Surf Coast Shire - Salinity Management Overlay

Salinity occurrences and mapping

Background report No 4

June 2006

Report prepared for: EnPlan Australia Pty Ltd. ***EP 04/06***

Authored by: **Peter Dahlhaus**
Dahlhaus Environmental Geology Pty Ltd, P.O. Box 318, Buninyong Vic 3357
(ABN: 81 085 846 813 ACN: 085 846 813)

Prepared for: **EnPlan Australia Pty Ltd**
Rural Planning and Environment
(ABN: 21 093 543 536)
96 Yarra St
Geelong Vic 3220
Web: www.enplan.com.au

Rev No.	Authors	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Draft 1	P. Dahlhaus	D. Brewin				
Final	P. Dahlhaus			G. David		

Preferred bibliographic citation:
Dahlhaus P.G. 2006. Surf Coast Shire Salinity Management Overlay: salinity occurrences and mapping. *Background Report 4, prepared for EnPlan Australia Pty Ltd, Surf Coast Shire and the Corangamite Catchment Management Authority by Dahlhaus Environmental Geology Pty Ltd*

Project Title:
Salinity Management Overlays for the Colac Otway, Corangamite, Golden Plains and Surf Coast Shire Planning Schemes.

Project consultant team:
Graeme David, EnPlan Australia Pty Ltd, Geelong.
Darrel Brewin, Darrel Brewin and Associates Pty Ltd, Torquay
Chris Harty, Chris Harty Planning and Environmental Management, Camperdown
Peter Dahlhaus, Dahlhaus Environmental Geology Pty Ltd, Buninyong

Project management and steering committee:
Angela Vary, Corangamite CMA
Felicia Choo, Corangamite CMA
Matt Kelleher, Golden Plains Shire
Lyell Bond, Corangamite Shire
Mark Harwood, Surf Coast Shire
Geoff Morgan, Colac Otway Shire

Cover Photo:
Salinity along a drainage line south of Inverleigh. *(Peter Dahlhaus 16/1/2002)*

Executive Summary

This report provides the background to the derivation of salinity maps for inclusion in the Surf Coast Shire Planning Scheme. The project, a joint initiative between the Corangamite Catchment Management Authority and the Golden Plains Shire, Corangamite Shire, Colac Otway Shire and Surf Coast Shire, aims at managing salinity to mitigate the risk of damage to public and private assets. The project is funded by the National Action Plan for Salinity and Water Quality, a joint Federal and State Government program with a goal of protecting agricultural productivity, biodiversity, infrastructure and water quality from salinity. One option for protecting assets from the threat of salinity is to implement appropriate strategic planning of urban and rural development through the Municipal Strategic Statements, and the appropriate control of development through the inclusion of a Salinity Management Overlay in the municipal statutory planning schemes.

There are 287 mapped salinity sites in the Surf Coast Shire, ranging in size from 1,184 hectares (Lake Murdeduke) to 29 square metres. The majority of the salinity occurs in saline wetlands, accounting for 68% of the total of 4,552 hectares. The remaining 32% of land salinity is evenly divided between dominantly primary (16.3% total) and dominantly secondary (16.2% of total).

Groundwater flow systems characterise similar landscapes in which similar groundwater processes contribute to similar salinity issues. They are categorised into three types, according to their hydrologic response to management, *viz:* local systems which respond rapidly to changed land-use, intermediate systems, and regional systems, which have a very slow response to changed land-use. However, the process that causes salinity at any particular point in the landscape is quite unique and requires an understanding of the geology, groundwater flow systems and land-use at that particular location. Within the Surf Coast Shire, a number of salinity process models have been conceptualised and documented in various studies. Lakes Modewarre and Murdeduke are provided as examples that emphasise the importance of the conceptual models.

Areas in the Surf Coast Shire where salinity may potentially threaten assets have been mapped for inclusion into a Salinity Management Overlay. These include sites where salinity has been identified by previous mapping and areas where salinity is not obvious, but may develop in a relatively short time frame or within the design life of a development (taken as around 30 to 50 years). In these areas there is sufficient salt present in the soil to restrict plant growth or potentially threaten the integrity of buildings, infrastructure and utility services, and the area is underlain by relatively shallow saline watertables.

In the Surf Coast Shire, a number of the primary salinity wetlands and lakes are already covered in the Schedule 1 to the Environmental Significance Overlay (ESO1) of the Surf Coast Shire Planning Scheme. Among the environmental objectives to be achieved, ESO1 lists the maintenance of the physical and biological integrity and functioning of natural systems including the recharge and discharge of groundwaters. However, in some cases the shallow saline groundwater surrounding these lakes and wetlands may threatened by inappropriate development which may lower the watertables and dry out the environmental asset. In other cases, the integrity of smaller ephemeral saline wetlands may be threatened by fresh water input. These areas have been identified as potential primary salinity environmental assets and it is recommended that they are further investigated to determine their suitability for inclusion in the Environmental Significance Overlay.

Broad areas have been delineated in which there is potential for certain land-uses, such as extensive irrigation schemes, urbanisation or vegetation removal, to rapidly change the hydrology of responsive groundwater flow systems. These land-uses may lead to changes in groundwater levels which may exacerbate existing salinity or initiate new outbreaks elsewhere in the landscape. Mapping these areas is only possible at a regional scale, as they are based on the groundwater flow systems, mapped salinity and probability of shallow watertables being present. These areas are provided to the Surf Coast Shire for inclusion within the Municipal Strategic Statement (MSS) to highlight the issue of potential salinity hazard and for further strategic planning consideration in the next revision of their MSS.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

1 Introduction

Salinity has been recognised as a threat to agricultural production in the Surf Coast Shire since the first state-wide survey by the Soil Conservation Authority in the early 1950s (Cope 1958). In recent years, the *Corangamite Regional Catchment Strategy 2003 – 2008* recognises salinity as a threat to rural and urban infrastructure in the Shire, and sets targets to protect the number of urban dwelling allotments in the region from secondary salinity (CCMA 2003). This project is a joint initiative between the Corangamite Catchment Management Authority and the Surf Coast Shire aimed at managing salinity to mitigate the risk of damage to public and private assets.

In November 2000, the Council of Australian Governments announced the National Action Plan for Salinity and Water Quality, which identifies high-priority immediate actions to address salinity in key catchments across Australia (CoAG, 2000). The goal of the Action Plan is to motivate and enable regional communities to use coordinated and targeted action to: prevent, stabilise and reverse trends in dryland salinity affecting the sustainability of production, the conservation of biological diversity and the viability of our infrastructure; and improve water quality and secure reliable allocations for human uses, industry and the environment. This project is part-funded by the National Action Plan and mainly focuses on using the municipal planning controls to protect the viability of infrastructure.

Victoria's Salinity Management Framework - *Restoring our Catchments* - was released in August 2000 (NRE 2000). The framework recognises that both the geology of a region and the land-use of a region impact on urban salinity, including the land-use practices within the towns and cities themselves (such as over irrigation of recreation areas, gardens and lawns). Damage to built infrastructure is recognised in the form of deterioration of roads, paths, gutters, building foundations and utility services, as well as rising damp in buildings and salt crusting of brickwork. The key roles and responsibilities of Local Government in implementing the framework include cooperation with the Catchment Management Authorities, statutory land-use planning, facilitating local industry involvement, provision of local incentives and support to salinity management groups.

The Corangamite Salinity Action Plan is the sub-strategy of the Regional Catchment Strategy that provides the guidance for salinity management at the regional level. The Salinity Action Plan is based on protecting catchment assets such as water quality, rural and urban infrastructure and utilities, environmental assets, agricultural land and cultural and heritage assets from salinity impacts. Shire assets such as roads, towns, public parks and recreation reserves are included in the assessment and some are identified as potentially being at risk. One option for protecting the assets from the threat of salinity is to implement appropriate controls on development through the strategic and statutory planning schemes of the shires. These range from strategic planning of urban and rural development through the Municipal Strategic Statements, to the inclusion of a Salinity Management Overlay in the statutory planning schemes.

1.1 Scope of this report

This report documents the known occurrences of salinity within the boundaries of the Surf Coast Shire using previous and recent salinity mapping reports and investigations. Methods for deriving the maps for inclusion in the planning scheme are also documented. Although many of the mapped saline sites are known by the author, the boundaries and the locations of all sites have not been personally verified for this project. It is assumed that the original source information is valid and that the data collected at the time of mapping is correct.

A discussion of the active salinity processes in the Surf Coast Shire is provided, including some specific examples of conceptual models of the salinity processes. The majority of this information is sourced from the published scientific literature and unpublished scientific investigations and research documents. While every care has been taken to ensure the integrity of the source information, guarantees cannot be provided.

2 Salinity processes

Salinity usually refers to a significant concentration of mineral salts in soil or water as a result of hydrological processes. Salinity accumulates through ***salinisation***, which is the process by which land or water becomes affected by salt. Land salinisation occurs through the accumulation of salts in the root zone and on the soil surface, usually by the evaporation of saline groundwater from shallow watertables. Water salinisation occurs through an increase in the concentration of salt in the water, usually by the removal of fresh water through evaporation, harvesting or diversion.

In some landscapes the processes that cause salinity have been present for many hundreds or thousands of years, resulting in the formation of salt lakes and salt pans that are considered primary salinity sites. However, in many landscapes salinity processes have been induced as a result of changed land-use or water-use, resulting in the emergence of secondary salinity. The distinction between primary and secondary salinity is important. Primary salinity sites may include semi-permanent or permanent saline wetlands, many of which are highly valued ecosystems or environmental assets. By contrast, secondary salinity is rarely regarded as an asset and is generally seen as a threatening process.

Both primary and secondary salinity can be a threat to a variety of assets. Salinity can restrict the growth of plants in agricultural production, parks and gardens; it can destroy building foundations, sewer pipes and road materials; and salinity can corrode water pipes and telecommunication cables. The quality of urban water supplies can be degraded by salinity and remediation requires expensive treatment. Environmental and recreational values of waterways, lakes and native vegetation can also be lost through salinisation.

2.1 Groundwater Flow Systems

To a large extent the salinity processes in the Surf Coast Shire are related to groundwater processes. Groundwater is present in all the landscapes and moves slowly through the various geological materials, under the influence of gravity. Rainwater soaks into the ground and the portion that is not evaporated from the soil or used by plants, continues down to recharge the groundwater store. Groundwater slowly moves from the higher elevations to the lower parts of the landscape where it discharges onto the ground surface as a seep or spring, or into the base of a stream, lake or wetland. The path from recharge to discharge may be a few metres or tens of kilometres, and the travel time may be days, months, years, decades, centuries or millennia. A small quantity of salt is present in the initial rainwater and more is accumulated as the groundwater travels along the torturous path through the soils and rocks.

Groundwater flow systems *"…characterise similar landscapes in which similar groundwater processes contribute to similar salinity issues, and where similar salinity management options apply"* (Coram, et al. 2001). Groundwater flow systems have been developed in the National Land and Water Audit as a framework for dryland salinity management in Australia (NLWRA, 2001). They are categorised into three types, according to their hydrologic response to management, *viz:* local systems, intermediate systems and regional systems.

Local systems: In local systems, groundwater flows over distances of less than 5 kilometres within the confines of surface water sub-catchments. Watertables rise rapidly and saline discharge typically occurs within 30 to 50 years of land-use changes, such as wide-spread clearing of native vegetation for agricultural development. These systems can respond rapidly to salinity management practices, such as tree-planting and drainage, and provide opportunities to mitigate salinity at the property-scale. Conversely, the impact of large-scale developments that change the landscape hydrology, such as those which involve irrigation, watering parks and gardens, creating impervious surfaces, etc., within the boundaries of these local flow systems may initiate secondary salinity or adversely affect primary salinity assets. A risk assessment of the impact of the changed water balance to both the development and the surrounding environment should be considered in the planning of such developments.

Intermediate systems: In intermediate systems groundwater flows over distances of 5 to 30 kilometres and may occur across sub-catchment boundaries. These systems have a greater storage capacity and generally higher permeability than local systems and take longer to 'fill' following increased recharge. Increased discharge typically occurs within 50 to 100 years of widespread land-use change, such as the clearing native vegetation for agriculture. The larger extent and slower response of these systems presents greater challenges for salinity management.

Regional systems: Groundwater flow occurs over distances exceeding 50 kilometres at the scale of river basins. Regional systems have a high storage capacity and permeability and they take much longer to develop increased groundwater discharge than local or intermediate flow systems – probably more than 100 years after widespread land-use changes. The scale of regional systems makes property-based groundwater management options ineffective and these systems would require widespread community action and major land-use changes to impact on the water and salt balance. Effective salinity management in regional systems is limited to the management of saline groundwater discharge areas using vegetation and/or drainage to limit its extent.

Seventeen groundwater flow systems were delineated in the Corangamite region by consensus of opinion reached at a three-day workshop with regional experts. These are documented in a report which includes management options for each system (Dahlhaus et al., 2002). This first attempt at delineating the groundwater flow systems is a useful tool for salinity management, although subsequent projects will develop three-dimensional hydrostratigraphic models.

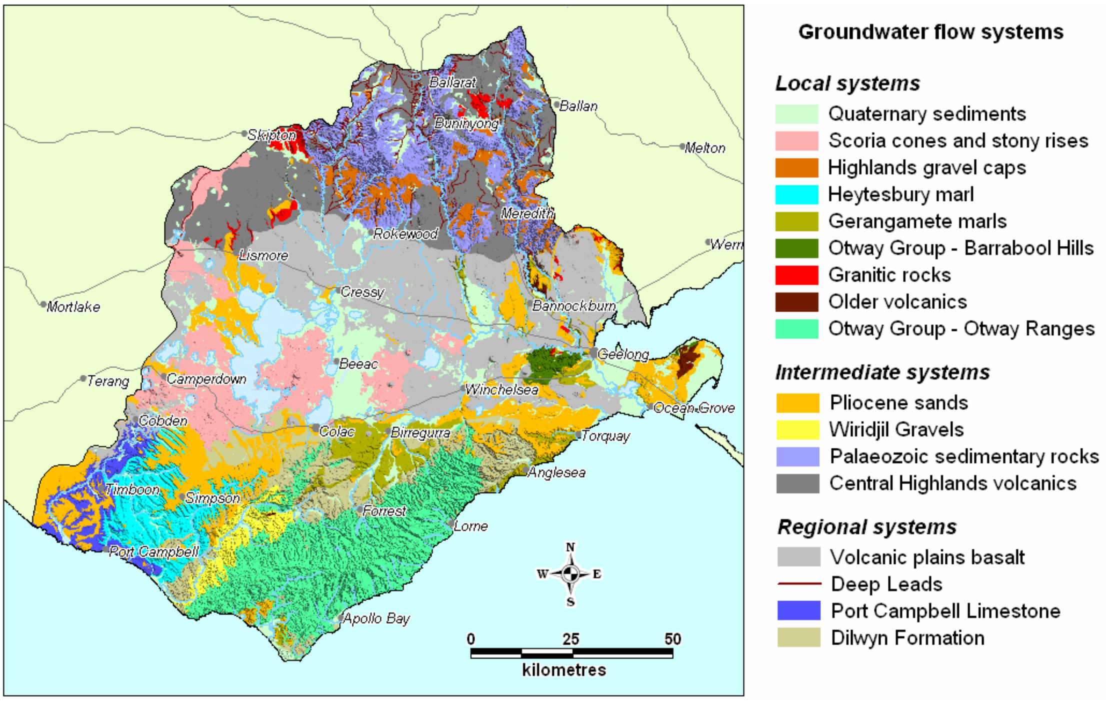


Figure 2.1 Groundwater flow systems in the Corangamite region

(Source: Dahlhaus et al. 2002)

2.2 Conceptual salinity models

Although groundwater flow systems characterise similar landscapes in which similar groundwater processes contribute to similar salinity issues, the process that causes salinity at any particular point in the landscape is quite unique. Understanding exactly why salinity occurs where it does requires the conceptualisation of a model based on an understanding of the geology, hydrology and land-use at that particular location. Within the Surf Coast Shire, a number of salinity process models have been conceptualised and documented in various studies. Lakes Modewarre and Murdeduke are provided as examples that emphasise the importance of the conceptual models.

2.2.1 Modewarre area

The Modewarre area is a target area for investment in the Corangamite Salinity Action Plan. Lake Modewarre is an important recreational lake and Gherang and Brown Swamps are of high environmental value. The land salinity in the area was mapped by for this project in late 2005, recording a 20% increase in salinity than previously mapped (Miller et al. 2006). It is assumed that this detailed mapping has recorded salinity that has emerged over the past 10 to 20 years, although a proportion of the new sites may have been previously present, but missed by the mappers at the time. This secondary salinity may slowly extend in area as the evapotranspiration accumulates salts in the soil and the land becomes degraded. If no change to land management is made, the accumulated salts will eventually kill the vegetation, creating scalds and erosion. Salt washing from the surface will add to the salt load of Thompson Creek.

There is no doubt that infrastructure will continue to be affected by the saline discharge and shallow saline watertables. Road infrastructure is particularly at risk as the capillary rise will bring salts to the road subgrade.

The geology and hydrogeology of the area is quite complex. The salinity is associated with three groundwater flow systems – the Quaternary alluvium (local), the Pliocene Sands (intermediate) and the Volcanic Plains basalt (regional). The salinity in the thin Quaternary alluvium is almost certainly associated with discharge from the more extensive underlying intermediate and regional systems. Based on the exposures and bore intersections of the various rock types, it is speculated that a variety of regional, intermediate and local processes contribute to the salinity (Figure 2.2).

In these landscapes the majority of recharge to the sands occurs from leakage through the overlying basalt plains to the north. Recharge control is generally considered ineffective because of its inability to sufficiently reduce the watertables within a human time-frame. Effectively it would require lowering the watertable across thousands of hectares of the Volcanic Plains and Pliocene sands. Towards the south some of the saline discharge is probably associated with groundwater moving up from deeper aquifers along the Bambra Fault, especially where the transmissive Dilwyn Formation aquifer is faulted against the poorly transmissive marl (Dahlhaus 2003).

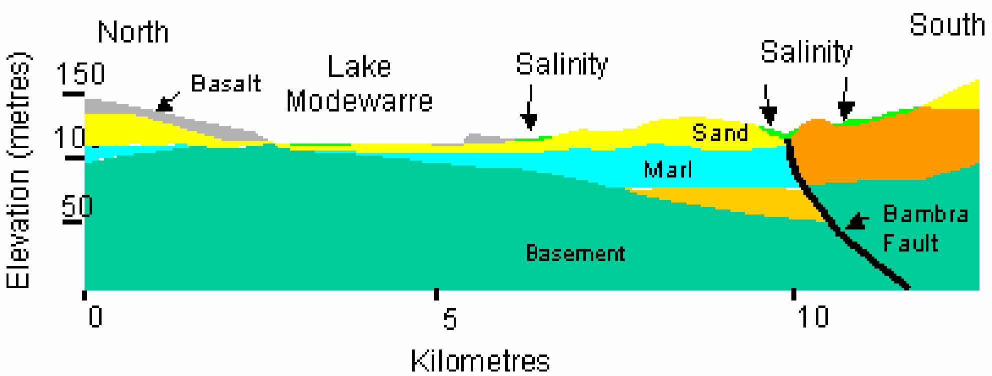


Figure 2.2 A conceptual cross-section of the hydrogeology at Lake Modewarre.

At present there is insufficient knowledge and understanding (or indeed, <u>proof</u>) of the sources and flow paths of the saline groundwater to a specific discharge area for the practical implementation of recharge control or interception tree belts. In the short term, discharge management techniques, such as surface and sub-surface drainage and/or productive uses and rehabilitation of saline land are considered more appropriate salinity management options.

About 30 groundwater monitoring bores have been constructed in the Modewarre target area in prior research and investigation programs. The water level hydrographs for these bores show uniformly steady to slightly falling trends during the monitoring period. Groundwater is generally within 3 metres of the surface in the lower landscapes and may be up to 7,000 mg/L dissolved salts. Since the groundwater bore hydrographs do not show significant trends and there appears to be little or no threat in the immediate or near-term future of rising groundwater levels.

2.2.2 *Lake Murdeduke area*

Lake Murdeduke is listed as an international environmental asset (i.e. Ramsar listed) and although the lake is fed by the Mia Mia Creek, studies have shown that groundwater throughflow is the dominant influence on the lake salinity. The groundwater processes of the lake and the flow systems between Lake Murdeduke and Barwon River (east of the lake) has been the subject of various previous research and investigation studies. The consensus of the studies is that the groundwater flows from the basalt plains into Lake Murdeduke on the western side and flows out of the lake on the eastern side across to the Barwon River. In its passage through the lake, the groundwater removes approximately the same mass of salts as is contributed by the inflowing groundwater, with the result that the salinity should remain relatively constant over time (Coram et al. 1998).

East of the lake, the groundwater flows follow a broad sub-surface valley under the basalt towards the Barwon River (Gill 1989, Giles 2004). This region is characterised by shallow (<2 metres), highly saline ($100,000^+$ µS/cm EC) watertables in the basalts. The groundwater discharges along approximately 8 km of the Barwon River, increasing salinities from around 1650 – 2300 µS/cm to 2700 – 3400 µS/cm (SKM 1997).

A local groundwater flow system occurs in the large lunette along the eastern side of Lake Murdeduke. The lunette flow system provides additional recharge to the lake and some discharge along the eastern toe of the dune, resulting in the formation of shallow hypersaline wetlands.

The groundwater flow systems and discharge mapping suggests that much of the land salinity in the area is primary and that the shallow highly saline groundwater and associated discharge has been a feature of the landscape for centuries. The hydrographs of several groundwater bores show a variation in waterlevel trends depending on the depth and location of the bores. In general, there are no apparent continuously rising watertables, but low amplitude rises and falls over long time periods, as expected in a regional system responding to climatic influences (Figure 2.3).

The current scenario is that saline land areas will continue to accumulate salt through evapo-transpiration and export salt when surface water flows occur. Because the groundwater is shallow (<2 metres depth) and highly saline the accumulation of salt in the soil has the potential to quickly create scalding and further degradation of agricultural land. Road infrastructure is particularly at risk of the saline discharge and shallow saline watertables.

Recharge control in this landscape is considered ineffective, given the vast nature of the regional groundwater system in the volcanic plains. Land salinity is best managed by discharge treatment, including surface and sub-surface drainage or the productive use of saline land. Protection of infrastructure and utility assets is possible by continuous pumping to lower the groundwater table in the immediate vicinity of the asset, but is unlikely to be cost effective, given that the disposal of highly saline groundwater would require the construction of leak-proof evaporation basins. Alternatively relocation or reconstruction of the asset may be required. Improved engineering could significantly extend (perhaps double) the design-life of roads, if the design of road construction and repairs took into account the presence of the shallow saline groundwater (Nicholson et al. 2006).

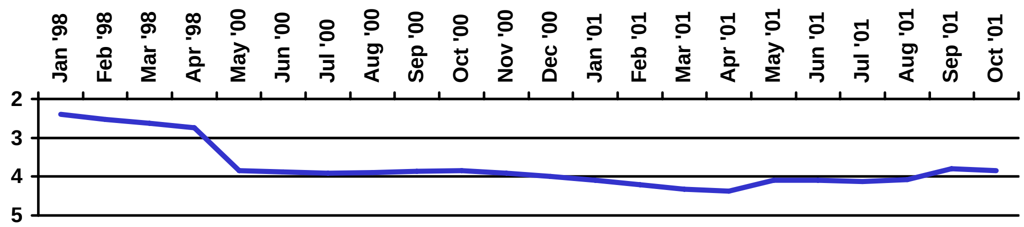


Figure 2.3 Water levels in a shallow bore east of Lake Murdeduke (#4605).

3 Salinity mapping

There are 287 mapped salinity sites in the Surf Coast Shire, ranging in size from 1,184 hectares (Lake Murdeduke) to 29 square metres. The average size is 16 hectares. The majority of the salinity occurs in saline wetlands, accounting for 68% of the total of 4,552 hectares. The remaining 32% of land salinity is evenly divided between dominantly primary (16.3% total) and dominantly secondary (16.2% of total) (Figure 3.1, Table 3.1).

Primary		Secondary		Saline wetland	
Number	Area (ha)	Number	Area (ha)	Number	Area (ha)
114	740	138	737	35	3,075

Table 3.1 Types of mapped salinity in the Surf Coast Shire

The salinity mapping has been derived from several sources. The main source has been the salinity mapping undertaken by the Department of Primary Industries specifically for this project, which has been documented separately (Miller et al. 2006). This was combined with other known salinity mapping that was assembled for the Corangamite Salinity Action Plan (Nicholson et al. 2006), which is documented in the action plan's Background Report No. 9 (Dahlhaus et al. 2005).

The extent of the salinity is identified using a number of mapping techniques. The most commonly used method is the identification of plant species which indicate that salinity is present in the soil. Other signs are the nature of the soil itself, and any indications of salt efflorescence at the surface. Most sites have been mapped by ground surveys using GPS (global positioning systems), aerial photographs and maps to accurately locate the salinity. However, more remote sites have been mapped using only aerial photographs. At a few sites where more intensive research has been undertaken geophysical methods, boreholes and soil tests may have been used. A comprehensive guide to salinity mapping methods has been published by the Natural Resource Management Ministerial Council (Spies & Woodgate 2005).

Figure 3.2 An example of secondary salinity south of Inverleigh.

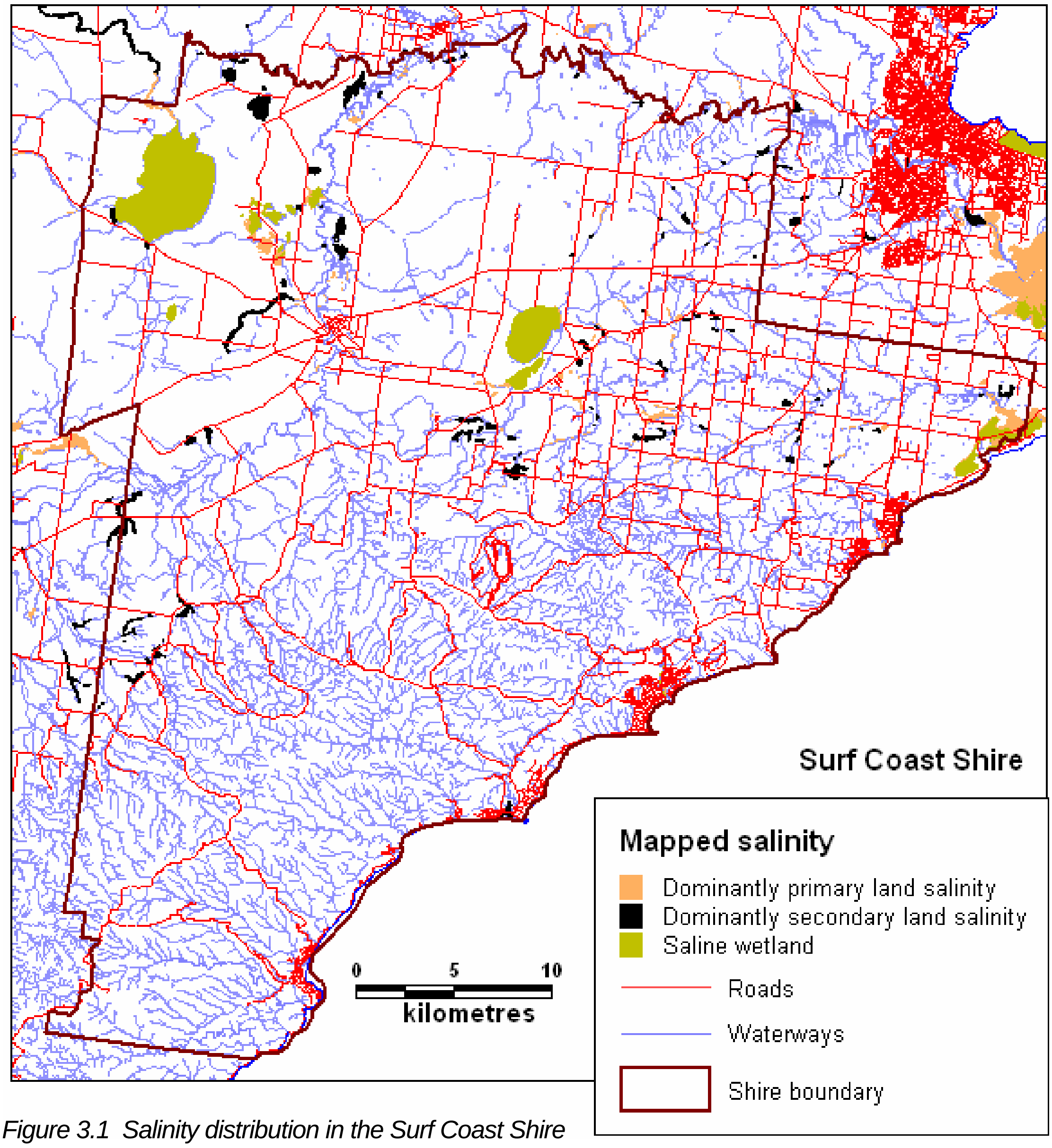


Figure 3.1 Salinity distribution in the Surf Coast Shire

3.1 Mapping salinity as a threat to assets

To delineate areas in the Surf Coast Shire where salinity which may potentially threaten assets, two components need to be identified:

1) The areas where there is sufficient salt present in the soil to restrict plant growth or threaten the integrity of buildings, infrastructure and utility services. These are the areas where salinity has been identified by the previous mapping.

2) The areas where salinity is not obvious, but may develop in a relatively short time frame or within the design life of a development (taken as around 30 to 50 years). These are areas where shallow saline watertables occur, and where a rise in the groundwater level may induce salinity at the surface (or close to the surface).

Salinity potentially threatens urban development in the Torquay, Modewarre, Winchelsea and Deans Marsh areas, and some rural buildings and road infrastructure (Miller et al. 2006). Throughout the Surf Coast Shire there are 154 occurrences of salinity within a 50 metre buffer of a road, which amount to 142 hectares.

Approximately 48% of the mapped salinity occurs in the Public Conservation and Resource Zone, accounting for most of the saline wetlands. Around 42% of the mapped salinity occurs in the Rural Zone of the Shire, and 9% in the Environmental Rural Zone. The remainder occurs in the other Zones as tabulated below (Table 3.2).

Planning Zone	Number of intersections	Area of salinity (hectares)
Comprehensive Development 2 Zone	5	14.9
Environmental Rural Zone	27	421.6
Low Density Residential Zone	3	1.1
Public Conservation and Resource Zone	20	2174
Public Park and Recreation Zone	15	22.5
Public Use Zone Service and Utility	3	3.1
Public Use Zone Transport	3	0.05
Residential 1 Zone	6	1.7
Road Zone Category 1	21	3.7
Road Zone Category 2	5	11.3
Rural Living Zone	4	2.9
Rural Zone	277	1887.2
Special Use Zone 1	1	0.1

Table 3.2 Occurrence of salinity by Planning Zone

The areas underlain by shallow saline watertables were determined using the relatively recent depth-to-watertable models constructed by Sinclair Knight Merz for the Department of Sustainability and Environment (DSE 2006). The models were provided by the Corangamite Catchment Management Authority and the Department of Sustainability and Environment for use in this project. The models use two techniques to estimate the depth-to-watertable in 2004 and 2050 (Peterson & Barnett 2004). A model showing the probability of a groundwater table less than two metres deep within the Surf Coast Shire is shown in Figure 3.3.

Groundwater monitoring bores in the areas where salinity has been mapped were checked in the Corangamite Groundwater Monitoring and Research Database (Dahlhaus et al. 2004). The fluctuations in waterlevels over the monitoring period were assessed to indicate the likely range of watertable depths in the future (Figure 3.4).

The monitoring record shows that the majority of groundwater levels in saline areas generally fluctuate no more than one metre. However, there are some areas where the seasonal fluctuations are in the order of several metres. Overall, groundwater levels have been dropping over the past decade, probably in response to the prolonged period of below average rainfalls.

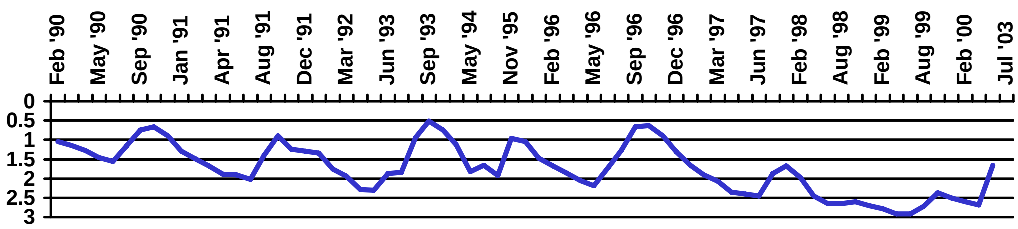


Figure 3.4 Fluctuating waterlevels in a groundwater monitoring bore at Modewarre.

Bore # 7002 is at the corner of Hendy Main Road and Giddings Road about 150 metres from a saline discharge site. Seasonal fluctuations of the watertable are in the order of 1 to 1.5 metres.

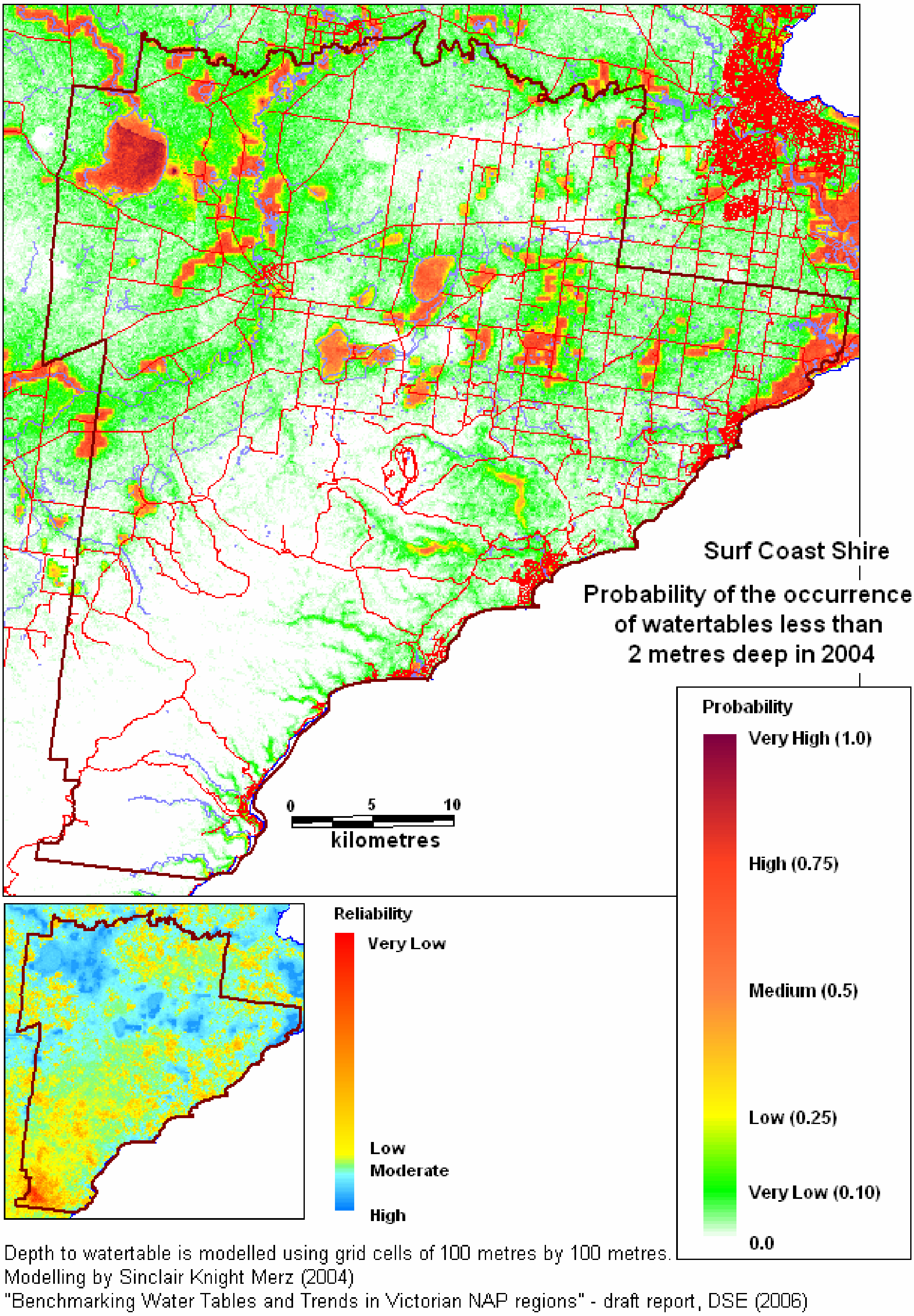


Figure 3.3 2004 Probability Map of a groundwater table less than two metres deep

3.1.1 Drawing the SMO boundaries

Areas where salinity potentially threatens assets are those which are included in the Surf Coast Shire SMO. The SMO polygons were delineated using the currently mapped salinity and a buffer area around the salinity to accommodate a one metre rise in the groundwater table. The assumption that there would be no more than a one metre rise in the watertable over the life of this version of the SMO (assumed to be 30 years) is based on the groundwater monitoring record.

Since the area affected by a one metre rise in the groundwater levels is proportional to the terrain slope (Figure 3.5), the buffer area was constructed using the following 'rules':

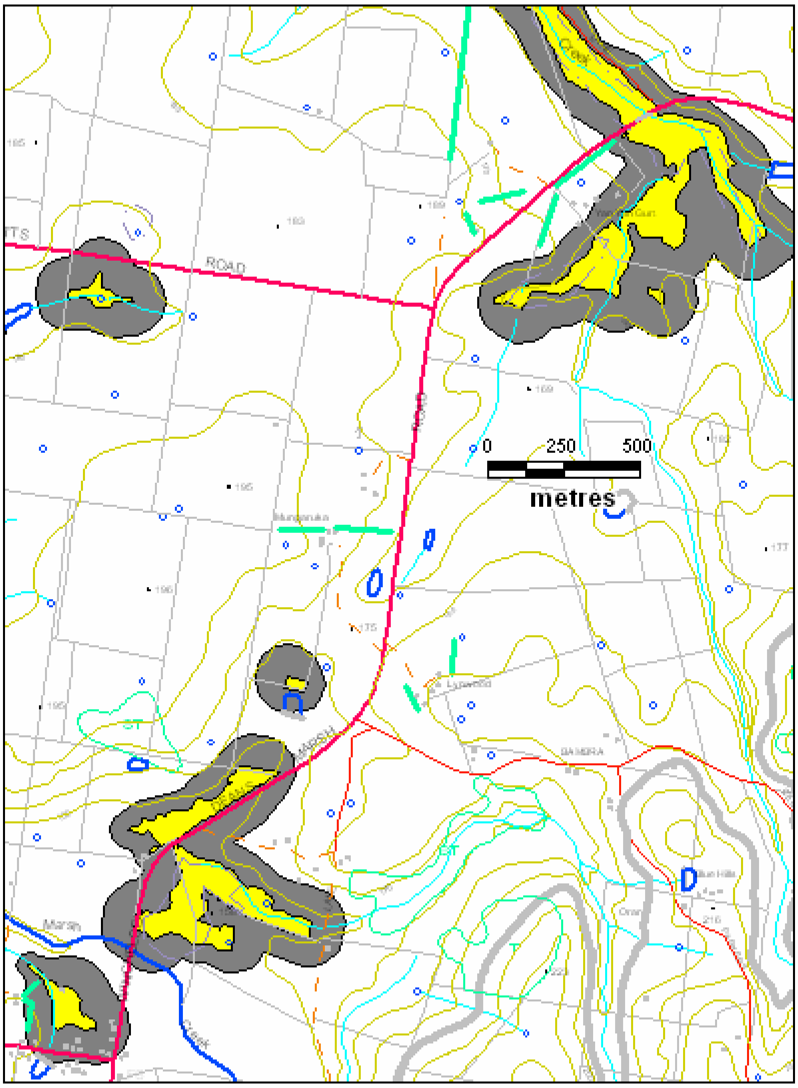
- a 100 metre buffer was applied to the proportion of the mapped salinity polygons which occur on terrain slopes of less than 2% (i.e. less than 1 in 50);
- a 50 metre buffer for the proportion of mapped salinity polygons lying on slopes of between 2% (1 in 50) and 4% slope (1 in 25);
- a 25 metre buffer was applied to the proportion of mapped salinity polygons on slopes of between 4% (1 in 25) and 10% (1 in 10);
- a 10 metre buffer applied to the proportion of salinity polygons lying on slopes of between 10% (1 in 10) and 20% (1 in 5); and
- no buffer applied to the proportion of salinity polygons on slopes greater than 20%.

The buffers around the mapped salinity polygons were then combined, and enclosed with a 10 metre buffer, which is the basis of the SMO polygons. The nodes of the SMO polygons were thinned and generalised (3-node co-linear deviation = 5 metre; node separation = 5 metres), and the polygon boundaries smoothed. The combined dataset was then disaggregated into individual polygons. Where polygons were separated by short distances (<25 metres) the polygons were manually coalesced based on an interpretation of likely groundwater behaviour.

Areas of the SMO data outside a one kilometre buffer around the Surf Coast Shire boundary were erased from the SMO data set. The data was then sent to the Department of Sustainability and Environment for preparation of the standard Planning Scheme maps.

Figure 3.5 An example of the SMO boundary, near Deans Marsh.

(The mapped salinity is shown in yellow and the SMO boundary is shown in grey. The variable buffer distance is related to the terrain slope).



The SMO boundary is generally regarded as accurate at a map scale of 1:25,000, based on the based on the accuracy of the input data (salinity polygons, wetlands and Digital Elevation Model from which the slope contours were generated). Use of the data beyond the scale of 1:25,000 should consider the limitations of the original data sets, the imprecision in mapping land salinity boundaries, and the limitations of the input data sets.

The following limitations of the SMO mapping are recognised:

- Limitations of the input data sets are:

  Salinity data: Some saline sites have not been mapped. Despite a comprehensive effort to identify all known and mapped salinity sites, there will be some salinity sites that have not been identified. It is likely, however, that these will be in the same general locality as mapped areas. New salinity sites will emerge as the climatic and land-use changes will continue to change the hydrology and salt balance.

  Wetland data: Some wetlands may not be recognised in the Department of Sustainability and Environment data layer used, i.e. the Corrick wetland 1994 data layer.

  Slope data: The slope data was generated from the Digital Elevation Model (DEM) constructed from the 1:25,000 topographic contours (10 metre interval), and hydrologically enforced. The DEM data has been verified and checked against the spot heights. However, the limitations of the original contour mapping needs to be considered in the boundaries of the buffers applied to the mapped salinity polygons.

- The assumption in the buffers around the mapped salinity is that the groundwater will not rise by more than one metre in the mapped SMO areas over the life of this version of the SMO. This assumption is based on the bore hydrographs over the past twenty years. However, a run of above average wet years may cause the conditions to change and the salinity may breach the boundaries of the SMO.

- The assumption in buffering the salinity on low angled slopes (i.e. <2%) is that the mapped salinity will not extend by more than 100 metres over the life of this version of the SMO. This is based on observations and monitoring over the past 30 years. However, an extended period of above average rainfall or changes to the surface or subsurface drainage surrounding the saline areas may cause the salinity to extend beyond the SMO boundary.

3.2 Mapping salinity as an environmental asset

Some mapped saline areas are naturally occurring primary salinity sites which may retain halophytic plants and rare or threatened species associated with the evolution of these 'island ecosystems' of saline discharge over the past centuries. The most obvious examples are the semi-permanent and permanent saline wetlands.

To delineate areas in the Surf Coast Shire where salinity may potentially be an environmental asset, two components need to be identified:

1) The areas where the mapped salinity has been identified as primary in origin and which may retain some environmental value. These are the areas where semi-permanent and permanent saline wetlands have been identified and areas adjacent to them which are regarded as dominantly primary salinity sites.

2) The areas surrounding the primary saline sites in which inappropriate development may threaten the integrity of the environmental asset. These are areas where shallow saline watertables occur, and where a lowering of the groundwater level (for example, through tree planting) or disposal of fresh water (storm water, for example) may potentially destroy the environmental values.

In the Surf Coast Shire, a number of the primary salinity wetlands and lakes are already covered in the Schedule 1 to the Environmental Significance Overlay (ESO1) of the Surf Coast Shire Planning Scheme. Among the environmental objectives to be achieved, ESO1 lists the maintenance of the physical and biological integrity and functioning of natural systems including the recharge and discharge of groundwaters. This would include the protection of the quality and quantity of water entering the saline lakes and wetlands. However, in some cases the shallow saline groundwater surrounding these lakes and wetlands may be under threat by inappropriate development which may lower the watertables and dry out the environmental asset. In other cases, the smaller ephemeral saline wetlands, particularly east of Lake Murdeduke, and the estuarine wetlands north of Torquay, may have high environmental values still preserved.

The extent of the current ESO1 is shown in grey on Figure 3.6. The additional areas shown in green (on Figure 3.6) are delineated as potential primary salinity environmental assets and it is recommended that they are further investigated to determine their suitability for inclusion in the Environmental Significance Overlay (ESO1). The delineation of the areas is only approximate as the exact boundary would be refined by the assessors at the time of their investigation. A broad range of potential threats such as drainage, pest plants and animals, and recreation access, would be considered in the boundary.

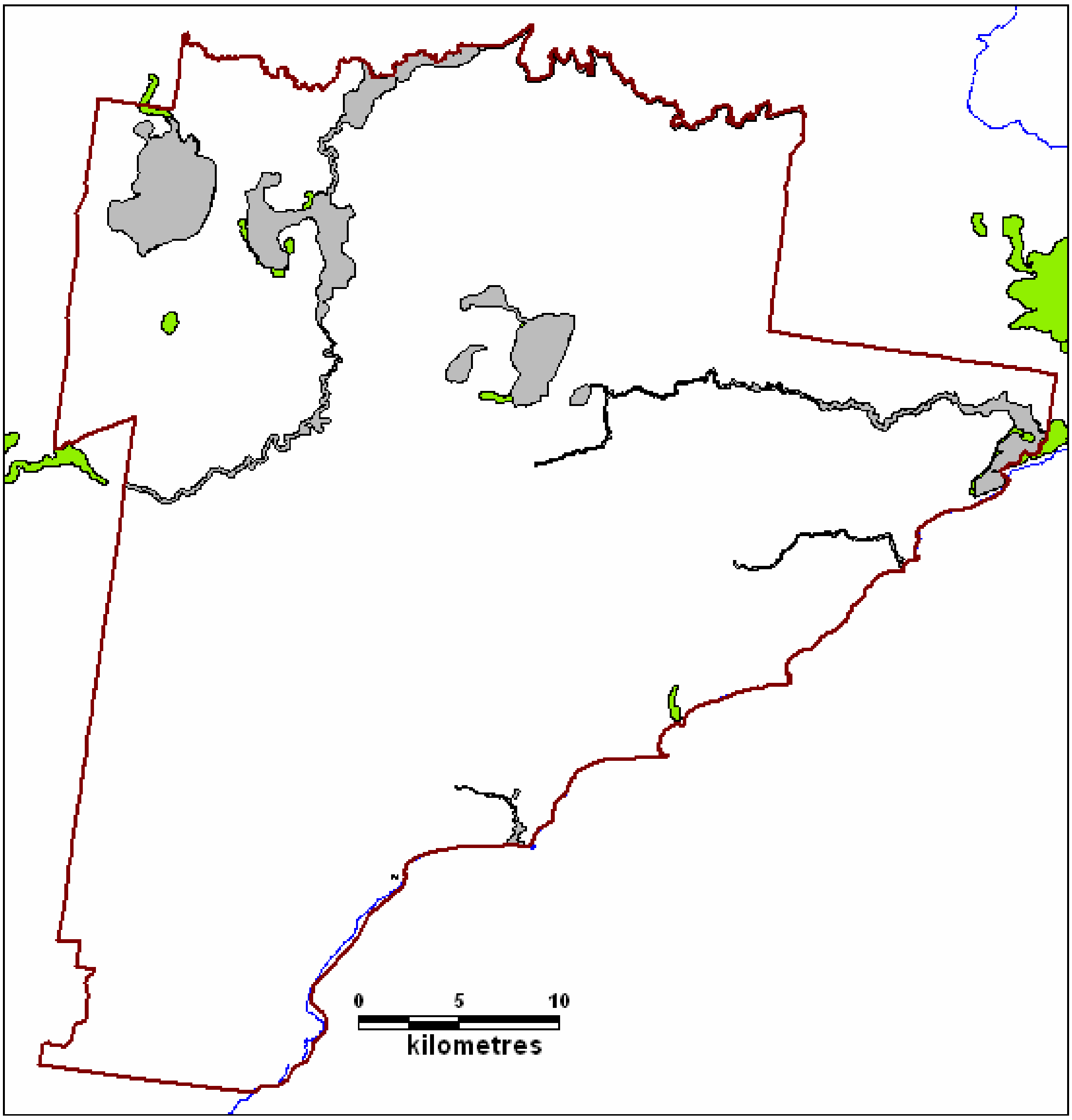


Figure 3.6 Primary salinity sites which are potential environmental assets.

The extent of the current ESO1 is shown by the grey polygons. The green polygons represent areas which are potential primary saline assets and should be further investigated for inclusion in ESO1.

3.3 Mapping areas where land-use can change salinity

Where local groundwater flow systems are present in the Surf Coast Shire there is the potential for certain land-uses to change the hydrology of the landscape such that groundwater levels could respond within five to thirty years. However, the occurrence of salinity at any particular site is dependent on the local landscape parameters, such as the geology, terrain, soils, site hydrology, micro-climate, land management and environmental history. Therefore mapping the potential areas where land-use may impact on existing salinity, or initiate new salinity outbreaks, is only possible at a regional scale (1:100,000 scale), as predicting the interaction of the landscape factors with groundwater flow systems is an inexact science at the site-scale.

In the Surf Coast Shire there are six local groundwater flow systems (Figure 3.7), one of which – the Otway Group – Otway Ranges system – is a not major influence in salinity processes (Dahlhaus et al. 2002). In addition, the intermediate flow systems of the Pliocene sands may behave as local systems if they occur as isolated outcrops or in deeply dissected land-scapes where local flow cells may develop. The majority of the secondary salinity sites occur in these six flow systems.

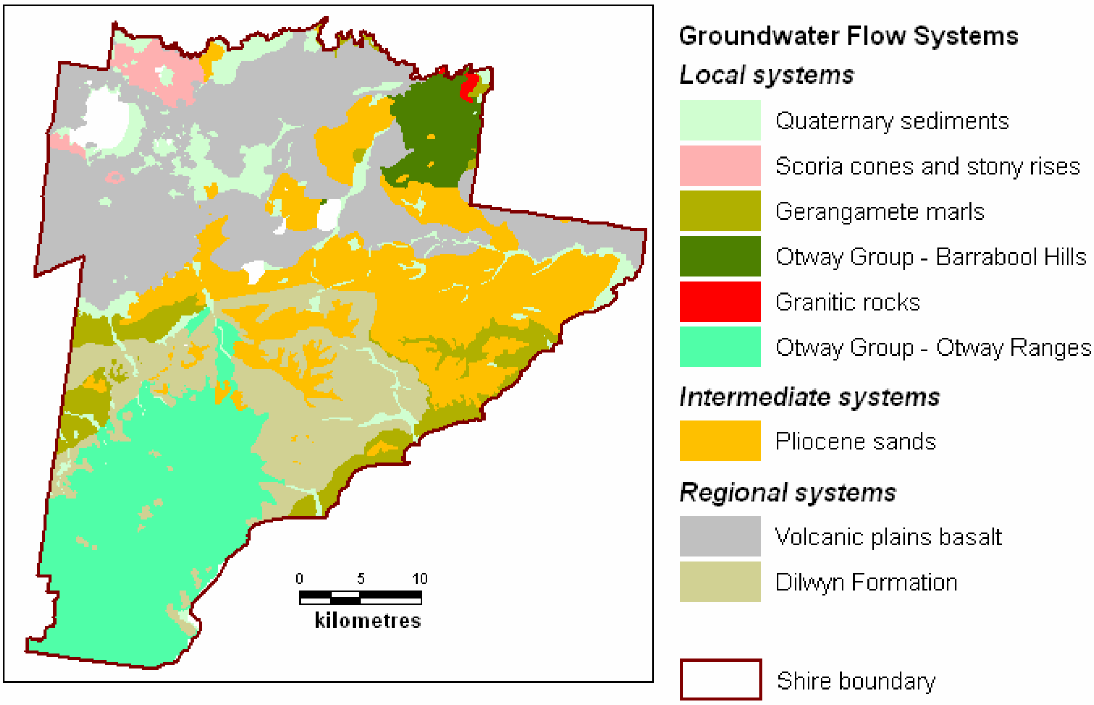


Figure 3.7 Groundwater flow systems in the Surf Coast Shire

Broad areas have been delineated in which there is potential for land-use to rapidly change the hydrology in these six groundwater flow systems (Figure 3.8). The areas are based on the groundwater flow systems, mapped salinity and probability of shallow watertables being present. These areas are provided to the Surf Coast Shire for inclusion within the Municipal Strategic Statement (MSS) to highlight the issue of potential salinity hazard and for further strategic planning consideration in the next revision of their MSS.

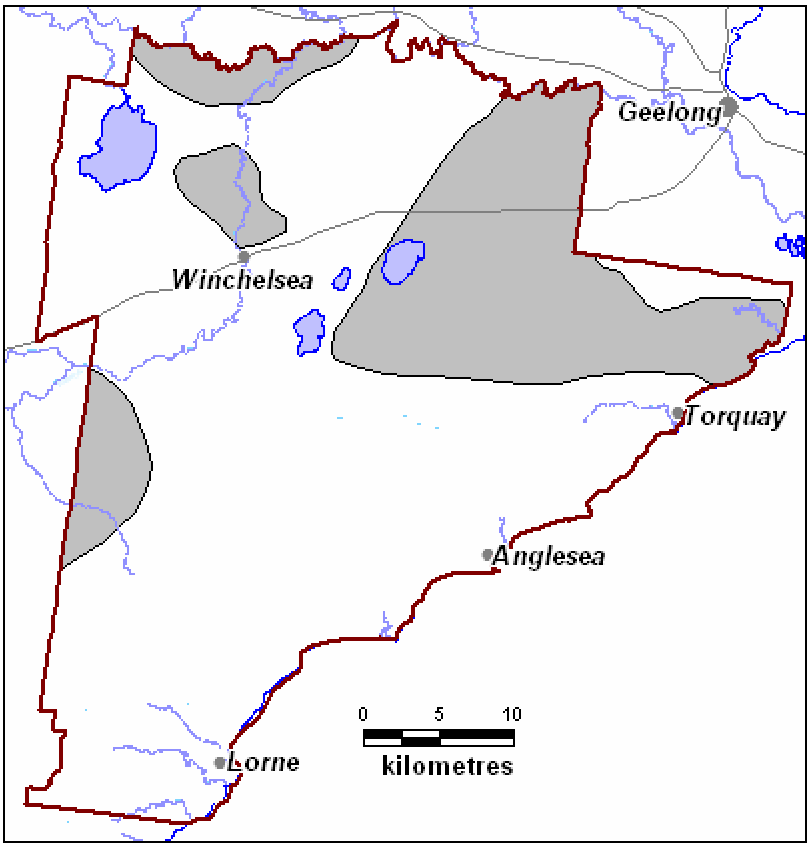


Figure 3.8 General areas where land-use that changes the hydrology may impact on salinity

In these areas, certain land-uses may impact on the groundwater hydrology by increasing recharge, causing watertables to rise and exacerbate or initiate salinity. Such land-uses include, but are not limited to:

- broad-scale irrigation schemes
- the construction of large lakes, lagoons, tailing ponds, etc.
- urban sub-division that includes extensive gardens and parks (that require watering)
- irrigated recreational areas such as golf-courses and sporting fields
- diversion of waterways, or construction of channels
- widespread permanent clearing of native vegetation or tree plantations

Land-uses such as the above would require long-term predictive water-balance studies to ensure that the on-site or off-site salinity impacts were considered before development occurs.

References

CCMA 2003. *Corangamite Regional Catchment Strategy 2003-2008*. Corangamite Catchment Management Authority, 232p.

CLARK R.M. & HEKMEIJER P. 2004. Victorian Salinity Monitoring: reassessment of six reference discharge monitoring sites in the Corangamite region *Centre for Land Protection research report* 43, Primary industries Research, Victoria, 70p.

CoAG 2000. *A National Action Plan for Salinity and Water Quality*, Council of Australian Governments. Published by Agriculture, Fisheries and Forests - Australia & Environment Australia, 12p.

COPE F. 1958. *Catchment Salting in Victoria*, Soil Conservation Authority of Victoria, 88p.

CORAM J.E., DYSON P.R. & EVANS W.R. 2001. *An Evaluation Framework for Dryland Salinity.* National Land & Water Resources Audit Dryland Salinity Project. Bureau of Rural Sciences, Canberra.

CORAM J.E., WEAVER T.R. & LAWRENCE C.R. 1998. Groundwater-surface water interactions around shallow lakes of the Western District Plains, Victoria, Australia. *Groundwater: Sustainable Solutions*, International Association of Hydrogeologists (Australian National Chapter), pp.119-124

DAHLHAUS P.G., HEISLERS D.S. & DYSON P.R., 2002. *Groundwater Flow Systems.* Consulting report CCMA 02/02, Dahlhaus Environmental Geology Pty Ltd, for the Corangamite Catchment Management Authority. 75p.

DAHLHAUS P.G 2003. Corangamite Salinity Action Plan: Salinity target areas: assessment, trends, resource condition targets, & management options. *Background Report 3, Corangamite Salinity Action Plan (2005 – 2008),* Corangamite Catchment Management Authority, Colac Victoria.

DAHLHAUS P.G., MULLER B.J., DIXON M., FELTHAM W., BEATTIE N.M. & SMITH R. 2004. Groundwater Monitoring Guidelines and Review *Research report for Corangamite Catchment Management Authority*, University of Ballarat, Geology, 63p.

DAHLHAUS P.G., SMITT C.M., COX J.W. & NICHOLSON C. 2005. Corangamite Salinity Action Plan: Setting resource condition targets. *Background Report 9, Corangamite Salinity Action Plan,* Corangamite Catchment Management Authority, Colac Victoria.

DSE 2006 (draft). *Decision making processes for investment in land management: The asset based approach.* Discussion paper Department of Sustainability and Environment. Melbourne.

GILES S.R. 2004. Geological modelling of the Lake Murdeduke - Barwon River region. B.App.Sci.(Hons) geology, unpublished thesis, University of Ballarat (unpubl.) 145p.

GILL B. 1988. Hydrogeological review of salinity problems in the Barwon / Corangamite Region. *Investigations Branch Report* 1988/16, Rural Water Commission, 66p.

MILLER L., KRUGER T & SHURVELL I. 2006 *(in prep) Salinity Discharge Mapping across priority areas in the Surfcoast, Colac Otway, Golden Plains and Corangamite Shires.* Department of Primary Industries, Geelong.

NICHOLSON C., DAHLHAUS P.G., ANDERSON G., KELLIHER C.K. & STEPHENS M. 2006. *Corangamite Salinity Action Plan: 2005 – 2008.* Corangamite Catchment Management Authority, Colac, Victoria.

NLWRA 2001. *Australian Dryland Salinity Assessment 2000: Extent, Impacts, Processes, Monitoring and Management Options.* National Land & Water Resources Audit, Canberra.

NRE 2000. *Victoria's Salinity Management Framework. Restoring our Catchments*. August 2000. Department of Natural Resources and Environment, Victoria. 36p.

PETERSON, T. & BARNETT, B. 2004. Spatially quantifying the uncertainty of salinity risk assessments. *Proceedings, 1st National Salinity Engineering Conference, 9-12 November 2004, Perth, WA.*

SKM 1997. Groundwater processes in the Lake Murdeduke – Barwon River area. *Report for the Corangamite Salinity Implementation Group*, Sinclair Knight Merz Pty Ltd, September 1997, 19p.

SPIES B. & WOODGATE P. 2005. *Salinity Mapping Methods in the Australian Context.* Report prepared for the Natural Resource Management Ministerial Council. Department of the Environment and Heritage; and Agriculture, Fisheries and Forestry, June 2005.

Appendix A Maps (on CD)

1. SMO maps prepared for Surf Coast Shire Planning Amendment No. C38
2. Suggested areas for possible inclusion in the Surf Coast Shire ESO
3. Suggested areas for inclusion in the Surf Coast Shire MSS