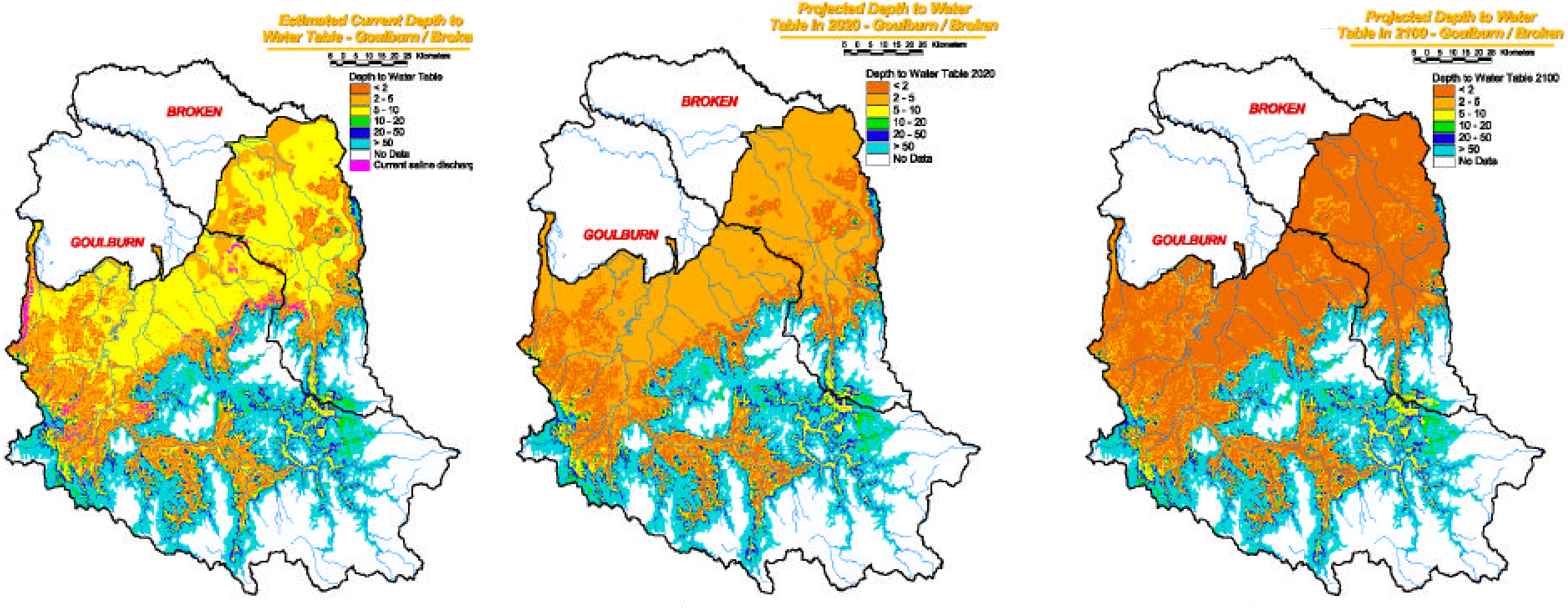

Figure 1 Change in depth to water table to the year 2100 (SKM, 1999)

Relationships to other Natural Resource Management issues

Water quality

Excess salt is clearly a water quality issue. It adversely affects in-stream habitat for many aquatic and riparian species. Dryland salinity also impacts on waterway health by increasing rates of soil erosion in catchments, and along stream banks and beds.

The effectiveness of recharge management for improving in-stream condition depends largely on the connectivity between the recharge zones and the streams, and will vary across the catchment. Work is currently underway to provide a better understanding of connectivity across the landscape, and the impact of salinity on aquatic ecosystems.

Salinity mitigation works to reduce salt accession to streams (eg. revegetation of stream buffer strips) will have obvious benefits for other water quality issues. Areas where priority zones for salinity and waterway health are likely to correspond include the Goulburn and Broken Highlands and the South West Goulburn. The association between waterway health and salinity priority zones will be investigated over the next 18 months.

Soil acidity

Soil acidity has already had a significant impact on the salinity program in the Broken Highlands by limiting the area suited to lucerne and perennial pastures. This is likely to be an increasing problem with the area of low pH soil projected to increase significantly over the next 50 to 100 years. It is of particular concern where low pH soils are expected to expand into the lower rainfall zones of the catchment, since these areas are where pasture-based solutions are more likely to be adopted than the option of high density trees.

The major challenge for management of low pH soils is the insidious nature of the problem. Plant water use efficiency can be severely reduced before the more obvious signs of soil acidity, such as the emergence of indicator species, present themselves. This has implications for the effectiveness of proposed solutions for the salinity problem based on high water use by vegetation. Much of the high priority area along the Plains-Upland interface has naturally acidic soils with low buffering capacity. There is a tendency to further acidification, even under native vegetation, albeit at much lower rates than under high-risk practices such as annual pastures, cropping and horticulture. It is important to make an assessment of the risk posed to the successful management of dryland salinity by acidification of the landscape.

Water supply

Management of water supply is equally as important as water quality. The impact of large-scale land use change on water supply for downstream irrigated agriculture or environmental flows need to be considered carefully. The implications of revegetation on catchment water yield are being investigated as part of the National Action Plan for Salinity and Water Quality, for each sub catchment in the dryland area. This issue will be an integral part of the community planning process for setting salinity management targets. By necessity, such planning will extend to the irrigation community through the agency of the GBCMA.

The supply of water in the Goulbum catchment is dominated by catchment yield upstream of Eildon, an area not targeted for salinity remediation works. Most of the area targeted for extensive revegetation occurs in the lower rainfall areas, where runoff is much lower, and reduction in runoff following revegetation is less. Because of this, it is unlikely that revegetation works carried out in the catchment for salinity control will seriously threaten downstream flows. The main concern from revegetation in this instance is some localised impacts on stream salinity, as a result of short-term loss of dilution flows. The GB Salinity Program will link to the work carried out under the Catchment Characterisation project to estimate the effects of revegetation on stream salinity and salt loads.

Native Vegetation and Biodiversity

There are already close associations between biodiversity programs and the salinity program in the Goulburn Broken Dryland. The Environmental Management Grants system determines rates of incentives for revegetation and vegetation protection works based on combined salinity and biodiversity priority criteria. All non-commercial plantings are carried out within the guidelines specified in the Goulburn Broken Revegetation Guide. It is anticipated that the Salinity Plan will also utilise information developed from the Bioregional Planning process wherever possible.

The Plan is also working towards the integration of biodiversity principles into commercial plantings, including the strategic placement of corridors and buffers of native vegetation within commercial plantations.

Pest Plants and Animals

The management of pest plants and animals is an important issue for the catchment community. Areas of native vegetation can be harbours for weeds and vermin, if not managed appropriately. Rabbits can severely limit the success of revegetation and natural regeneration. There is considerable scope to manage pastures throughout the region for the combined objectives of productivity, weed control and recharge management. Appropriate rotational grazing systems, which promote the spread of perennial species, can be a highly efficient weed control strategy.