UNDERSTANDING AND PREVENTING IMPACTS OF SALINITY ON INFRASTRUCTURE IN RURAL AND URBAN LANDSCAPES

Dr Suzanne M. Wilson
(Wilson Land Management Services Pty Ltd)

INTRODUCTION

Dryland salinity and rising saline watertables have long been recognised as a significant and worsening problem across many rural areas of Australia, reducing agricultural production and damaging the natural environment. However, it has become increasingly apparent that the full impacts of salinity are far more widespread in both our rural and urban landscapes, and causing extensive damage to our public and private infrastructure (Wilson 2003).

There is no comprehensive estimate of full impacts and costs of salinity on public and private infrastructure in rural and urban landscapes across Australia. However, recent research indicates that the impacts may be significant in some areas. For example, latest research place the current salinity damage cost to infrastructure located in the non-irrigation areas of the Murray-Darling Basin at around $206 million per annum (Wilson 2003).

Clearly, a good understanding of the full impacts and costs of salinity damage to infrastructure will be essential if we are to identify the extent, severity and cost of the problem, and to set priorities and strategies for managing the problem across our rural and urban landscapes.

The purpose of this paper is to outline the nature and importance of salinity impacts on infrastructure, and to discuss the implications of these impacts for the future management of salinity in our urban and rural landscapes. The paper begins with an overview of the extent of salinity in our rural and urban landscapes. This is followed by a description of the nature of salinity impacts on various types of infrastructure, and the various stakeholder groups who may incur costs from this damage. The paper concludes with a discussion of the importance of infrastructure damage to total salinity damage across our landscape, and the implications of these findings for on-going salinity management in our urban and rural areas.

WHAT IS THE EXTENT OF SALINITY IN OUR RURAL AND URBAN LANDSCAPES ?

We still do not have a comprehensive estimate of the full extent of salinity across Australia's rural and urban landscapes. However, recent modelling conducted as part of the National Land and Water Resources Audit suggest that the area of the Murray-Darling Basin and several coastal catchments subject to watertables less than 2m below the soil surface (and hence at risk from salinity) was 180,600 hectares in 2000. This area has the potential to increase to 579,224 hectares by 2020 and to 1,300,807 hectares by 2100 (NLWRA 2000).

There are a further 220 rural towns and cities located within the Murray-Darling Basin that are currently known to display urban salinity problems linked to high saline watertables. There are also likely to be many other towns where the current problems are less well known, or that are likely to develop serious problems in future years (Wilson 2003).

THE NATURE OF SALINITY IMPACTS ON INFRASTRUCTURE

The impacts of salinity on infrastructure in both urban and rural landscapes fall into two main classes:

- those caused by saline water supplies; and
- those caused by saline watertables that have risen close to the soil surface.

Saline water impacts on infrastructure

Saline water supplies lead households to incur higher costs on plumbing infrastructure (including water pipes, taps and shower rosettes), hot water services, water tanks, water filters and domestic water softeners (GHD 1999). It also leads commerce and industry to incur higher costs on water coolers, boilers, water supply infrastructure, water treatment plants, and industrial water treatment (including food and beverage preparation, paper production, and electroplating). (PPK 2001). A more detailed description of these impacts, together with cost functions that describe the relationships between the salinity level of town water supplies and costs imposed on households, commerce and industry, can be found in the report by Wilson and Laurie (2002).

High saline watertable impacts on infrastructure

High saline watertables can cause adverse impacts on public and private infrastructure located in our urban and rural landscapes including:

- roads (including gutters and culverts) and bridges;
- stone and brick buildings;
- footpaths, driveways and other concrete structures;
- water, stormwater and sewerage systems;
- powerlines, fences and other steel structures; and
- railway lines.

Roads and bridges

Most roads and bridges have been designed for sites with a dry sub-soil and a low frequency / duration of soil saturation. Where groundwater saturates the soil within 2 metres of the surface, the foundation often deteriorates rapidly causing a breakdown of the base and deterioration of the surface (Hamilton 1995).

This deterioration in the road surface occurs because the downward pressure applied to the surfaces, especially those subject to frequent truck use, penetrates to a depth of 1.5 m or more. When the subsoil at this depth is saturated, there can often be considerable movement of the sub-soil, especially if this sub-soil has a high clay content. This sub-soil movement is frequently transmitted upwards through the road base, and eventually results in localised 'heaving' of the road surface, followed by cracking of the bitumen surface, complete break-up of the road itself, and further penetration of surface water into the road foundation (ACTEW 1997; Wooldridge 1998). The end result is premature road failure, more frequent and costly maintenance, or a combination of both.

However, there are numerous factors that ultimately influence the impact of high saline watertables on roads and bridges, including:

- the intensity of use;
- rainfall;
- groundwater level and salinity concentration;
- soil type;
- method and material used during construction;
- quality of the road drainage;
- elevation of the road above the surrounding area; and
- condition of the bitumen seal (Hill 1999).

Buildings and other concrete structures

High watertables can often bring moisture and salts close to the foundations of houses and other buildings. This periodic wetting of the foundations may cause rising damp where the groundwater is drawn into the brick, stone or cement by capillary action (Salt Action 1997).

The extent and severity of a rising damp problem will depend on the materials used, the amount of moisture and salt present, the amount of evaporation, and the effectiveness of any damp-proof barrier (these barriers are designed to prevent moisture moving from the foundations to the walls of the buildings).

Salinity and rising damp damage to houses and other buildings is most noticeable when the damp-proof course is absent (common in older houses), broken (common in houses with renovations), or bypassed. Bypassing the damp proof course is the most common, and can be caused by:

- adding new floors;
- rendering the outside of the building;
- installing raised paths next to walls; and
- accumulation of topsoil or garden mulch against walls (Salt Action 1997).

As the building materials undergo periodic wetting and drying cycles, salt crystals often grow within the confined pore spaces. In severe cases, these crystals can cause deterioration of the brick, stone and cement, and can result in cracked bricks or stone, mortar turning to dust, and cement render flaking off internal and external walls (Spennemann 1997).

While salinity damage to houses and buildings is often a very visible impact of salinity, other brick and concrete structures found extensively in urban areas can also be affected. These include footpaths and bicycle paths, paved or cemented areas, and driveways.

Underground water, sewerage and septic systems

Rising saline watertables is the main cause of corrosion to underground concrete, cast iron, brass, copper and galvanised iron water pipes and fixtures. When any such corrosion occurs, it can substantially increase the maintenance costs and reduce their useful operating life (Wilson and Laurie 2002). Any leakage of water from rusted pipes can also substantially increase the amount of recharge to groundwater in the urban areas, hence exacerbating the problem. In the urban city of Wagga Wagga, for example, it is estimated that approximately 47 per cent of total groundwater recharge originates from leaking water pipes (Slinger 1998). In many cases, however, these leaks go undetected.

When the watertable rises, groundwater can often flow into underground sewerage systems. The end result is that additional, and often saline, water drains into sewerage treatment plants, resulting in increased plant operating costs, a decrease in treatment efficiency, and less opportunity for re-using the treated water for other purposes such as irrigating urban parks (Hamilton 1995, Wilson and Laurie 2002).

High watertables can also lead to a failure of septic systems. Failures can result from groundwater entering septic systems and/or poor function of 'rubble pits' which accept the processed outflows from the septic systems. The end result may be raw sewerage overflowing from septic tanks.

Railways, powerlines and other steel structures

There are a number of metal structures present in urban and rural areas that are prone to corrosion from high saline watertables. These include:

- railway tracks;
- surface mounted steel water storage tanks;
- underground steel fuel storage tanks;
- concrete power poles with internal steel reinforcing;
- underground cast iron gas supply lines and telephone cable casings;
- reinforced concrete structures and tower footings;
- underground power cables;
- steel lattice towers and hollow or concrete filled steel poles; and
- nuts, bolts, screws and flange plates (Electricity Association of NSW 1997).

Corrosion of metal structures can cause an increase in operating costs, an increase in maintenance costs, a reduction in expected lifespans, or a combination of all three. More importantly, system safety and reliability can be compromised, and the local environment can be contaminated if any spill of toxic chemicals occurs because of a corrosion-induced leak (Electricity Association of NSW 1997).

Miscellaneous

High saline watertables can also have an adverse impact on lawns, gardens, street trees, sporting fields and parklands. The symptoms are often the same as for agricultural production, and can include the decline or death of the salt-sensitive turf, shrub and tree species, and waterlogged playing areas. Depending on the severity of the impacts, some areas may no longer be suitable for their intended use and may be either downgraded or abandoned. Soggy backyards can also be found where rubble pits associated with septic tanks are no longer functioning effectively.

To address this problem, households, businesses, and local governments often apply higher rates of fertiliser and seed in an attempt to mask the adverse impacts of 'sick' lawns, replace salt-sensitive shrubs and trees with more salt tolerant species, or install sub-surface drainage to lower the watertable. In worst-case scenarios, the affected areas are simply covered up by landscaping such as concrete or brick and clay pavers, often at a considerable cost.

Similarly, high watertables can also cause problems with cellars and grain silo loading hoppers located below ground level. These structures frequently fill with water and require continuous pumping, all of which are associated with on-going costs for the owners or managers of this infrastructure.

THE STAKEHOLDERS AFFECTED

Salinity damage to infrastructure affects a large number of stakeholder groups living and working in our rural and urban landscapes. The groups considered most at risk include:

- urban and rural households;
- farmers;
- commercial and industrial businesses;
- local governments;
- state government agencies responsible for the management of major infrastructure;
- water, gas and electricity suppliers; and
- road and rail authorities (Wilson 2003).

As noted earlier, salinity may also adversely affect natural terrestrial and riparian environments, and places of natural, historic, cultural and aboriginal significance.

THE NATURE OF SALINITY DAMAGE COSTS

The damage costs of salinity caused by both high saline watertables and saline water supplies in our rural and urban landscapes may be grouped into one or more of the following categories (Wilson 2002).

<u>1. Increased repair and maintenance costs.</u> These relate to the *additional* cost of maintaining assets in an undamaged state in saline areas. For example, if the annual cost of maintaining a sports oval increases from $20,000 to $25,000 due to salinity, the repair and maintenance cost attributable to salinity equals $5,000 per year.

2. Increased costs from the reduced lifespan of infrastructure. These relate to the cost of replacing infrastructure earlier than normal because of damage caused by the wet and/or saline conditions. For example, a council usually resurfaces sealed roads every 15 years, but must do this 5 years earlier in those areas affected by salinity. This imposes an additional cost on the council and the community.

3. Increased operating costs. These relate to the cost of using additional goods and services to overcome the adverse impacts of saline water supplies and high watertables. It may, for example, relate to the need to replace industrial chemicals more frequently.

4. The value of income foregone. This relates to the reduction in net income to stakeholders because of salinity. Most commonly, it involves agricultural production foregone on saline farmland, although it may also involve other areas, such as reductions in rates revenue to local governments due to lower property values of salinity-affected rural and urban properties.

In many cases, these costs will not occur independently. For example, a high saline watertable under a particular stretch of road may reduce the time before major reconstruction is required, as well as increase the ongoing funds needed to maintain the road in an acceptable condition.

The presence or threat of salinity may also lead the various stakeholder groups to allocate funds to implement salinity-related preventative actions in an attempt to minimise current or future problems. This may, for example, include the up-front cost of purchasing rainwater tanks and pressure pumps, planting trees in recharge areas, or installing sub-surface drainage. This may also include the cost of undertaking salinity-related research, extension and/or education programs (Wilson 2003).

HOW SIGNIFICANT IS SALINITY DAMAGE TO INFRASTRUCTURE ?

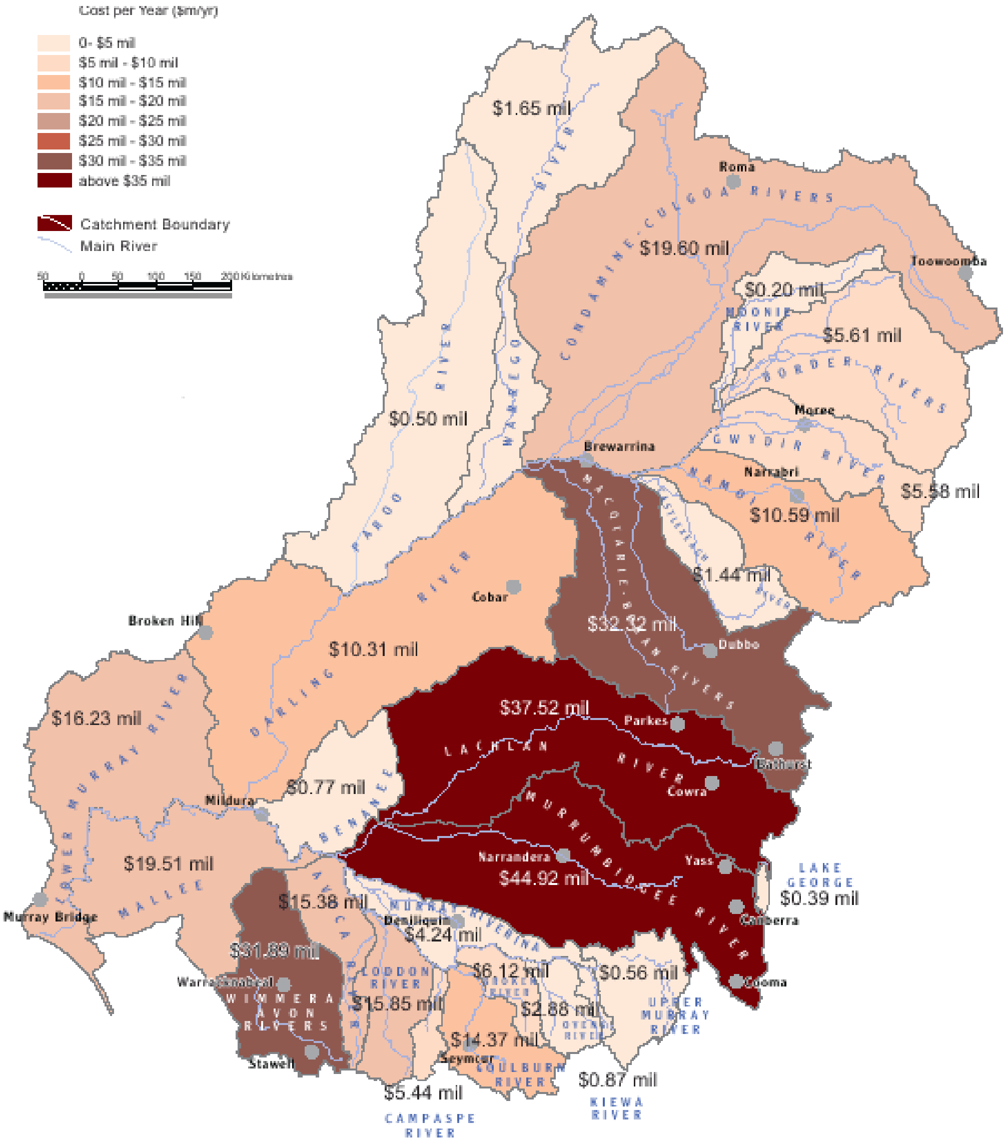
To obtain a detailed understanding of the full impacts and costs of dryland and urban salinity across the Murray-Darling Basin, the Murray-Darling Basin Commission and the National Dryland Salinity Program funded a major research project entitled '*Determining the full impacts and costs of salinity across the Murray-Darling Basin* (see www.ndsp.gov.au for information on this project). One of the key objectives of this project was to compile a detailed audit of the full impacts and costs of salinity to dryland agricultural producers, infrastructure, the natural environment and cultural heritage across all 26 major catchments within the Murray-Darling Basin.

This project has confirmed that the total cost of salinity damage in the non-irrigated rural and urban areas across the Basin is indeed a significant problem, currently costing the various stakeholder groups around $304.7 million per annum (Map 1). Damage costs are estimated to be greatest in the Murrumbidgee River catchment (at $44.92 million per annum), followed by the Lachlan catchment (at $37.52 million per annum) and the Victorian Wimmera (at $31.89 million per annum). As these cost estimates exclude the non-market impacts of salinity on the natural environment and cultural heritage, the true social cost is even larger (Wilson 2003).

This project has also confirmed that there are at least 220 rural towns and cities within the Basin currently displaying urban salinity damage to varying degrees (Wilson 2003).

Suprisingly, damage costs to dryland agricultural producers were found to represent only around 33 per cent of total Basin-wide costs. Rather, the largest costs were estimated to arise from damage to public infrastructure in the urban and rural areas, and by households, commerce and industry located primarily in the urban areas (Fig 1). This trend was also observed in the majority of catchments located within the Basin, with salinity costs to dryland agricultural producers only representing 50 per cent or more of total costs in only 8 of the 26 individual catchments investigated (Wilson 2003).

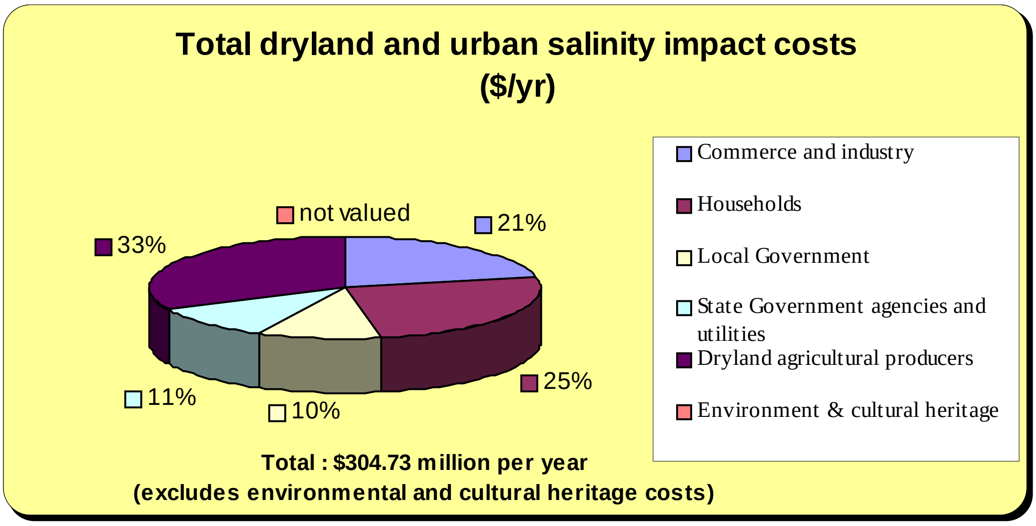
Map 1: Total current annual cost of dryland and urban salinity to key stakeholders across the Murray-Darling Basin ($mil/yr)



Notes: Figures include all estimated current impact costs to urban and rural households, commerce and industry, local governments, state government agencies and utilities and dryland agricultural producers, but exclude all costs of salinity to agricultural producers in irrigation areas, and to the natural environment and cultural heritage. Figures also exclude any costs of salinity to Adelaide, as this city is located outside the Murray-Darling Basin.

***Source*:** (Wilson 2003).

Figure 1: Breakdown of current dryland and urban salinity costs across the Murray-Darling Basin, by major stakeholder group



Source: Wilson (2003)

IMPLICATIONS FOR FUTURE SALINITY MANAGEMENT

The issues and results discussed above have a number of important implications for on-going salinity management across our urban and rural landscapes.

First, the results demonstrate that salinity is not just a 'farm-level' problem, causing a reduction in dryland agricultural production and lower property values. Rather, they have demonstrated that salinity is a far more insidious problem, with the majority of salinity damage being imposed on the various non-agricultural stakeholder groups owing or managing infrastructure located across our rural and urban landscapes.

Secondly, the number of rural towns and cities identified with an urban salinity problem is substantially higher than previously recorded. This revised information has important implications for:

- the people living and working in these towns;
- the relevant Councils whose rates may be affected by declining property values and who are responsible for managing public infrastructure in these towns;
- salinity policies and programs being developed for each catchment or region; and
- the focus of existing state and federal salinity management guidelines.

Thirdly, the results show that it is the cost of saline town water supplies to urban households, commerce and industry that make the largest individual contribution to total quantified costs across the Basin. This also has important legal and operational implications for:

- local governments and the water authorities or boards responsible for the management and supply of town water supplies; and
- state, regional and catchment salinity planning across our landscape.

Fourthly, the focus of most Regional Strategies and Local Action Plans at present is to address salinity problems in our rural areas. However, given the importance that urban salinity appears to make to total salinity costs, the results appear to have important implications for the majority of salinity programs and catchment plans being implemented across the eastern States of Australia.

Despite the apparent importance of urban salinity, there is still a general absence of definitive biophysical data available to underpin and support sound management decisions. A key recommendation from this work is therefore the need to better understand the causes, the consequences, and the management of urban salinity in our rural towns and cities. One potential model for this research is that used in Western Australia's Rural Town's Program.

The Western Australian Rural Towns Program was initiated in 1997 as an initiative of the State's Salinity Strategy and currently involves around 42 towns in the South West. The Program is managed under Agriculture Western Australia's Sustainable Rural Development Program, and helps communities in each town:

- identify the causes of their particular salinity problem;
- monitor groundwater levels and quality under their town,
- conduct an assessment of the current and likely future impacts and costs of their salinity problem;
- determine the costs and benefits of introducing various salinity management strategies; and
- identify treatments suitable to their town.

One of the reasons why urban salinity has generally not been included in catchment plans to date could be that communities and governments have generally believed that this issue can be dealt with through separate urban salinity management plans. This is true for some towns such as Wagga Wagga in NSW, where the urban salinity problem is generally self-contained and hence unrelated to groundwater recharge in the surrounding rural areas.

Unfortunately, for many other towns, the urban and rural areas are linked by common groundwater systems. Hence, failure to assess the full impacts and costs of both dryland and urban salinity in a catchment or region may:

- result in a substantial under-estimation of the net benefits from implementing salinity control works in the rural areas; and
- hamper the identification of equitable cost sharing arrangements to pay for the recommended on-ground works, and the prioritisation with which these on-ground works should be implemented.

Finally, there is ongoing uncertainty regarding the degree to which landholders will adopt the broadscale land-use changes recommended in many Local Action Plans. Even where broad landuse changes are implemented, many decades may be needed before any noticeable impact on salinity outbreaks can be realised in areas characterised by intermediate or regional groundwater flow systems. For these two reasons, there may be increasing merit in investigating the viability of engineering works – rather than broadscale land use change – to protect high value infrastructure from salinity damage in many of our rural and urban landscapes.

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