Secondary salinity status and assessment in Queensland, Australia

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Introduction

Secondary salinity (as against primary salinity) in Queensland has been the subject of anecdotal comment since the 1950s, and more serious investigation since the 1980s. Like the very nature of secondary salinity in Queensland, periods of research and investigation have been cyclic, usually coinciding with, or following wet climate phases.

The two major periods of work in Queensland were from the early 1980s to the early 1990s, and then from about 1999 onwards. During the first of these periods, the focus was on understanding salinity processes at the local scale. Many of these studies were published in the proceedings of a series of "Landscape, soil and water salinity" workshops around Queensland. Both irrigation and dryland salinity were covered, and the development of 12 conceptual models for the formation of dryland salinity was completed. These documents culminated in the Salinity Management Handbook (Salcon 1997), which remains a comprehensive resource on the topic in Queensland.

During the current period of work, the focus has shifted towards catchment/regional scale questions, methodologies and answers, with more focus on stream salinity. This has been in part driven by national initiatives such as the National Action Plan for Salinity and Water Quality (NAPSWQ), and the Murray Darling Basin Salinity Management Strategy (BSMS), both of which require targets to be set for a variety of parameters related to salinity, in particular end-of-valley stream salt load targets. As part of work related to these initiatives, the extent of secondary salinity in some parts of Queensland has been re-examined, and significant progress has occurred in the development of methods and models for predicting the future extent/severity of salinity.

Extent of secondary salinity

Considerable anecdotal evidence exists that the major phase of expression of dryland salinity in Queensland commenced in the 1950s. This was usually 50-80 years after clearing, but importantly at the commencement of a wet phase in the period 1950-1960. One of the affected areas was the "Traprock", an area of Permian metasediments in southern inland Queensland. In the 1960s, elevated chloride levels were recorded in upland streams impacting on the downstream irrigated tobacco industry near Inglewood (McNee and Skerman 1965).

Hughes (1979) provided the first review of salinity across Queensland, and this was followed by a number of local studies such as Thorburn (1989). Gordon (1991) provided a second review of the state, capturing digital location data for the first time, as well as a number of descriptive attributes e.g area affected, vegetation health etc. As part of a re-initiation of salinity activities in the Murray- Darling Basin, Biggs and Power (2003) updated the data of Gordon (1991) and others, and expanded the range of attributes described for each site. They confirmed the general observation to date that the extent of dryland salinity outbreaks was largely driven by climatic phase, and the extended drought had lead to a general reduction in the size and severity of many expressions. Biggs and Power (2003) also found small areas of irrigation salinity were widespread in the horticultural areas of the "Granite Belt", considerable interactions between civil infrastructure and both dryland and irrigation salinity in this same area, and presence of urban salinity in the town of Warwick. The area of salt affected land in the basaltic uplands of the Eastern Darling Downs had not increased.

Reconnaissance investigations elsewhere in southern Queensland at the time discovered widespread examples of urban salinity and other interactions with civil infrastructure, in particular roads, primarily in south-east Queensland. Elements of major infrastructure (highways, bridges, pipelines) are all affected by secondary salinity. Salinity has been noted in many urban settings, including Kingaroy, Beaudesert, Maryborough and Marburg.

R. Ellis (unpub) has collated data concerning salt affected areas from land resource mapping in southeast Queensland. While a significant step, this exercise was limited by the extent of the land resource data. Ellis and Bigwood (2006) studied a small catchment in south-east Queensland, mapping 654 hectares of dryland salinity. In central Queensland, Forster (2007) recently described the nature and extent of dryland salinity, documenting over 2200 ha of affected land, primarily associated with basalts east of Rockhampton. Webb et al. (2006) has continued studies into salinity in the Mareeba area, in far north Queensland.

Data concerning land affected by secondary salinity has recently been migrated to a single, state-wide database, allowing easier statistical and spatial analysis. The majority of sites are in agricultural lands of south-east Queensland, varying in size from square metres to many tens of hectares. Basalt/sandstone interface, catena form and catchment constriction form are amongst the most common. The current extent of land affected in Queensland (Figure 1) is estimated to be in excess of 50 000 ha, more than 40 000 ha of which is dryland salinity. While this does not represent a significant change from previously reported numbers, the accuracy of the estimate is greater. It is still however considered to be an under-estimate, as many catchments known to have salt affected areas have not been systematically studied. Furthermore, the extent and severity of sites is expected to increase following the next wet climate phase.

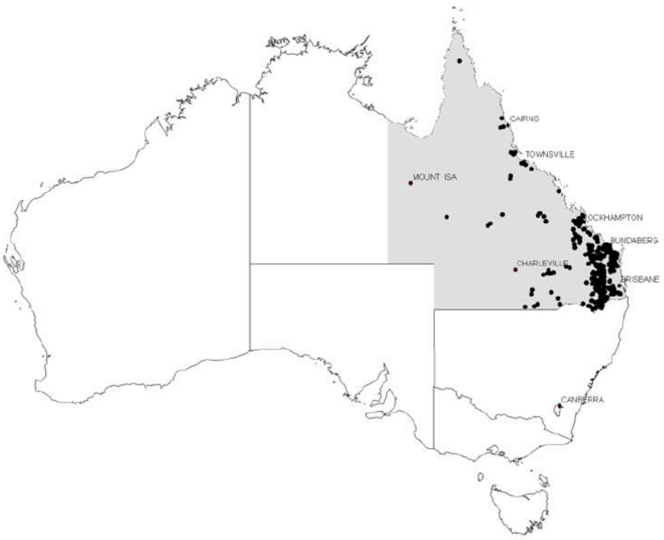

Figure 1 Location of salinity sites in Queensland

The importance of excessive deep drainage under irrigated lands and the potential for irrigation salinity was highlighted by a number of researchers in the last 5 years and is discussed further by Brough et al. in this Forum. Other works such as Biggs et al. (2005) and Biggs et al. (2006) have highlighted the significant risk in some of these areas, not from the perspective of deep drainage, but the large salt stores in the unsaturated zones, and presence of very saline (EC 30 000- 50 000 µS/cm) shallow groundwater. Thus the impacts of salt mobilisation to stream are potentially very large. Leading on from this work, Biggs et al. (in prep) have highlighted the associated risks of acidic surface and groundwaters in both dryland and irrigation salinity sites.

Prediction of future extent/severity of secondary salinity

In the late 1990s, the development of a salinity hazard map for south-east Queensland by Searle and Baillie (2000) marked the commencement of efforts to consider future extent/impact of salinity. The requirement to do so is now driven by policy instruments such as the BSMS and the Vegetation Management Act. In Queensland, a distinction has been made between salinity hazard and risk that can be simply summarised as: *Salinity hazard is a function of the inherent properties of the landscape, while salinity risk is the result of mans interactions with those properties.* The degree of impact of secondary salinity is determined by both the severity of the salinity expression (stream EC, land area affected etc) and the resilience of the object being impacted. This relationship then determines economic and other costs.

Following the work of Searle and Baillie (2000) was the similar work of Moss et al. (2001), covering some inland cropping areas. Subsequently, hazard maps were produced for the four NAPSWQ priority catchments in Queensland, namely the Queensland Murray-Darling Basin, south-east Queensland, Dawson-Fitzroy and Burdekin. Extensive drilling programs also occurred during the period. These discovered the widespread presence of sporadic, shallow (<30 m) saline aquifers in southern and central inland Queensland cropping zones.

Applying the distinction between hazard and risk discussed above, Biggs et al. (2003) took a simple step towards risk, via a minor modification to the hazard mapping of DNR (2000). The recharge layer in the hazard map was driven by the concept of excess water – the long term difference between evaporation and rainfall. Biggs et al. (2003) replaced this with modelled deep drainage based on current land use. This approach was still limited though, as it didn't take into account the time-lag in the system i.e the effect of all land use activities between first clearing and current land use. This becomes particularly significant in instances where historic land use e.g long-fallow wheat may be an inherently leaky land use, but current land use e.g opportunity cropping is less so. Our ability to include deep drainage as a driver of risk has been greatly enhanced over the past decade by major studies of deep drainage across the cropping lands of Queensland and using modelling to provide these data in a spatial context, as described by Silburn et al. in this Forum.

At the same time, work had commenced on salinity "audits" in the Queensland Murray-Darling Basin. These are required to address a number of criteria related to future extent, severity and impacts of salinity. The development of spatial "bucket" models such as BC2C and 2Csalt at this time was partly to satisfy the demand of such activities. Works such as Biggs et al. (2005) and Silburn and Owens (2005) explore the use of these models at varying scales.

More recently, Grundy and Silburn (2006) further progressed the development of a salinity risk framework for Queensland, deriving a four component structure, namely biophysical hazard, current management influence, stage and value of assets. This framework was implemented in the Condamine and Fitzroy catchments, as described in other papers in this Forum. A particular advance in the application of the framework in the Condamine, was spatial delineation of specific dryland conceptual models, rather than a generic groundwater rise model.

Spatial hazard and risk frameworks are only some of the approaches used in Queensland. The requirement of the BSMS to set and review end-of-valley salt loads sets a challenge not easily dealt with by the hazard and risk frameworks employed, as they do not deal quantitatively with catchment hydrology. Furthermore, the level of data required to successfully model future salinity impacts is rarely present.

Key learnings and future directions

The closure of the NAPSWQ, and re-alignment of Murray-Darling Basin activities has provided an important opportunity to consider the activities and results of the last decade, and consider future directions for salinity research in Queensland. The lack of attention to the interactions between civil infrastructure and secondary salinity has been a potential oversight, as the economic cost is likely to be far greater than the cost of lost agricultural production in salt affected rural areas. This is particularly the case in south-east Queensland, for it is in this area where the rapid expansion of urban populations into old agricultural lands with many existing salinity sites will create the greatest potential for impacts.

A common constraint to modelling either hazard or future risk and impacts has been basic data (e.g. the scale of soil and geology mapping), and further efforts are required in collection of fundamental properties of regolith and extent of existing salt affected lands. New areas of research include the relationship between salt affected areas and public health, recently raised by Biggs and Mottram (in press), and the extent of inland acid sulphate soils associated with salinity expressions.

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