DWLBC REPORT

Minimising Salt Accession to the South East of South Australia.The Border Designated Area and Hundred of Stirling Salt Accession Projects. Volume 1 - Methods, Site Description and Instrumentation

2006/19

Government of South Australia
Department of Water, Land and Biodiversity Conservation

Minimising Salt Accession to the South East of South Australia.

The Border Designated Area and Hundred of Stirling Salt Accession Projects.

Volume 1 – Methods, Site Description and Instrumentation.

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Department of Water, Land and Biodiversity Conservation

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Government of South Australia
Department of Water, Land and Biodiversity Conservation

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FOREWORD

South Australia's unique and precious natural resources are fundamental to the economic and social wellbeing of the State. It is critical that these resources are managed in a sustainable manner to safeguard them both for current users and for future generations.

The Department of Water, Land and Biodiversity Conservation (DWLBC) strives to ensure that our natural resources are managed so that they are available for all users, including the environment.

In order for us to best manage these natural resources it is imperative that we have a sound knowledge of their condition and how they are likely to respond to management changes. DWLBC scientific and technical staff continues to improve this knowledge through undertaking investigations, technical reviews and resource modelling.

Rob Freeman
CHIEF EXECUTIVE
DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

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1. INTRODUCTION

1.1 BACKGROUND

The groundwater resources of the South East region of South Australia are generally of high quality and are the major water source for agricultural and domestic supplies. However, groundwater salinities in the unconfined aquifer system of some parts of the South East of South Australia are increasing rapidly.

Groundwater salinity in the unconfined aquifer in the predominately flood irrigated Hundred of Stirling (Fig. 1) is increasing at unsustainable rates. Groundwater salinity generally varies between 3000–9000 mg/L and is increasing in parts of the concentrated irrigation area at between 50–100 mg/L/yr. This is compounded by declining groundwater levels that are indicating groundwater is being extracted from storage. Similarly, long-term monitoring of the unconfined aquifer in the Border Groundwaters Agreement Designated Area (hereafter referred to as the Border Designated Area) along the South Australian/Victorian border (Fig. 1) is showing rising groundwater salinities, generally between 0–20 mg/L/yr and up to 100 mg/L/yr in isolated areas. These rises are attributed to a rapid accession of salt to the groundwater. This investigation focuses on Zones 2A to 7A of the Border Designated Area.

The long-term viability of the groundwater resource and irrigated agriculture in the regions described above is threatened by the increasing groundwater salinity, and a clear understanding of the nature and magnitude of the problem is required. The salinity hazard may put at risk existing and potential groundwater users that could lead to undesirable economic, social and environmental impacts. The key element in determining a sustainable level of groundwater use is to quantify the magnitude of salt accession to the unconfined aquifer by properly understanding the driving processes.

The following mechanisms are considered to be responsible for the observed groundwater salinity increase:

- In the Hundred of Stirling, groundwater extraction in excess of vertical recharge, combined with the recycling of irrigation water, resulting in the accession of concentrated salt back to the unconfined aquifer.
- In the Border Designated Area, mobilisation of the historic salt store in the unsaturated zone resulting in an increase in vertical groundwater recharge (natural and anthropogenic) due to the clearance of native vegetation.

The “Minimising Salt Accession to the South East of South Australia” project aims to assess and quantify salt accession via the proposed mechanisms under different land use practices and, based on this, develop sustainable groundwater management options for both regions.

The project is funded through the National Action Plan for Salinity and Water Quality (NAP) and is administered through the Centre for Natural Resource Management (CNRM). The project is being carried out by the Department of Water, Land and Biodiversity Conservation (DWLBC).

This report, Volume 1 of a series to be produced by the project, details the background, approach, methodology, instrumentation and site details of the study. Subsequent volumes will provide details on results, models, discussion, conclusions and recommendations for groundwater management strategies.

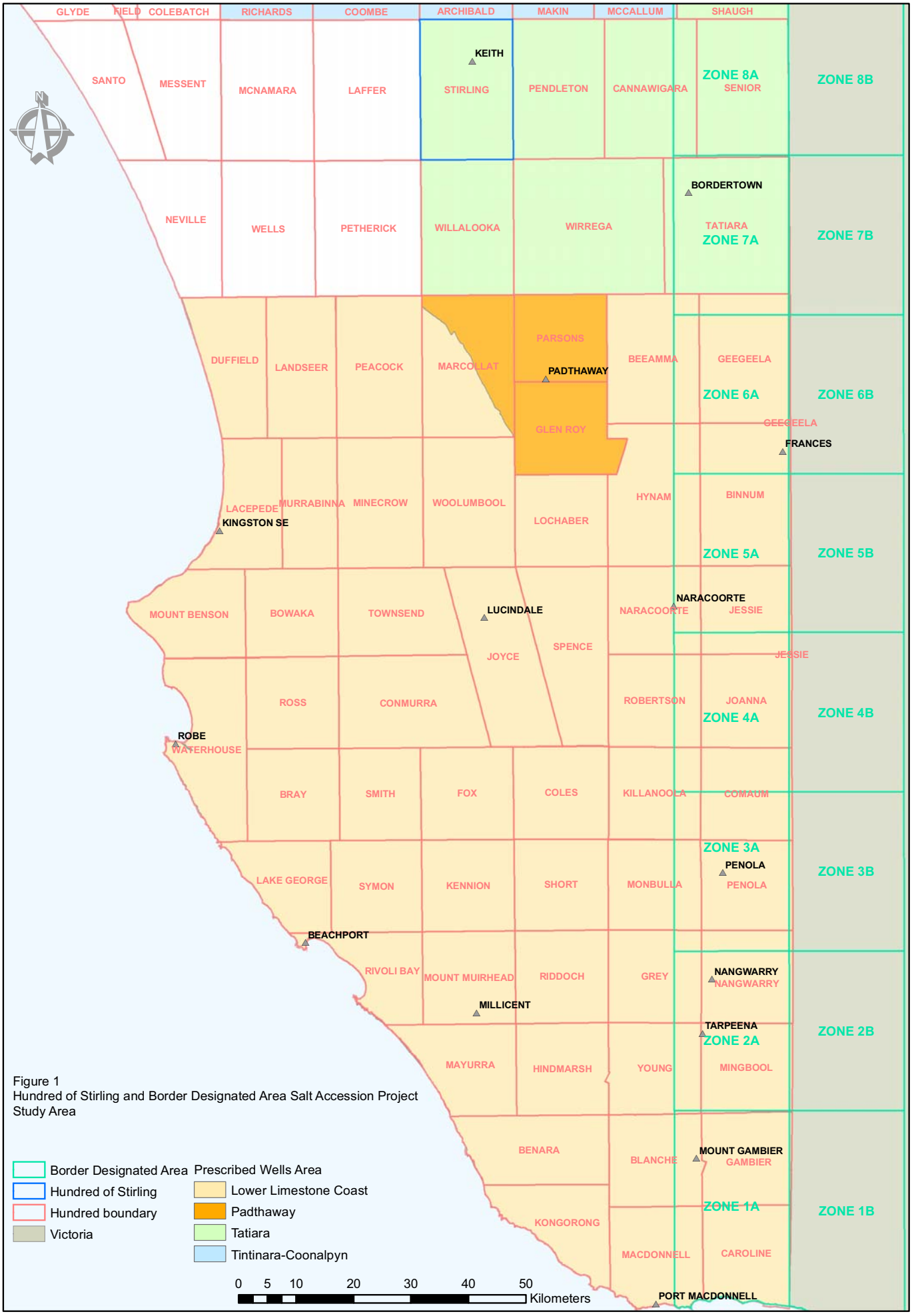


Figure 1
Hundred of Stirling and Border Designated Area Salt Accession Project Study Area

2. OBJECTIVES

The objectives of the Minimising Salt Accession to the South East of South Australia project are to:

1. In consultation with the Chief Scientist CRC for Irrigation Futures review existing literature on salinity accession under irrigation.
2. Review applicability of several unsaturated numerical models (including SWAGMAN ModFLOW HMS and LEACHM) to provide desired project deliverables.
3. In the Border Designated Area, quantify the historic salt store contained within the soil profile; determine recharge rates, and estimates of the expected time lag associated with groundwater salinisation at selected sites.
4. In the Hundred of Stirling, quantify groundwater extraction, irrigation application, crop water use, evaporation, and salt/water accession to the unconfined aquifer under bay flooding, pivot and drip irrigation practices.
5. Where appropriate up-scaling of the site specific results obtained from (3) and (4) to determine the current salt and water budgets for the critical sub-areas within the main irrigation area and model the future changes in groundwater salinity under different land-use scenarios.
6. Determine the potential long-term impact of increased groundwater recharge on salt accession to the unconfined aquifer at a broader spatial scale.
7. In consultation with existing groundwater users develop groundwater management strategies to achieve particular long-term groundwater salinity targets, and test the outcomes of these using the groundwater flow and solute transport models.
8. Where applicable incorporate the management strategies into relevant water allocation plans for the respective areas of investigation.
9. Determine the sustainable extraction limit (PAV) for individual groundwater management areas that will result in sustainable resource management and arrest groundwater quality deterioration (and, where relevant, groundwater level decline) for the areas of increasing groundwater salinity, and the region as a whole, and revise management prescriptions.
10. Review the existing groundwater (salinity) monitoring program to ensure that the program is effective and relevant.

3. OUTCOMES

The expected outcomes of the Minimising Salt Accession to the South East of South Australia project are:

- An improved understanding of the processes influencing the salt and water balances in the Border Designated Area and Hundred of Stirling.
- Better management of the groundwater resources of the unconfined aquifer in the Border Designated Area and Hundred of Stirling through the development of effective groundwater management strategies.
- A reassessment of the Permissible Annual Volumes (PAVs) for the Zones within the Border Designated Area and for the Hundred of Stirling.
- Greater confidence for the community that the data and knowledge the project acquires will enable strategies to be developed within the sustainable capacity of the groundwater resource.

4. THE HUNDRED OF STIRLING AND BORDER DESIGNATED AREA

4.1 GENERAL

The Border Designated Area forms part of the Lower Limestone Coast Prescribed Wells Area (PWA), and also part of the Tatiara PWA. The Hundred of Stirling forms part of the Tatiara PWA (Fig. 1).

Both the Hundred of Stirling and Border Designated Area experience typical South East climates, with warm relatively dry summers and cool to cold, wet winters. Potential evapotranspiration varies from ~1400 mm in Zone 2A of the Border Designated Area to ~1700 mm in Zone 7A of the Border Designated Area and the Hundred of Stirling. Mean annual rainfall varies considerably across both study areas from ~710 mm at Penola to ~580 mm at Naracoorte and 460 mm at Keith, with the majority of rainfall occurring in the cooler winter months. Mean daily maximum temperature is 29.9^{o}C for Keith and 27.3^{o}C for Penola in February, and the mean daily minimum temperature for Keith is 5.5^{o}C and 4.5^{o}C for Penola in July.

The predominant land use in the Border Designated Area is dry land agriculture. Grazing of sheep and cattle on improved pastures of sub-clover, Lucerne and medics is important particularly in the south of the Border Designated Area where higher rainfall is not as suitable for cropping. Wheat and barley production is more prominent in the northern section of the Border Designated Area where rainfall and soils are more suitable. Irrigated Lucerne and other pastures are also important forms of agriculture for the region, with irrigated vineyards becoming more prevalent. Native vegetation and plantation forests cover significant sections of the study area. In the Hundred of Stirling, the major land use is agriculture, in particular flood irrigated Lucerne for seed, hay and grazing being most predominant.

4.2 GEOLOGY

The South East region can be characterised by several extensive low-lying flats with a series of northwest tending remnant sand dune ridges characterised by discharge swamps and lakes. Beyond the Kanawinka Fault (Fig. 2) the topography rises towards the east into higher inland plains (Cobb and Brown, 2000a & b). The highlands can be divided into the Naracoorte Ranges and Naracoorte plateau. The ranges, a remnant dune ridge consisting of Bridgewater Formation lie immediately northeast and parallel to the Kanawinka Fault. The plateau lies further northeast and consists mainly of Gambier Limestone overlain by Bridgewater Formation or sand sheets (Cobb and Brown, 2000a).

The Border Designated Area comprises parts of two main geological provinces. The Otway Basin in the south and Murray Basin to the north. Sediments occurring in the two basins have similar characteristics and are separated by an axial high extending from the Dundas Plateau in the east and the Padthaway Ridge to the west (Fig. 2). The Hundred of Stirling contains lithologies of both the Murray Basin and the Padthaway Ridge. The Padthaway Ridge separates the Gambier Basin from the Murray Basin to the north and northeast.

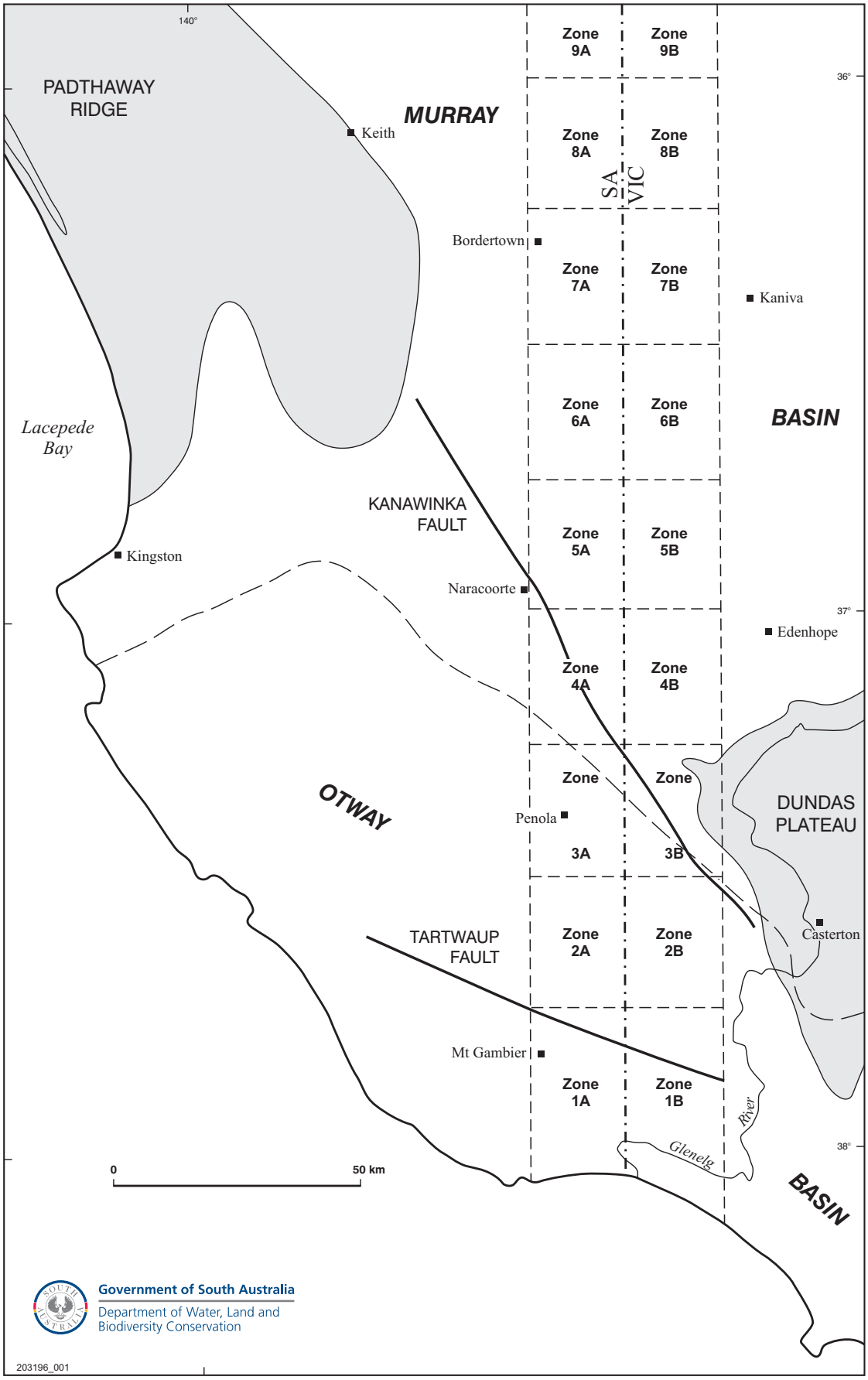


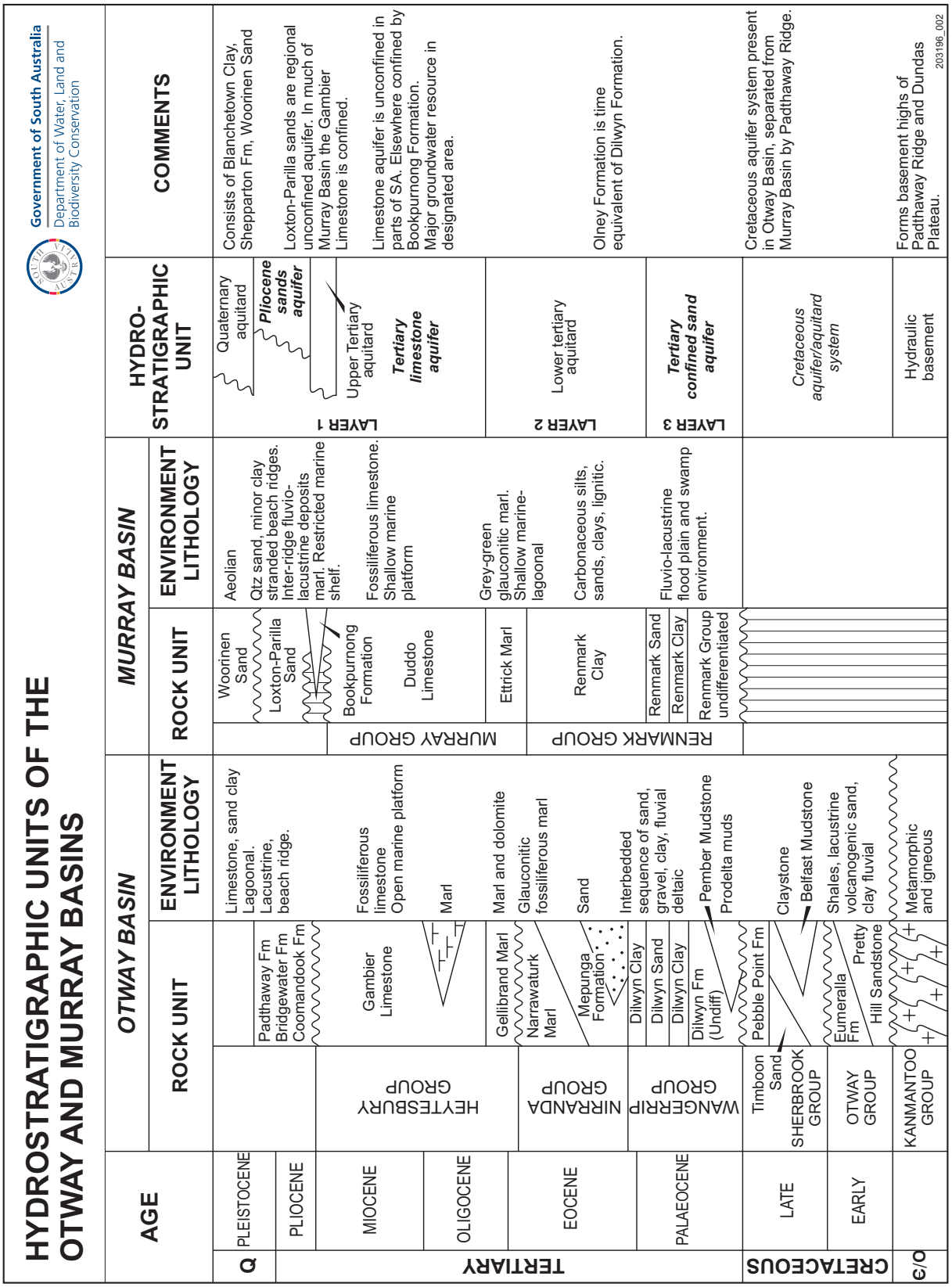
Figure 2. Hydrogeological Basins

Sedimentation depth in the Tatiara PWA (of which the Hundred of Stirling and sections of the Border Designated Area forms a part) generally thickens away from the Padthaway Ridge towards the north and northeast. The lithologies in the central and eastern portion of the region are typical of the Murray Basin sequence, the order of deposition being the Renmark Group, Buccleuch Beds, Ettrick Formation, Murray Group Limestone Loxton-Parilla Sands and Blanchetown Clay. In the west, the Murray Group Limestone was truncated in the Late Pleistocene and the sedimentary sequence is more typical of the Padthaway Ridge deposition (Coomandook, Bridgewater and Padthaway Formations) (Fig. 3).

Tertiary sedimentation in the Murray Basin commenced in the Late Paleocene through to the Early Oligocene under non-marine to marginal marine fluvial, lacustrine, channel, flood plain and swamp environments to give the Renmark Group, consisting of the Warina Sand and the Olney Formation (Rogers et al., 1995). A marine transgression during the Late Eocene to Middle Miocene produced sediments of the Murray Group, of predominately shallow marine fossiliferous limestone and sandstone with minor clay and slit, which include the Buccleuch Formation, Ettrick Formation, Mannum Limestone, Finniss Clay, Winnambool Formation and Geera Clay. During the Late Miocene through to the Late Pliocene the deposition of the Bookpurnong Formation (a shallow water marine deposit), the Loxton Sands (a regressive sequence of shallow water marine and marginal marine into beach and coastal barrier deposits) and the Parilla Sands (a non-marine deposit) occurred (Rogers et al., 1995). Blanchetown Clay disconformably overlies Tertiary sediments of the Murray Basin, deposited during the Late Pliocene-Middle Pleistocene in a fluviolacustrine environment (Rogers et al., 1995) (Fig. 3).

Tertiary sedimentation in the Otway Basin began in the Late Paleocene to Middle Eocene under low-energy, interdistributary bay and deltaic marine environments to give the Wangerrip Group, consisting of the Pebble Point Formation, the Pember Mudstone and Dilwyn Formations (Blake, 1980; Holdgate, 1982; Gravestock et al., 1986; White, 1995). A marine transgression during the Middle to Late Eocene produced the deposition of the Nirranda Group, consisting of the Mepunga Formation (a beach barrier sand) and the Narrawaturk Marl (from a middle shelf environment) (Blake, 1980; White, 1995). The Narrawaturk Marl then grades to a lithologically similar member as the Gambier Limestone. Further marine transgression during the Late Eocene to the Middle Miocene initiated the deposition of the Heytesbury Group, consisting of the Gambier Limestone deposited in an open marine shelf environment (Fig. 3).

Quaternary sedimentation in the South East was dominated by high-energy swell from the Southern Ocean and prevailing onshore westerly winds. This resulted in deposition of bioclastic beach, barrier and transgressive dune complexes (Belperio, 1995). Repeated marine transgressions have resulted in construction, destruction and reworking of these complexes (Belperio, 1995) and the formation of the Coomandook and Bridgewater Formations. The marine transgression extended to the Kanawinka Fault at Naracoorte and crossed the Padthaway Ridge north of Coonalpyn. This resulted in extensive reworking of the underlying Pliocene sands and Miocene limestone, forming the sandy limestone, calcareous and shelly sandstones and clay lithologies of the Coomandook Formation (Belperio, 1995).


HYDROSTRATIGRAPHIC UNITS OF THE OTWAY AND MURRAY BASINS
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AGE
OTWAY BASIN
ROCK UNIT
ENVIRONMENT LITHOLOGY
MURRAY BASIN
ROCK UNIT
ENVIRONMENT LITHOLOGY
HYDRO-STRATIGRAPHIC UNIT
COMMENTS
Q
PLEISTOCENE
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
PALAEOCENE
TERTIARY
LATE
EARLY
CRETACEOUS
O/C
KANMANTOO GROUP
OTWAY GROUP
SHERBROOK GROUP
WANGERRIP GROUP
NIRRANDA GROUP
HEYTESBURY GROUP
MURRAY GROUP
RENMARK GROUP
Timboon Sand
Pebble Point Fm
Claystone
Belfast Mudstone
Eumeralla Fm
Pretty Hill Sandstone
Shales, lacustrine volcanogenic sand, clay fluvial
Metamorphic and igneous
Dilwyn Fm (Undiff)
Dilwyn Clay
Dilwyn Sand
Dilwyn Clay
Pember Mudstone
Prodelta muds
Interbedded sequence of sand, gravel, clay, fluvial deltaic
Mepunga Formation
Sand
Narrawaturk Marl
Glauconitic fossiliferous marl
Gellibrand Marl
Marl and dolomite
Gambier Limestone
Marl
Fossiliferous limestone
Open marine platform
Padthaway Fm
Bridgewater Fm
Coomandook Fm
Limestone, sand clay
Lagoonal.
Lacustrine,
beach ridge.
Renmark Group undifferentiated
Renmark Clay
Renmark Sand
Renmark Clay
Carbonaceous silts, sands, clays, lignitic.
Fluvio-lacustrine flood plain and swamp environment.
Ettrick Marl
Grey-green glauconitic marl. Shallow marine-lagoonal
Duddo Limestone
Bookpurnong Formation
Fossiliferous limestone. Shallow marine platform
Loxton-Parilla Sand
Woorinen Sand
Qtz sand, minor clay stranded beach ridges. Inter-ridge fluvio-lacustrine deposits marl. Restricted marine shelf.
Aeolian
LAYER 1
Quaternary aquitard
Pliocene sands aquifer
Upper Tertiary aquitard
Tertiary limestone aquifer
LAYER 2
Lower tertiary aquitard
LAYER 3
Tertiary confined sand aquifer
Cretaceous aquifer/aquitard system
Hydraulic basement
Consists of Blanchetown Clay, Shepparton Fm, Woorinen Sand
Loxton-Parilla sands are regional unconfined aquifer. In much of Murray Basin the Gambier Limestone is confined.
Limestone aquifer is unconfined in parts of SA. Elsewhere confined by Bookpurnong Formation. Major groundwater resource in designated area.
Olney Formation is time equivalent of Dilwyn Formation.
Cretaceous aquifer system present in Otway Basin, separated from Murray Basin by Padthaway Ridge.
Forms basement highs of Padthaway Ridge and Dundas Plateau.
203196_002

Figure 3

The series of major coastal barriers that were constructed intermittently throughout the Pleistocene as sub-parallel topographic ridges across the coastal plain are referred to as the Bridgewater Formation. This is the main unconfined aquifer in the Naracoorte Ranges and comprises skeletal calcarenite and marl consisting of seaward dipping, medium to coarse carbonate and quartz sands with abundant broken shells. The bulk of the visible ranges are formed by the transgressive dune or aeolianite facies, comprising weakly cemented fine to medium grained well-sorted and rounded skeletal sand (Belperio, 1995). The dune facies interfinger with or overlie sediments of the lagoonal Padthaway Formation in the interdunal corridors. The Padthaway Formation consists of dense, white, calcitic and dolomitic mudstone with interbedded greenish clay and clayey quartz sand (Belperio, 1995).

Local geology within the Hundred of Stirling study area and individual zones of the Border Designated Area study area are represented in a series of geological cross sections and associated figures depicted in Appendices A–B.

4.3 HYDROGEOLOGY

Groundwater flows within two main aquifer systems in the South East, an unconfined limestone aquifer and an underlying confined quartz sand aquifer. The regionally extensive unconfined aquifer consists of mainly calcareous sandstone and limestone deposited in the latter part of the Tertiary through to the Quaternary and incorporates the Gambier Limestone, Coomandook, Bridgewater and Padthaway Formations (Cobb and Brown 2000a & b). Groundwater flow in the unconfined aquifer is generally east to west (Figs 4–6), with depth to water table ranging from less than 5 m to greater than 40 m, dependent upon local topography. The Kanawinka Fault is the prominent fault in the study area, tending northwest-southeast, having a pronounced lineament and is down thrown to the southwest. The water table surface of the unconfined aquifer indicates a steepening of the hydraulic gradient immediately up gradient of the fault (Fig. 5). Large variations in salinity of the unconfined aquifer occur throughout the two study areas, with salinities ranging from less than 500–3000 mg/L in the Border Designated Area study area and from around 3000 mg/L to greater than 7000 mg/L in the Hundred of Stirling (Figs 7–9).

The confined aquifer consists of non-calcareous quartz sands, with interbedded dark brown carbonaceous clay deposited in the early Tertiary, and is referred to as the Dilwyn Formation in the Otway Basin and the Renmark Group in the Murray Basin. The unconfined and confined aquifers are separated by a low permeability aquitard of clay and marl, referred to as the Narrawaturk or Gellibrand Marl in the Otway Basin and Ettrick or Buccleuch Formations in the Murray Basin, that limits groundwater movement between the two aquifers. Recharge to the confined aquifer relies on downward leakage from the overlying unconfined aquifer along the eastern margin of the region (Cobb and Brown, 2000a & b) and via direct recharge in the Nangwarry area where the confining bed is absent (Brown et al., 2001).

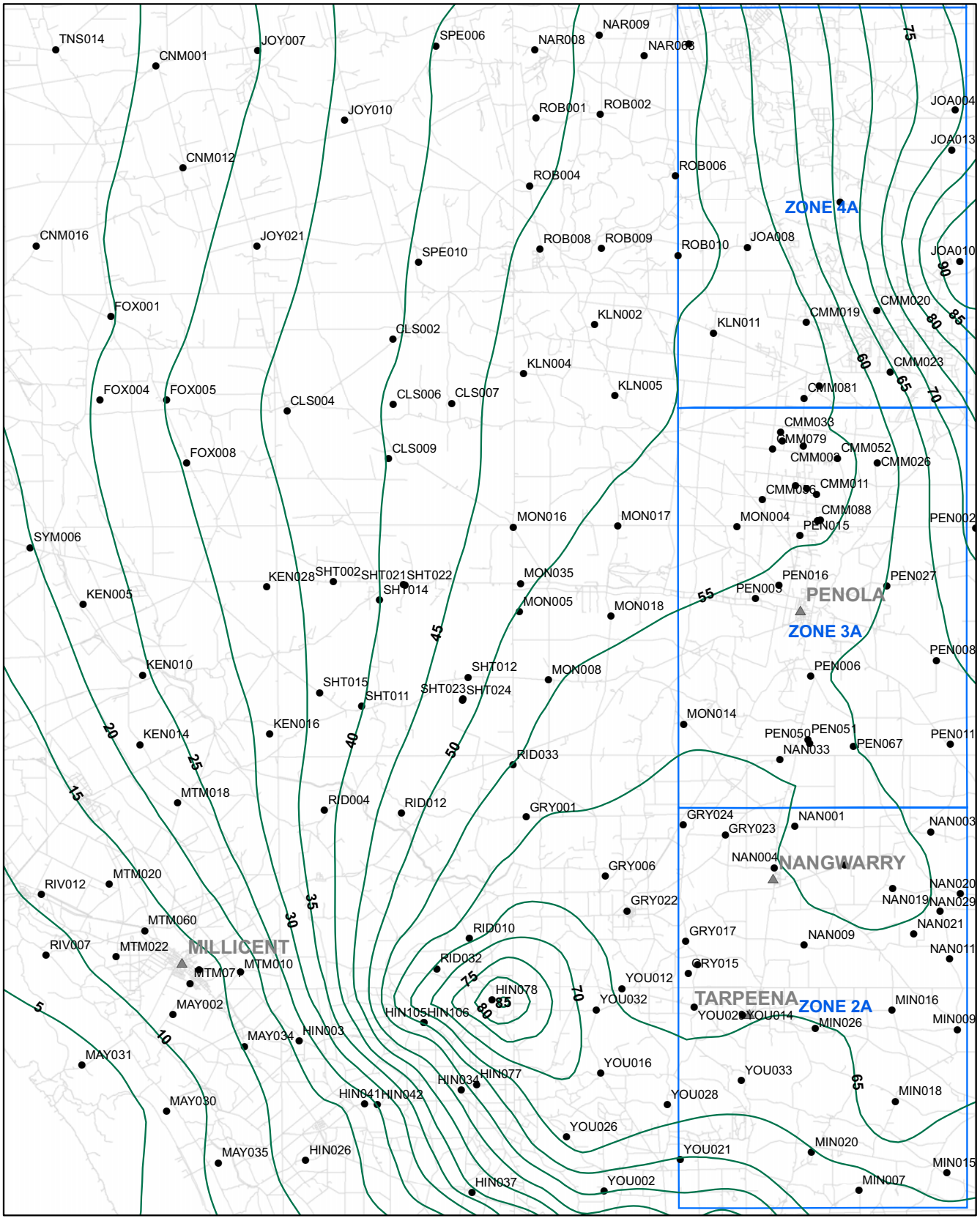

Figure 4
Hundred of Stirling and Border Designated Area Salt Accession Project
Border Designated Area (Zones 4A-2A) Unconfined Aquifer RSWL
(Latest RSWL Sept-Dec 2005)

RSWL (5 metre contour)
Current Water Level Observation Wells
Border Designated Area

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0 2.5 5 10 15 20 25 Kilometers

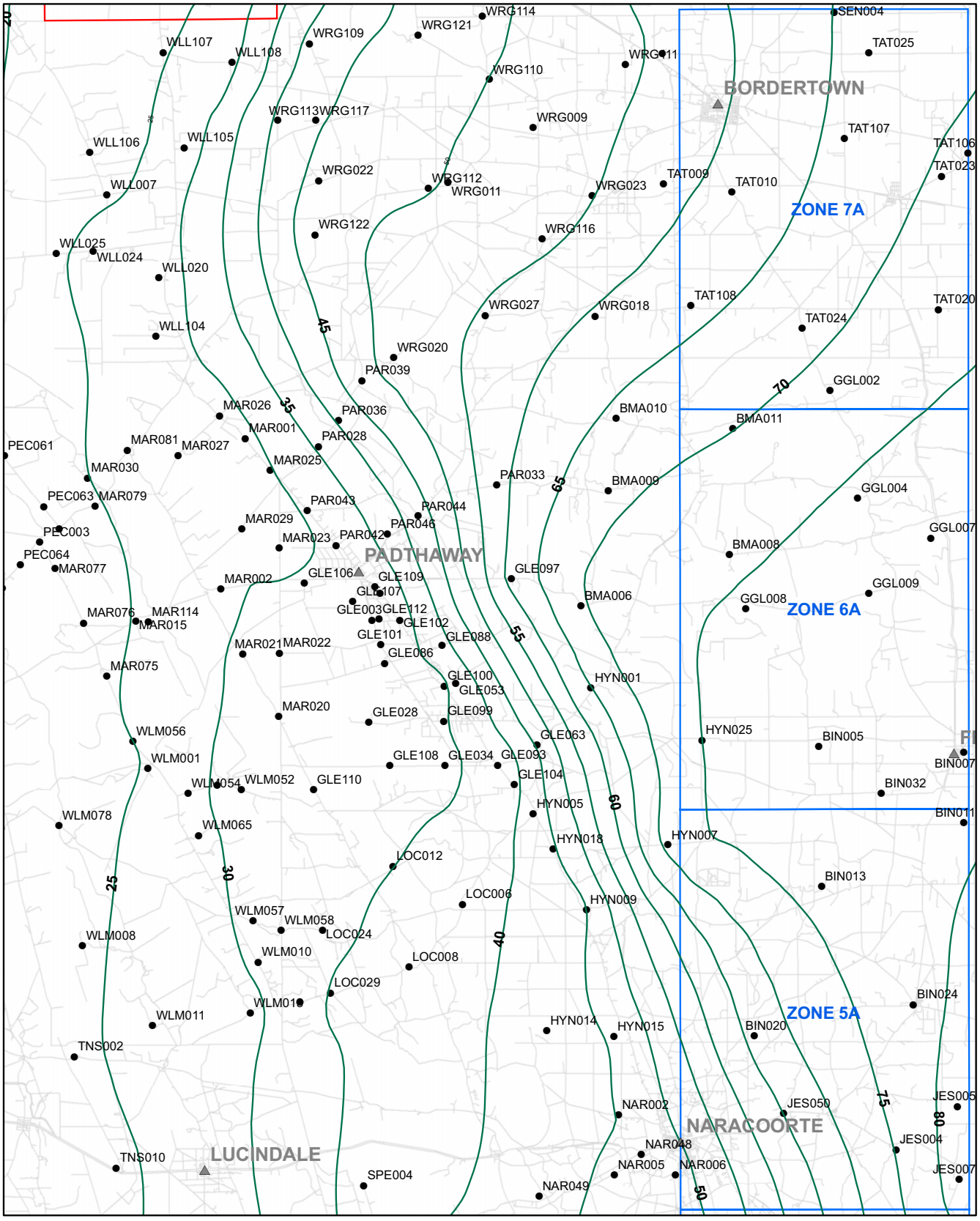

Figure 5
Hundred of Stirling and Border Designated Area Salt Accession Project
Border Designated Area (Zones 7A-5A) Unconfined Aquifer RSWL
(Latest RSWL Sept-Dec 2005)

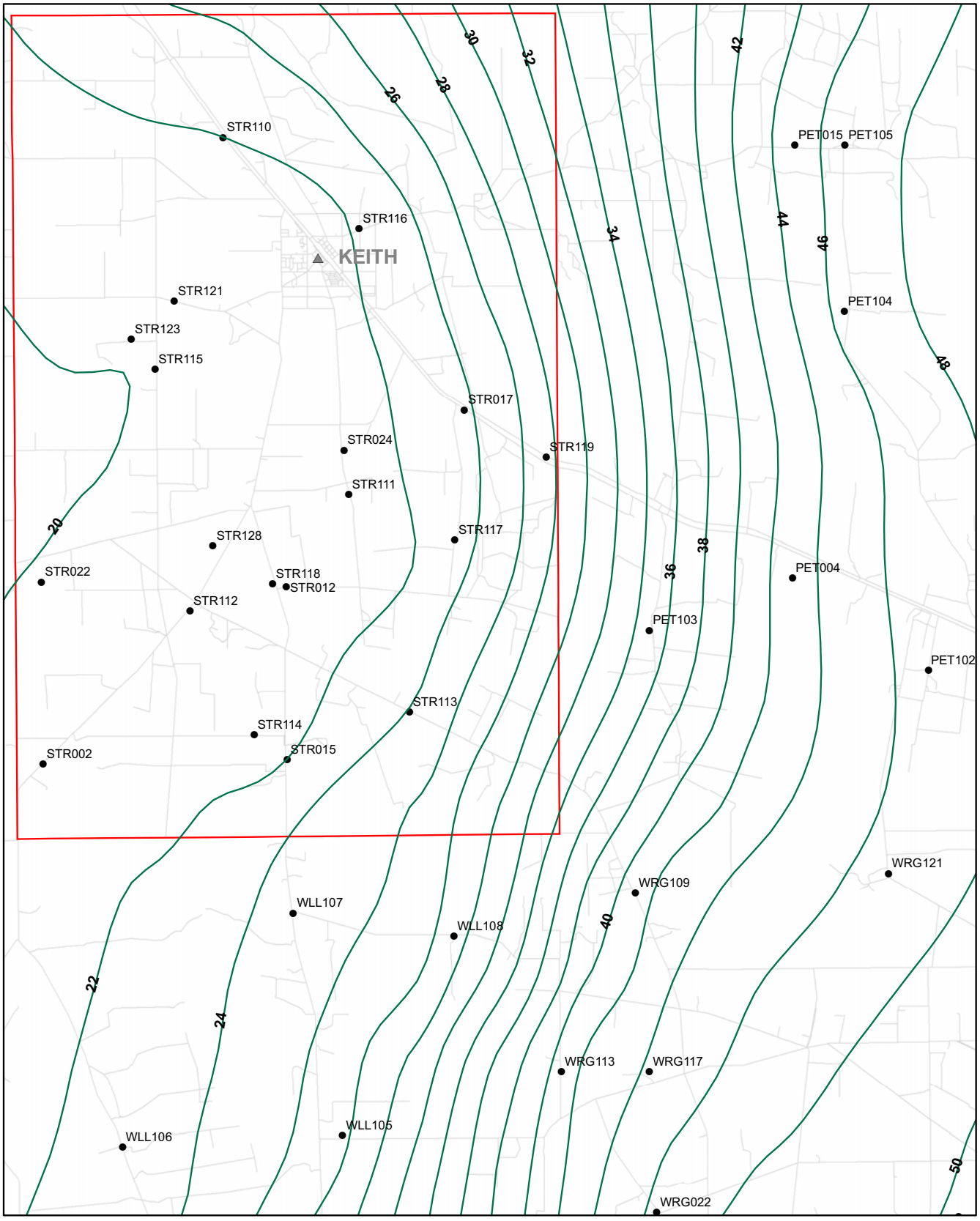

Figure 6
Hundred of Stirling and Border Designated Area Salt Accession Project
Hundred of Stirling Unconfined Aquifer RSWL
(Latest RSWL Sept-Dec 2005)

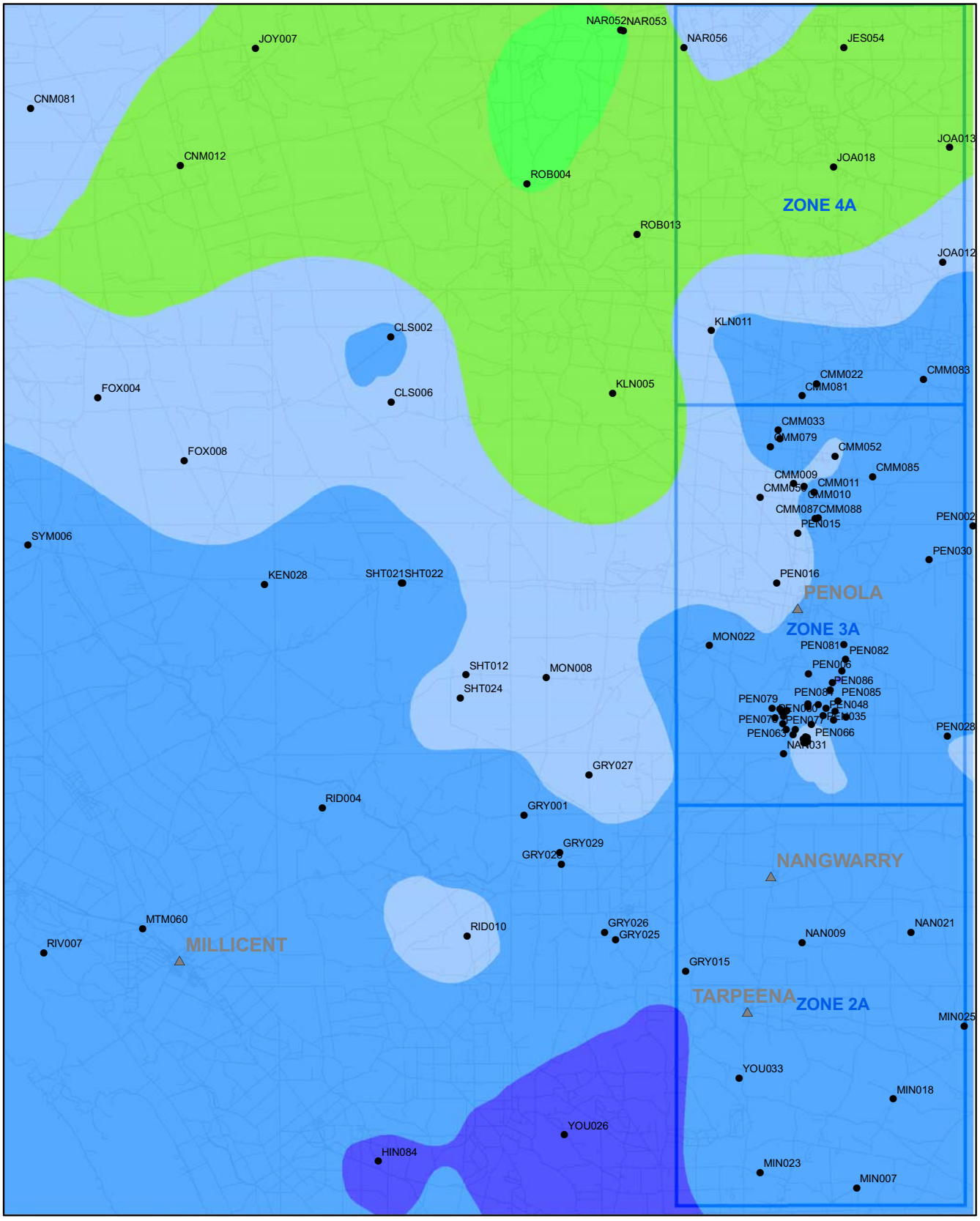

Figure 7
Hundred of Stirling and Border Designated Area Salt Accession Project
Border Designated Area (Zone 4A-2A) Unconfined Aquifer Salinity
(Latest Salinity Sept-Dec 2005)

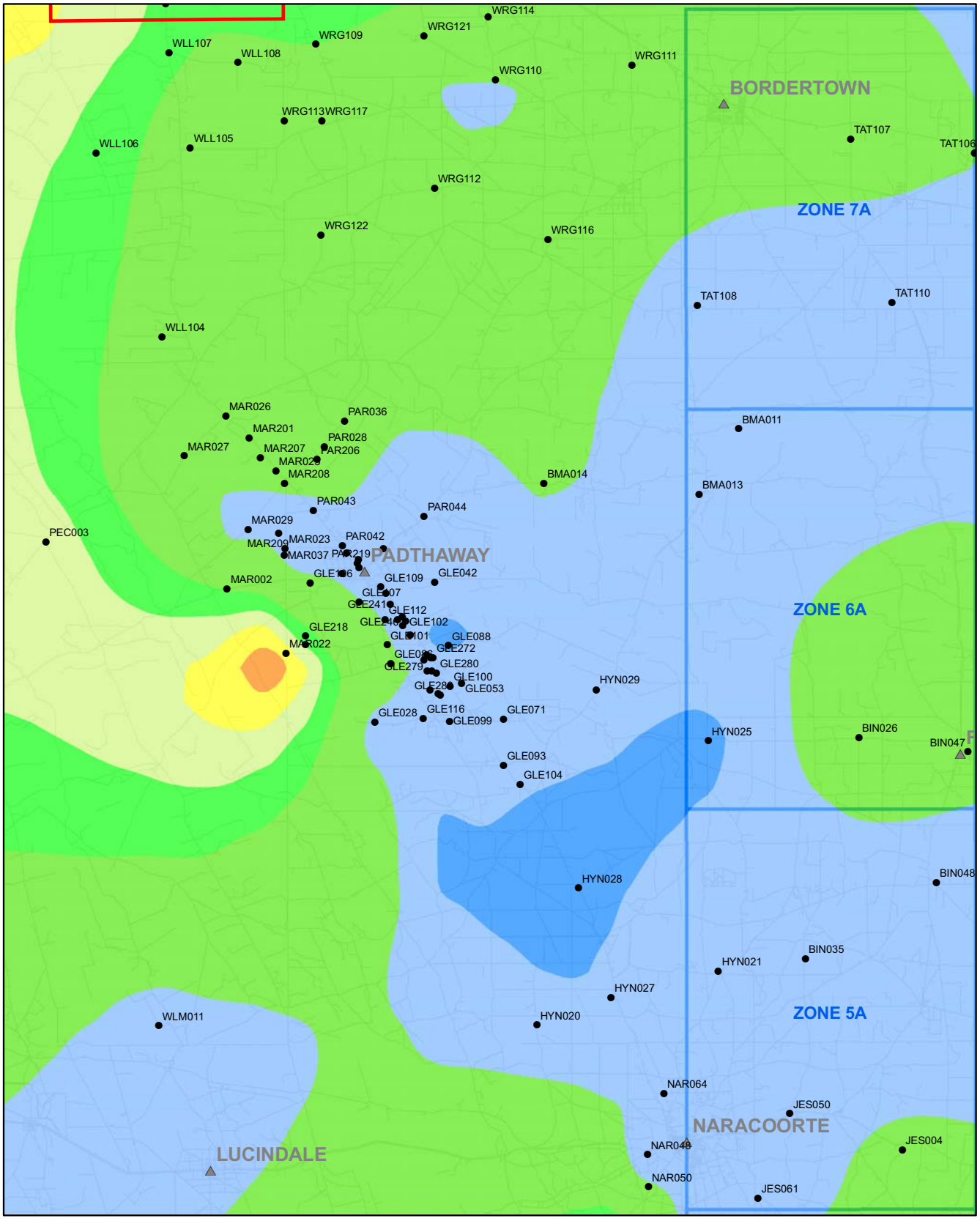

Figure 8
Hundred of Stirling and Border Designated Area Salt Accession Project
Border Designated Area (Zone 7A-5A) Unconfined Aquifer Salinity
(Latest Salinity Sept-Dec 2005)

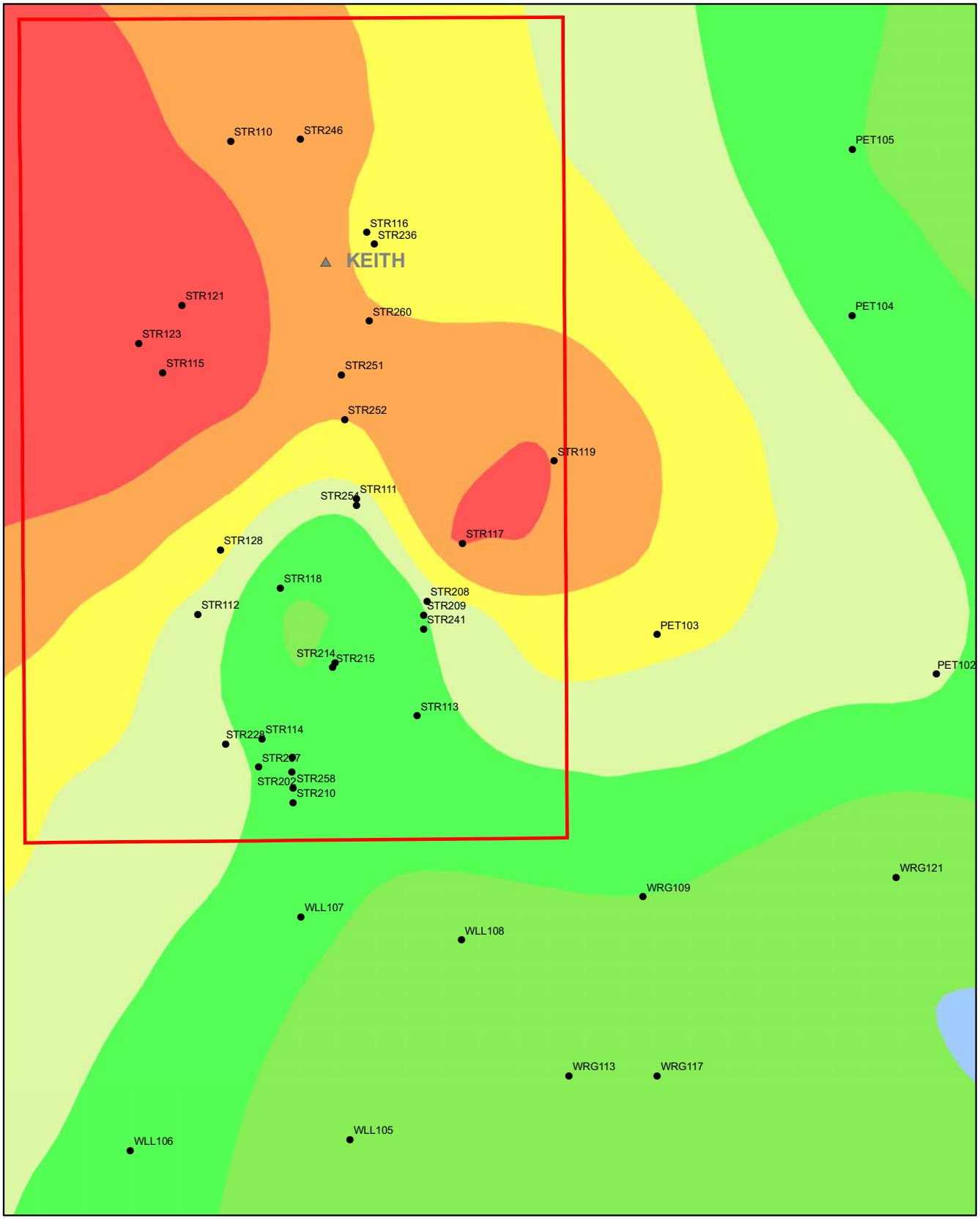

Figure 9
Hundred of Stirling and Border Designated Area Salt Accession Project
Hundred of Stirling Unconfined Aquifer Salinity
(Latest Salinity Sept-Dec 2005)

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4.4 SOILS

General soil descriptions for the two study areas are given as follows:

Border Designated Area – Shallow grey sandy surface horizon overlying heavier yellow or grey clays are dominant. Less significantly deep heavy grey soils, sandy soils, terra rossa (shallow loamy red soil) overlying limestone and red-brown earths (red-brown loam overlying cracking red-brown clay) (Stadter et al., 1985) (Fig. 10).

Hundred of Stirling – Generally shallow soils over calcrete or limestone, with areas of deep sands, sand over clay soils and minor shallow soils over rock (Fig. 11).

4.5 GROUNDWATER USE AND CURRENT GROUNDWATER MANAGEMENT

In 2004, the Lower Limestone Coast Prescribed Wells Area (PWA) was formed through the amalgamation of the Naracoorte Ranges PWA, Lacepede-Kongorong PWA and Comaum-Caroline PWA. Zones 2A to 6A and part of 7A of the Border Designated Area study area fall within the Lower Limestone Coast PWA. The amalgamation of the former PWAs was brought about to improve management efficiency as considerable areas of the region have similar characteristics including several ecosystems and wetlands that stretch across the previous PWA boundaries. Water Allocation Plans (WAPs) for the three former PWAs are currently being reviewed, amended and consolidated into a single WAP for the Lower Limestone Coast PWA. The Naracoorte Ranges PWA, Lacepede-Kongorong PWA and Comaum-Caroline PWA were originally proclaimed in 1986, 1997 and 1986 respectively. The Tatiara PWA (originally proclaimed in 1984), incorporates the Hundred of Stirling study area and the northern part of Zone 7A of the Border Designated Area study area. The Tatiara PWA WAP is currently undergoing review and amendment for approval in 2006.

Another piece of legislation significant to the study areas is the Groundwater (Border Agreement) Act 1985, which was introduced to protect the groundwater resources along a 40 km wide strip of the South Australian and Victorian State border referred to as the Border Groundwaters Agreement Designated Area. The South Australian/Victorian Border Groundwaters Agreement Review Committee (BGARC) is responsible for managing the water resources along the Border Designated Area.

Historically, the volume of groundwater available for extraction was limited to the Permissible Annual Volume (PAV) set for each management area. The PAVs were based on vertical recharge (assessed via hydrographic responses to seasonal recharge events), lateral groundwater throughflow and groundwater storage and are calculated as follows:

$$PAV\ (ML/yr) = (\text{sum of } (A_n \times R_n)) \times S_f$$

Where:

- A_n is the land area (km^2) of a defined recharge region within the management area.
- R_n is the annual average vertical recharge rate (mm/yr) of the defined recharge region A_n.

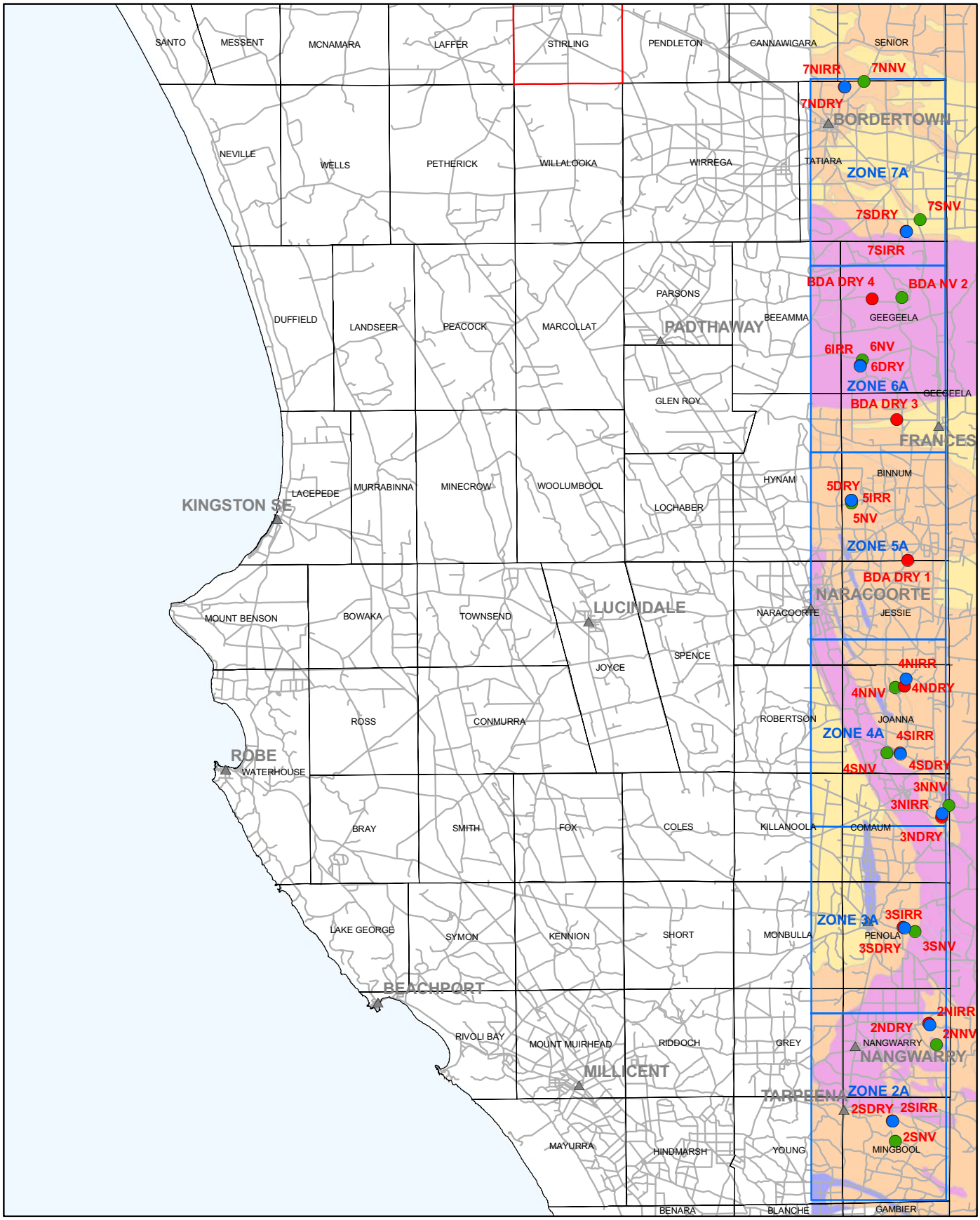

Figure 10
Hundred of Stirling and Border Designated Area Salt Accession Project
Border Designated Area Research Sites

Border Designated Area Research Sites
- Dryland
- Irrigation
- Native Vegetation

- CLAY SOIL
- DUPLEX SOIL
- SAND SOIL
- TERRA ROSSA SOIL

- Border Designated Area
- Hundred of Stirling

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0 5 10 20 30 40 50
Kilometers

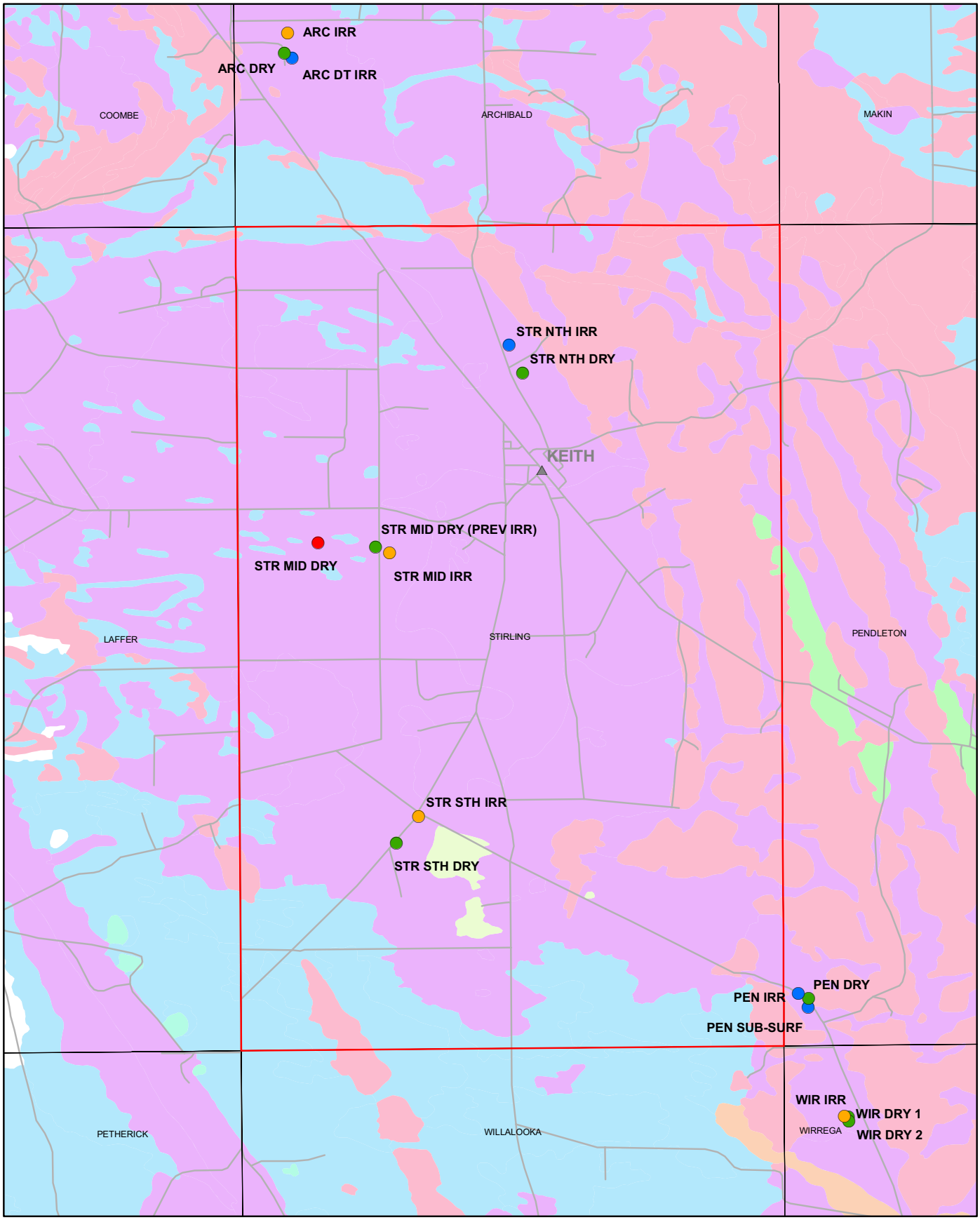

Figure 11
Hundred of Stirling and Border Designated Area Salt Accession Project
Hundred of Stirling Research Sites

Hundred of Stirling Research Sites Hundred of Stirling
- Established Dryland
- Established Irrigation
- New Dryland
- New Irrigation

Hundred of Stirling Soils
- Shallow soils on calcrete or limestone
- Cracking clay soils
- Deep loamy texture contrast soils
- Sand over clay soils
- Deep sands
- Shallow soils on rock
- Water

0 1 2 4 6 8 10 Kilometers

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- S_f is the salinity factor adopted for the management area. This factor is a proportional reduction applied to recharge, where extraction of 100% of recharge would lead to unacceptable salinity impacts.

The term PAV can only be applied to a whole zone of the Border Designated Area (BDA) under the Groundwater (Border Agreement) Act 1985; therefore each zone has a single PAV. There is currently considered to be a deficiency in the Agreement as it would be useful to apply separate PAVs to sub zones within each zone and likewise a provision should be in place to set separate PAVs for each aquifer (BGARC, 2001). Therefore the term "allowable annual volume" (AAV) is used to describe the individual volumes that can be extracted from each aquifer, with the sum of these volumes forming the PAV for each zone. The AAVs have been set to not exceed vertical recharge while maintaining through flow to provide flushing for salinity management.

When calculating the PAVs for each management area, stock and domestic use had been excluded, as a licence is not required for these purposes. It is now recognised that it is desirable to calculate a volume of water to allocate to each management area by including provisions for stock and domestic, forestry and the environment. The concept, Volume for Licensed Allocation (VLA) was used to calculate the total quantity of water available for licensed extractions on an annual basis within each management area by including the provisions for stock and domestic, forestry and the environment for the 2001 WAPs. VLAs for an unconfined aquifer were calculated as follows:

> VLA (ML/yr) = PAV – (provisions for the effects of forestry on recharge and stock, domestic and environmental demands) – (10% buffer in areas that are not fully allocated and do not become fully allocated as a result of the buffer).

The recent review of the groundwater condition and management of the unconfined tertiary limestone aquifer in the South East (Brown et al., 2006) adopts a new approach for determining allocation in each management area. The total available recharge (TAR) as described in Brown et al. (2006) is the component of recharge available for allocation after accounting for environmental needs. The use of TAR instead of PAV distinguishes between what level of development the resource can support in a sustainable manner (i.e. TAR) and what satisfies social and economic requirements for the resource (i.e. PAV) (Brown et al., 2006). Brown et al. (2006) point out that the key reasons for changes from the current PAV to TAR are improved estimates of average recharge rates, greater accuracy in determining land areas via GIS, environmental water requirements are now included in TAR and forestry recharge debits are not included in TAR.

Data provided by Brown et al. (2006), summarised in Table 1, indicates that several management areas are over allocated. Brown et al. (2006) recommends the PAVs for each management area outside the BDA be revised to the new TAR values and PAVs for the Tertiary Limestone Aquifer (TLA) of the BDA be retained at the AAVs. However, the AAVs may be revised by the BGARC as part of their five year management review, due in late 2006.

Groundwater allocations in the South East are currently based on theoretical crop water requirements, which form the basis of the area based Irrigation Equivalents (IE) allocation system rather than extraction. Therefore underground water usage is not a true reflection of the volume of underground water extracted which can be substantially more due to drainage, irrigation and evaporation losses. The IE system of allocating groundwater use is currently being converted to a volumetric allocation through the Volumetric Conversion Project.

Table 1. Groundwater use and current groundwater management

Management Area	**Existing PAV** (ML/yr)	**TAR** (ML/yr)	**Total Use^ (2004)** (ML)
Stirling	19260	17027	21223
Zone 2A	25000*	44796	86983
Zone 3A	24000*	45132	65491
Joanna	10000	12855	11259
Straun	3700	6147	4153
Glen Roy	4550	7357	5800
Comaum	1750	3388	3285
Zone 5A	18500*	18780	19509
Bangham	4170	5408	4255
Frances	4680	4393	4797
Western Flat	952	1154	994
Tatiara	6548	6185	7530

* Existing PAV is the Allowable Annual Volume (AAV) for the TLA as set by the Border Groundwaters Agreement Review Committee for licensed water allocations.

^ Total Use for each management area is not the volume pumped, but rather the sum of current allocations for irrigation (hectare IE), industry and public water supply; plus estimated stock and domestic use and estimated forestry impacts (recharge interception and direct groundwater extraction).

** Data sourced from Tables 9 and 10, Brown et al (2006).

5. APPROACH

5.1 PROJECT COMPONENTS

The project is divided into three components as described below and is being undertaken in three phases:

Component 1: Magnitudes and time scales of salt accessions in the Border Designated Area

- Quantify the amount of salt contained within the unsaturated zone in the Border Designated Area.
- Quantify groundwater recharge rates under various land-uses that occur in the Border Designated Area.
- Determine the potential for groundwater salinisation due to increased drainage as a result vegetation clearance.
- Determine flow paths and time scales for the salt to move through the Border Designated Area.

Component 2: Water and salt balances for the Stirling Management Area

- This component is being carried out in conjunction with De Barro Agricultural Consulting under a Consultancy Agreement.
- Estimate crop water use and, water and salt balances below different irrigation practices, including flood and subsurface drip irrigation of Lucerne on different soil types.
- Estimate water and salt balances below dry land agricultural practices.
- Quantify groundwater extraction and irrigation application using flow metres and depth loggers.
- Quantify water use efficiency through estimations of evapotranspiration and drainage using a combination of capacitance probes, neutron moisture meters, piezometers, suction lysimeters, weather station data and stable isotopes of water.

Component 3: Development of management strategies for the Border Designated Area and Hundred of Stirling

- Development of an analytical or numerical groundwater model for both the Border Designated Area and Stirling Management Area based on water and salt balances from Components 1 and 2.
- Use the models to assist in determining sustainable extraction limits. The sustainable extraction limit should result in the establishment of a new equilibrium of acceptable salinity and maintenance of sufficient groundwater through flow to mitigate potential future salinity impacts.
- Determine effective groundwater resource management strategies for each region and prediction of the impacts of these management strategies on groundwater levels and salinity.
- Evaluate of the current monitoring network to ensure that it meets future requirements.

Phases

- Phase 1: comprising of the establishment of field research sites including drilling, installation of instrumentation and soil analysis in the Border Designated Area and Hundred of Stirling.
- Phase 2: including ongoing data collection, analysis of data, assessment of water and salt balances and modelling.
- Phase 3: the assessment of the sustainability of the groundwater resource for the Border Designated Area and Hundred of Stirling, development of water management options and the regions long-term monitoring requirements.

6. METHODOLOGY

6.1 COMPONENT 1 (BORDER DESIGNATED AREA)

6.1.1 BACKGROUND AND APPROACH

Clearing of native vegetation in the Border Designated Area has occurred approximately over the last 100 years. Clearance of native vegetation and subsequent replacement with relatively low water use, shallow rooted crops and pastures causes an increase in drainage past the root zone. The increase in drainage establishes a pressure front that moves through the soil profile towards the groundwater table (Jolly et al., 1989). Resulting from this is a downward displacement of saline soil water (chloride front) as the pressure front moves down through the unsaturated zone. Therefore as the pressure front reaches the water table, an increase in aquifer recharge occurs.

The chloride ion behaves conservatively in the groundwater system and hence is used as a proxy for groundwater salinity. Core samples from the unsaturated zone beneath differing land use and soil types are used to locate the position of the chloride front at each location. An analytical model developed by Walker et al (1991) is applied to the data to predict unsaturated zone soil water movement. The point estimates of recharge and salt flux to the water table are applied spatially via a GIS interpretation of soil landscape unit (SLU) maps to provide potential groundwater salinisation maps.

6.1.2 SITE SELECTION

Climate, soil type and land use vary considerably over the Border Designated Area. To encapsulate the region as a whole, an approach using GIS was used to integrate soils and land use throughout the Border Designated Area, therefore determining the most suitable sites. The soils map was used to identify general sand, clay and duplex soil associations from which 10 areas were selected in the Border Designated Area that evenly represented the distribution of soil profile characteristics. Distinct land uses through the Border Designated Area; being native vegetation, dry land pasture and irrigated pasture were identified. At the 10 selected areas, cored investigation hole sites were chosen for each of the three land use practices (Fig. 10). This process provides good representation of changes to land use since clearing over differing soil units.

Periodically from February 2005 through to July 2005 a series of 30 continuously cored investigation holes were drilled at the selected sites then backfilled, with the exception of one, which was completed as a monitoring well in the Border Designated Area. Each site was numbered using the corresponding Border Designated Area number, N or S representing a location in the north or south of each respective zone (if more than one grouping of sites were located in that zone) and including a prefix; DRY for dry land sites, IRR for irrigated sites and NV for native vegetation sites.

Data from the February through to July 2005 drilling program was analysed, with preliminary results highlighting several areas that required additional investigation. Four new investigation sites were established in Zones 5A and 6A of the Border Designated Area where soil clay contents are markedly variable to the data already collected. Information gained from the additional investigation sites will overcome some keys knowledge gaps and significantly improve the confidence of the analytical modelling of groundwater recharge and salinisation in the Border Designated Area. One native vegetation and three dry land investigation holes were continuously cored during November 2006 and completed as monitoring wells for future groundwater analysis. The four investigation sites have the prefix BDA followed by either DRY or NV to indicate land use (Fig. 10).

6.1.3 SOIL SAMPLING AND CORE COLLECTION

Unsaturated zone soil cores were taken from each of the investigation holes using hollow flight augers and split-tube wire line recovery technique on an Investigator drill rig. The hollow flight auger and split tube wire line recovery method enables no additional air, water or drilling fluids to be used therefore minimising contamination effects on pore water chloride and water contents of the core samples. Core samples were taken at 0.5 m intervals to ~10 m depth then at 1 m intervals to the base of hole. At each interval, cores were split, with half being placed in airtight 500 ml glass jars for soil physical properties and pore water chloride analysis and the remaining part sample retained as a continuous core sample. Core samples were taken through the unsaturated zone to ~1 m below the water table, except at several sites where the water table was not cut due to unfavourable drilling conditions for hollow flight augers. Drilling continued past the water table at five investigation sites enabling the completion of 4N-NV, in phase one of drilling, and BDA DRY 1, BDA DRY 3, BDA DRY4 and BDA NV 2, in phase two of drilling, as monitoring wells (Fig. 10 and App. C). All lithological logs are included in Appendix C.

6.1.4 ANALYTICAL METHODS

The unsaturated zone core samples were analysed at CSIRO Water and Land, Adelaide, for gravimetric water content, matric potential, particle size and pore water chloride concentration.

Gravimetric water content, θ_g (grams of water per grams of dry soil) is determined by oven drying a weighed sample (≈20 grams) overnight at 105ºC. The dried samples are reweighed and the gravimetric water content calculated with the available data.

The dried core samples are then combined with 50 ml of (0.01M) BaNO3 solution and shaken on a mechanical shaker for two hours. They are settled overnight and decanted for [Cl^-] measurement.

Extracts are analysed by colorimetry (Taras et al. 1975) using the 4500-Cl^--E Automated ferricyanide method for [Cl^-] analysis.

The extracts are then measured for [Cl^-] using an Alpkem Flow Solution analyser. These [Cl^-] results are combined with the gravimetric water content values to provide the pore water chloride in mg/litre.

Estimates of particle size were carried out using the time settling method. Sand is considered to be coarser than 0.02 mm, silt between 0.02–0.002 mm and clay finer than 0.002 mm.

6.1.5 GROUNDWATER SAMPLING

A review of existing data suggested that it would be useful to collect groundwater samples from a selection of wells over the course of the project for major ion and other environmental tracer analyses; including stable isotopes (δO^{18} and δD), chlorofluorocarbons (CFC's) and carbon 14. The chemical and isotopic composition of groundwater may provide useful information about recharge conditions, evapotranspiration and groundwater flow paths.

During September and December 2006 a selection of monitoring wells were selected and sampled for major ions and environmental tracers. Water levels in each sampled monitoring well were measured using a water level meter prior to sampling. Groundwater samples were taken from each monitoring well after three casing volumes had been pumped from the well and readings of pH, temperature and EC at the pump discharge pipe became constant.

6.2 COMPONENT 2 (HUNDRED OF STIRLING)

6.2.1 BACKGROUND AND APPROACH

Salt, present at low concentrations in rainfall, can be concentrated by evapotranspiration and stored in significant quantities in the unsaturated zone. This salt store has the potential to be displaced into the groundwater as a result of native vegetation clearance and, to a greater extent, following the development of irrigation (Leaney et al., 1999). The Hundred of Stirling is a heavily developed irrigation region, particularly flood irrigation, and increases in groundwater salinity are believed to be occurring in response to salt accession resulting from irrigation recycling.

Given the shallow and variable characteristics of the soil zone, and heterogeneous nature of the underlying geology; the most suitable method to calculate groundwater recharge and salt flux beneath flood irrigation was considered to be a water and chloride mass balance approach. Stable isotopes (δD and $\delta^{18}O$) will be used to estimate and compare recharge and evaporation against the mass balance approach.

De Barro Agricultural Consulting will carry out monitoring and data collection, particularly during the irrigation season.

6.2.2 WATER, CHLORIDE AND STABLE ISOTOPE (δD AND $\delta^{18}O$) MASS BALANCE FOR RECHARGE AND SALT FLUX ESTIMATES

Based on the law of conservation of mass, the water mass balance says that any change in the water content of a soil volume during a specified time must equal the difference between the amount of water added and amount of water removed from the soil volume (Zhang et al., 2002). Therefore the water content of a soil will increase via infiltration and decrease through evaportranspiration or deep-drainage. Assuming zero surface run-off, the water mass balance can be given as the following:

$$P + I = ET + D + \Delta S$$

Where P = precipitation, I = irrigation, ET = evaportranspiration, D = deep-drainage and ΔS = change in storage.

Since chloride behaves conservatively in groundwater and is therefore assumed to be solely concentrated by evaporation, the chloride mass balance can be used to estimate recharge (R) under steady state conditions:

$$R = (P + I)\frac{\left(PCl_P + ICl_I \middle/ P + I\right)}{Cl_S}$$

Where P = precipitation, I = irrigation, Cl_P = chloride concentration of precipitation, Cl_I = chloride concentration of irrigation and Cl_S = average chloride concentration of soil below the root zone.

The comparison of the stable isotopic composition of rainfall, groundwater, surface water (delivery channel and flood bay) and soil water will be used to improve the evaporation rate estimates when calculating the water mass balance. The stable isotopes of the water molecule (δD and δ^{18}O) are subject to a fractionation process that occurs during evaporation. As the influence of evaporation on soil moisture decreases with depth below the ground surface (to ~2–3 m), the isotopic composition of the soil water also varies with depth. Transpiration however does not cause changes to the isotopic signatures. Therefore the percentage of rainfall and irrigation water evaporated can be estimated in isolation from transpiration.

6.2.3 SITE SELECTION

De Barro Agricultural Consulting had five established research sites located in or in close proximity to the Hundred of Stirling (Fig. 11). Four of these monitor flood bay Lucerne while one monitors dry land Lucerne. The number of investigation sites was then expanded to include alternative management practices and background sites.

Two additional Lucerne irrigation sites where chosen, one monitoring traditional flood bay irrigation and one monitoring sub-surface drip irrigation (Fig. 11). To ascertain the influence of irrigation on salt accession, five dry land sites (Fig. 11) were chosen as background sites, each having close proximity to an irrigation site. One (of five) dry land site was previously irrigated, with irrigation ceasing approximately 10 years ago.

Piezometers were installed and investigation holes drilled for suction lysimeters, c-probes and neutron moisture meters at the new research sites during August and September 2005.

A key component of the project is to enable strategies to be developed within the sustainable capacity of the groundwater resource and identify resource management options including any practical irrigation delivery alternatives to flood irrigation. Following the 2005–06 irrigation season a shortfall was identified in that the water balance and salt flux beneath pivot and drop tube pivot irrigation had not been considered.

Three new research sites were established during May 2006 to the north of the Hundred of Stirling, in the Hundred of Archibald and constructed beneath a drop tube pivot and conventional pivot (both irrigating Lucerne), and on a non-irrigated Lucerne background site. Currently, no pivot irrigation system is located in the Hundred of Stirling.

6.2.4 MEASURING COMPONENTS OF THE WATER, CHLORIDE AND STABLE ISOTOPE (δD AND δ^{18}O) MASS BALANCE

6.2.4.1 Piezometer Installation - Water Level and Groundwater Salinity Measurements

Piezometers had previously been installed at all existing (De Barro Agricultural Consulting) research sites and were installed at all new research sites during August and September 2005 and May 2006. All monitoring wells were completed with 50 mm class 9 PVC including a 50 mm class 9 PVC screen, gravel pack, bentonite seal and cemented to surface (see App. C for details of drilling and installation of new piezometers).

At several of the newly installed sites, continuous groundwater level or groundwater level/salinity loggers will be installed, while at all other sites; regular groundwater level, salinity and stable isotope measurements will be taken manually to measure groundwater response to groundwater pumping, irrigation and rainfall.

6.2.4.2 Meteorological Measurements

Two automated weather stations courtesy of De Barro Agricultural Consulting are located at monitoring sites in the study area that record parameters used for potential evaporation (Eto) calculation and local rainfall amount, while Bureau of Meteorology site number 025507 (Keith) is also accessed for meteorological information. Rainfall is collected monthly for chloride and stable isotopes (δD and δ^{18}O) at sites WIR IRR, STR STH IRR and STR NTH IRR in specially constructed rainfall collection containers. To reduce the potential for evaporation, a layer of paraffin oil is added to the rainfall collection containers.

6.2.4.3 Groundwater Extraction, Irrigation and Channel Drainage Measurements

Groundwater extraction is measured by flow meters at all flood irrigation pumps, which record flow rate (L/s), daily volume (kL) and cumulative volume (ML) pumped from the irrigation well. Irrigation to the bay is measured using Dataflow Systems 392 depth loggers that record the depth of water flowing through the irrigation gate to the irrigation bay and the timing of an irrigation event as a function of the depth of water passing over it (De Barro, 2004). Delivery channel drainage loss from the irrigation pump to the flood bay as described by De Barro (2004) is calculated using the pondage test. The rate of water loss via channel drainage is calculated for several positions along the channel then averaged.

6.2.4.4 Soil Moisture Measurements

The installation of suction lysimeters at all sites allows measurements of soil moisture salinity to be taken at regular intervals with in the unsaturated zone. Three or four 75 mm diameter holes ranging between 0.45–7.5 m total depth, depending upon soil structure, rooting depth and land use, were drilled and suction lysimeters installed (see Table 2 for installation details). The construction of each suction lysimeter involved attaching a 0.15 m porous ceramic cup to the desired length of 16 mm PVC conduit. Installation involved placing the suction lysimeter in the hole with diatomaceous earth packed around the ceramic cup to ensure good contact with the surrounding soil, a bentonite seal set above the diatomaceous earth followed by a cement plug to ground surface.

Table 2. Suction lysimeter depths

Site	Hole Depth (m)
WIR DRY 2	0.8
	1.7
	2.85
WIR IRR	1
	2
	3
PEN SUB-SURF	0.45
	0.75
	1.15
	2.45
PEN DRY	0.5
	1.3
	2.45
PEN IRR	0.5
	2
	3
STR STH DRY	0.5
	1
	3
STR STH IRR	1
	2
	3
STR MID DRY (PREV IRR)	0.5
	1
	1.5
	3
STR MID DRY	0.5
	1
	1.5
	3
STR MID IRR	1
	2
	3
STR NTH DRY	0.5
	1
	3
	7.5
STR NTH IRR	0.45
	0.8
	1.45
	3
ARC DT IRR	0.4
	0.8
	1.2
	2
ARC DRY	0.4
	0.8
	1.5
ARC IRR	0.4
	0.8
	1
	2
	3

De Barro Agricultural Consulting has capacitance probes (C-probes) installed on existing irrigation investigation sites utilising an Agwise® telemetry system to log and transmit data. At all new irrigation investigation sites, holes were drilled during August and September 2005, and May 2006 for the installation of C-probes, which were subsequently installed by De Barro Agricultural Consulting during November 2005 and June 2006. Currently the C-probes are not calibrated to local conditions. However during May 2006 five investigation holes were continuously cored for the purpose of instrumentation calibration at existing Hundred of Stirling sites. Saturated and non-saturated soil samples were collected for soil physical property analysis, hence allowing calibration. Once calibrated, the C-probe is able to provide soil moisture profiles versus depth in the root zone and associated lag times of soil moisture movement, which are useful in determining crop water use and drainage.

To provide a more robust estimate of unsaturated zone soil moisture change (ΔS) more than one method of measuring ΔS is being used. In addition to the C-probe, changes in soil moisture of the unsaturated zone are also measurable using a calibrated neutron moisture

meter (NMM). Currently, as with the C-probe, the NMM is not calibrated to local conditions. However during the course of the project soil samples will be taken for soil physical property and soil moisture analysis to provide suitable local calibration. NMM access holes where drilled and aluminium tubing installed to three meters during August and September 2005 and May 2006 at each new site. De Barro Agricultural Consulting has operational NMM access points at existing research sites.

6.2.5 BACKHOE PITS

On 24–25 May and 1 June 2005, 12 backhoe pits were excavated at all irrigated and non-irrigated investigation sites. Backhoe pits reached to a depth of 3 m below ground surface. Ideally, all pits were to be excavated to water table (5–6 m), however an excavator with additional reach could not be used, as the excavator tracks would have excessively disturbed the Lucerne. Soil samples were collected at 0.5 m intervals along the face of the backhoe pit and placed in airtight 500 ml glass jars for soil physical properties and pore water chloride analysis. Backhoe pits were excavated for soil sample collection rather than using an Investigator drill rig to minimise any detrimental impacts on the Lucerne crops.

6.2.6 ANALYTICAL METHODS

The unsaturated zone core samples were analysed at CSIRO Water and Land, Adelaide, for gravimetric water content, matric potential, particle size and pore water chloride.

Gravimetric water content, θ_g (grams of water per grams of dry soil) is determined by oven drying a weighed sample (≈20 grams) overnight at 105ºC. The dried samples are reweighed and the gravimetric water content calculated with the available data.

The dried core samples are then combined with 50 ml of (0.01M) BaNO3 solution and shaken on a mechanical shaker for two hours. They are settled overnight and decanted for [Cl^-] measurement.

Extracts are analysed by colourimetry (Taras et al. 1975) using the 4500-Cl^--E Automated ferricyanide method for [Cl^-] analysis.

The extracts are then measured for [Cl^-] using an Alpkem Flow Solution analyser. These [Cl^-] results are combined with the gravimetric water content values to provide the pore water chloride in mg/litre.

Estimates of particle size were carried out using the time settling method. Sand is considered to be coarser then 0.02 mm, silt between 0.02–0.002 mm and clay finer than 0.002 mm.

APPENDICES

A. GEOLOGICAL CROSS SECTION PLANS

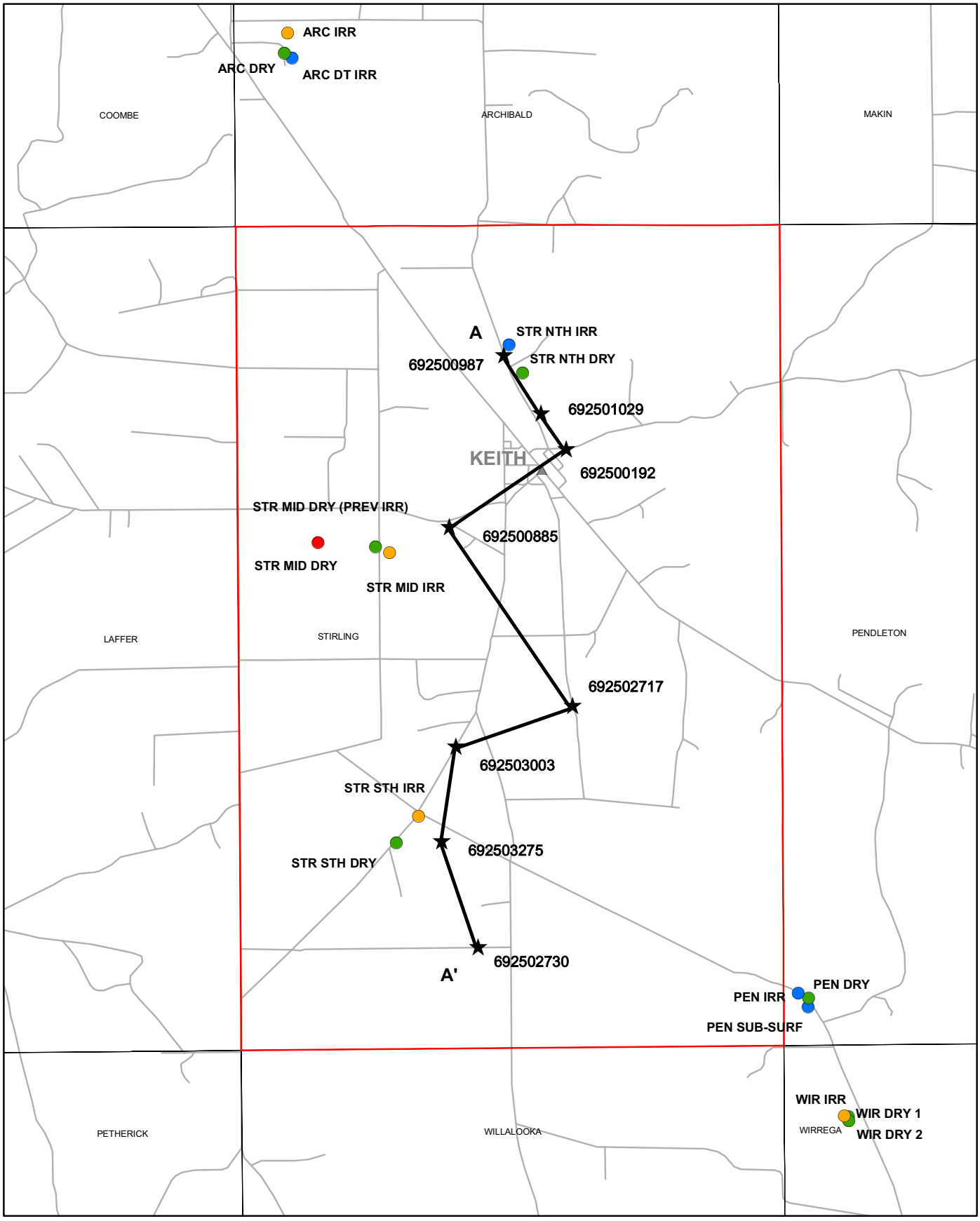

Figure 12
Hundred of Stirling and Border Designated Area Salt Accession Project
Cross Section A - A'

Hundred of Stirling Research Sites

- Established Dryland
- Established Irrigation
- New Dryland
- New Irrigation
- Cross Section A - A'
- Hundred of Stirling

Government of South Australia
Department of Water, Land and Biodiversity Conservation

0 1 2 4 6 8 10 Kilometers

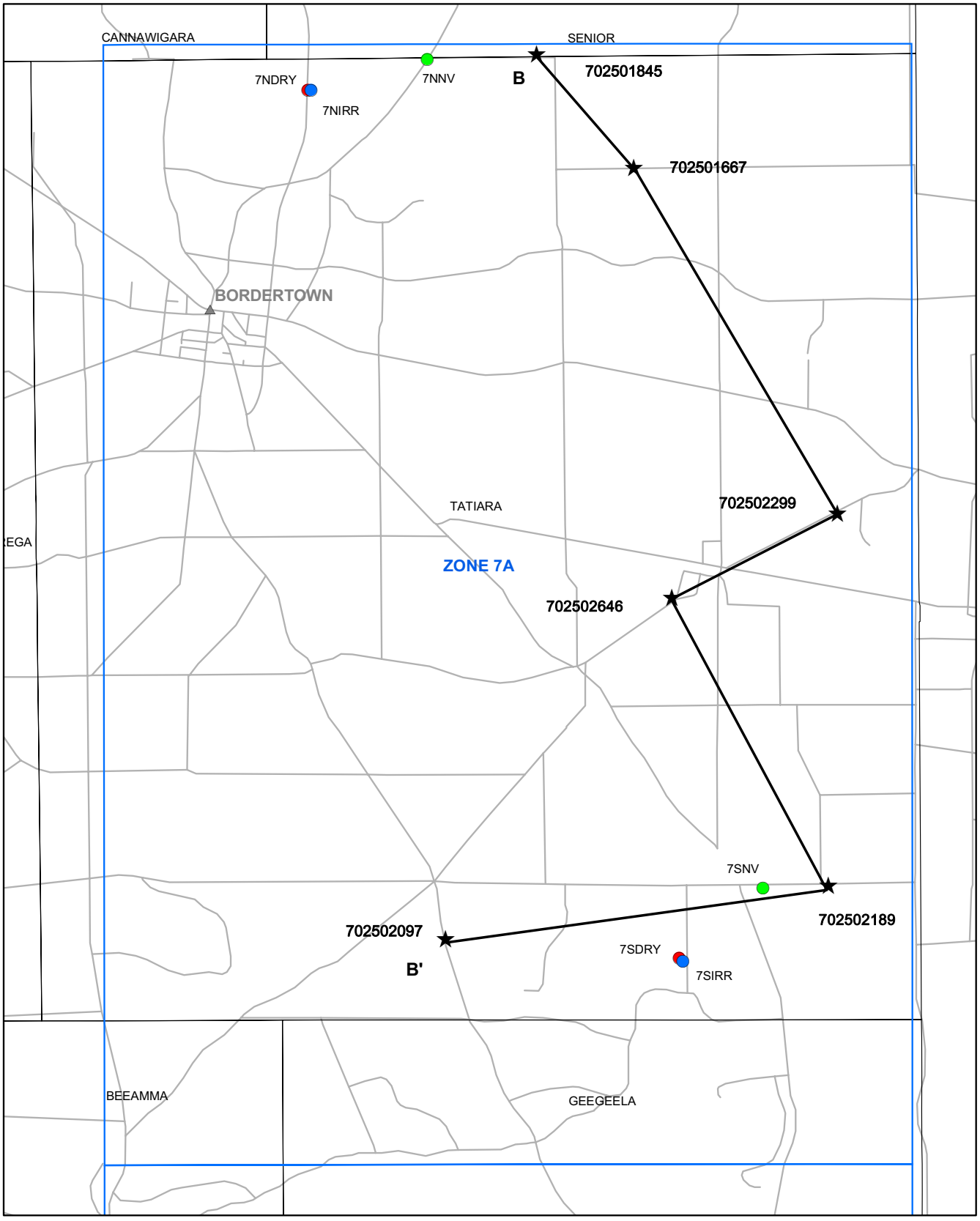

Figure 13
Hundred of Stirling and Border Designated Area Salt Accession
Cross Section B - B'

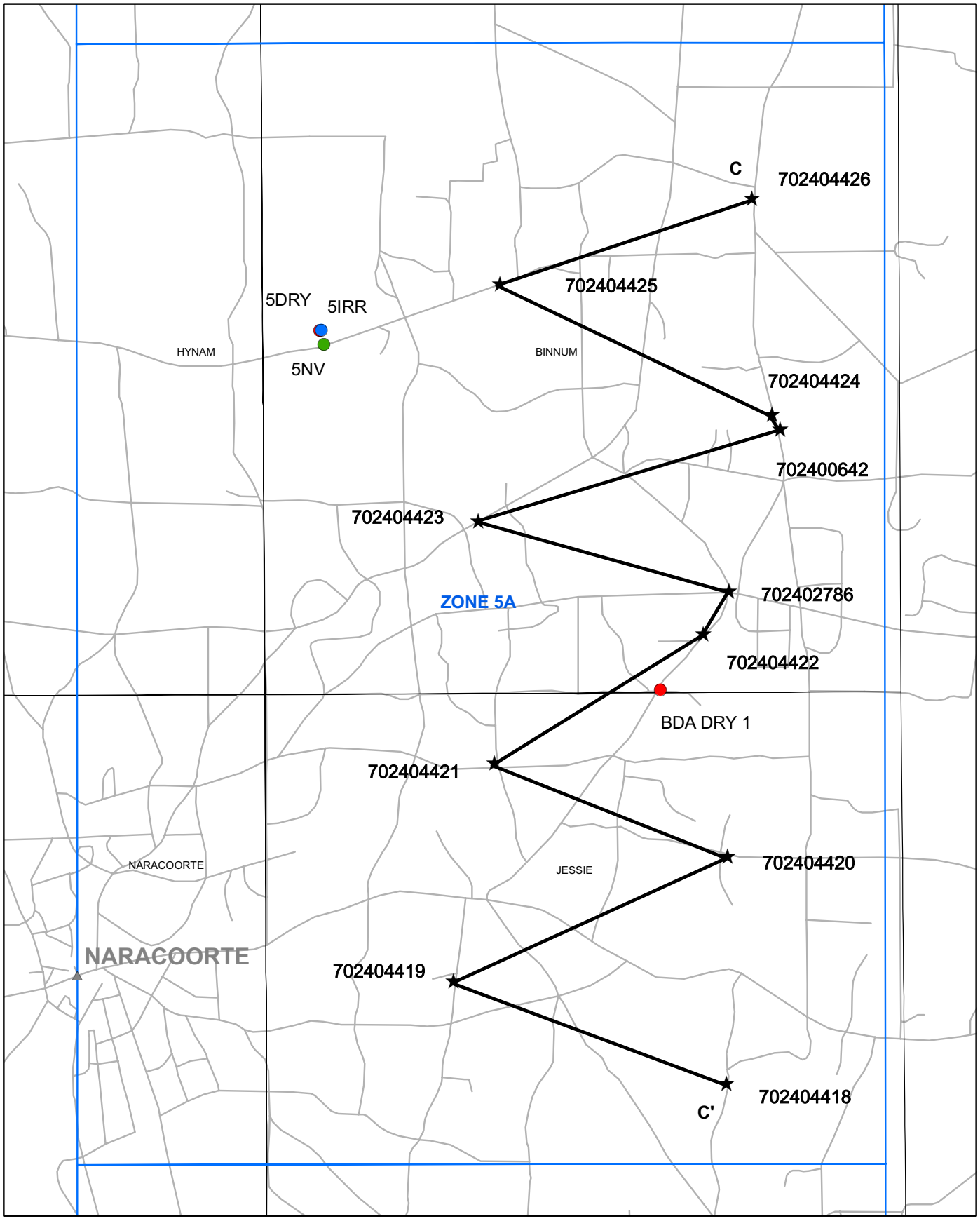

Figure 14
Hundred of Stirling and Border Designated Area Salt Accession
Cross Section C - C'

Border Designated Area Coring Sites
- Dryland
- Irrigation
- Native Vegetation

Cross Section C - C'
Border Designated Area

Government of South Australia
Department of Water, Land and Biodiversity Conservation

0 1 2 4 6 8 10 Kilometers

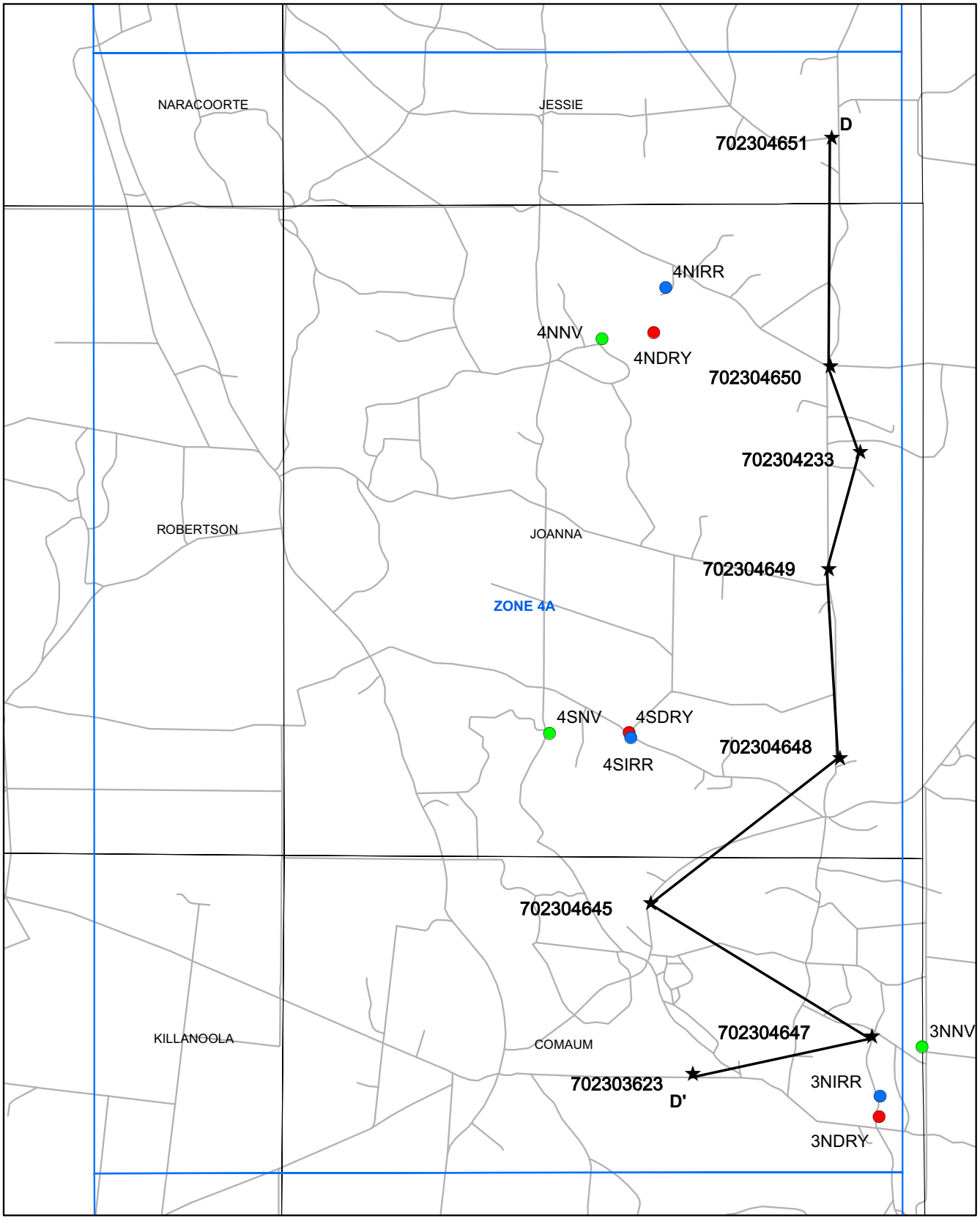

Figure 15
Hundred of Stirling and Border Designated Area Salt Accession
Cross Section D - D'

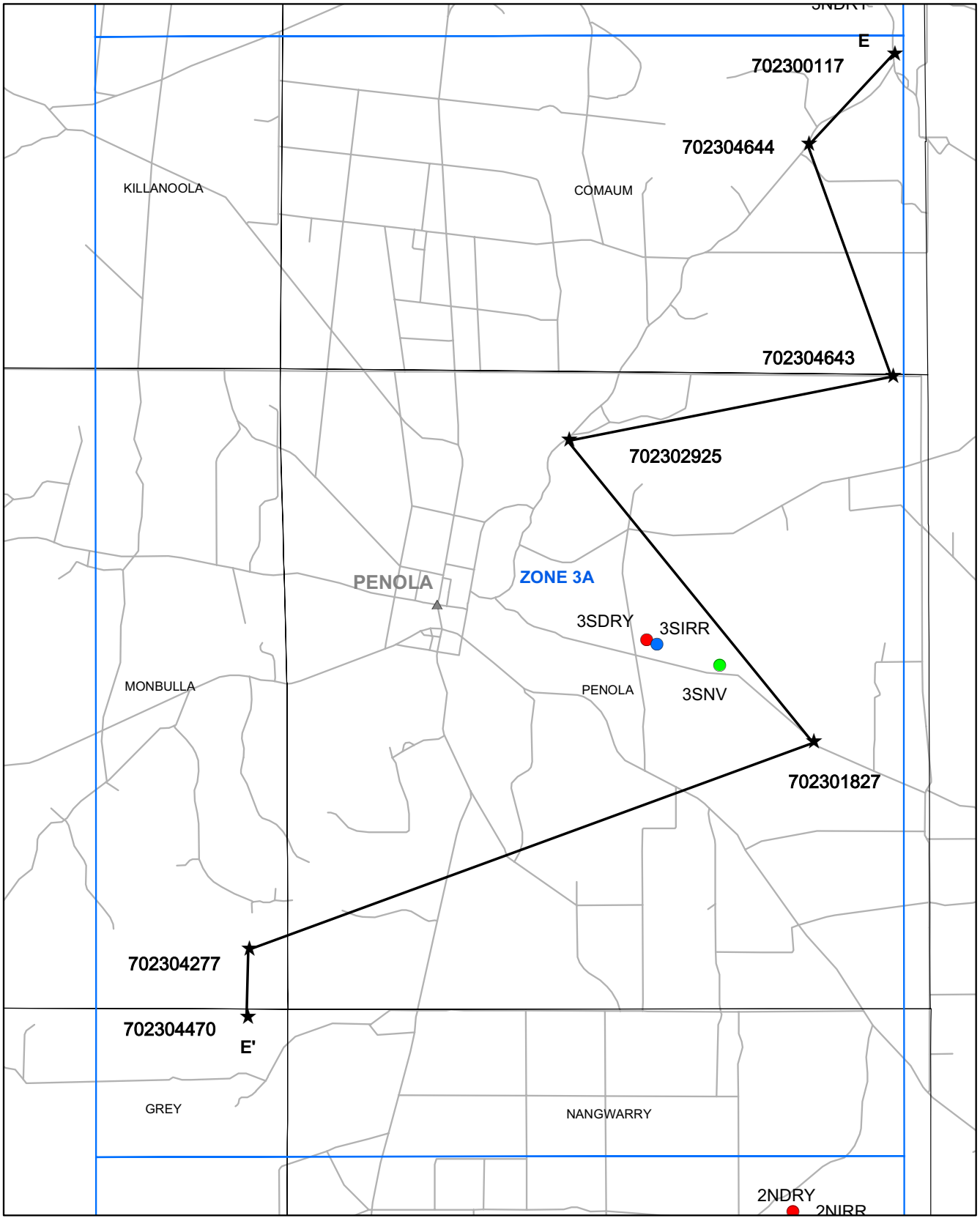

Figure 16
Hundred of Stirling and Border Designated Area Salt Accession
Cross Section E - E'

Borde Designated Area Coring Sites
- Dryland
- Irrigation
- Native Vegetation

Cross Section E - E'
Border Designated Area

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0 1 2 4 6 8 10 Kilometers

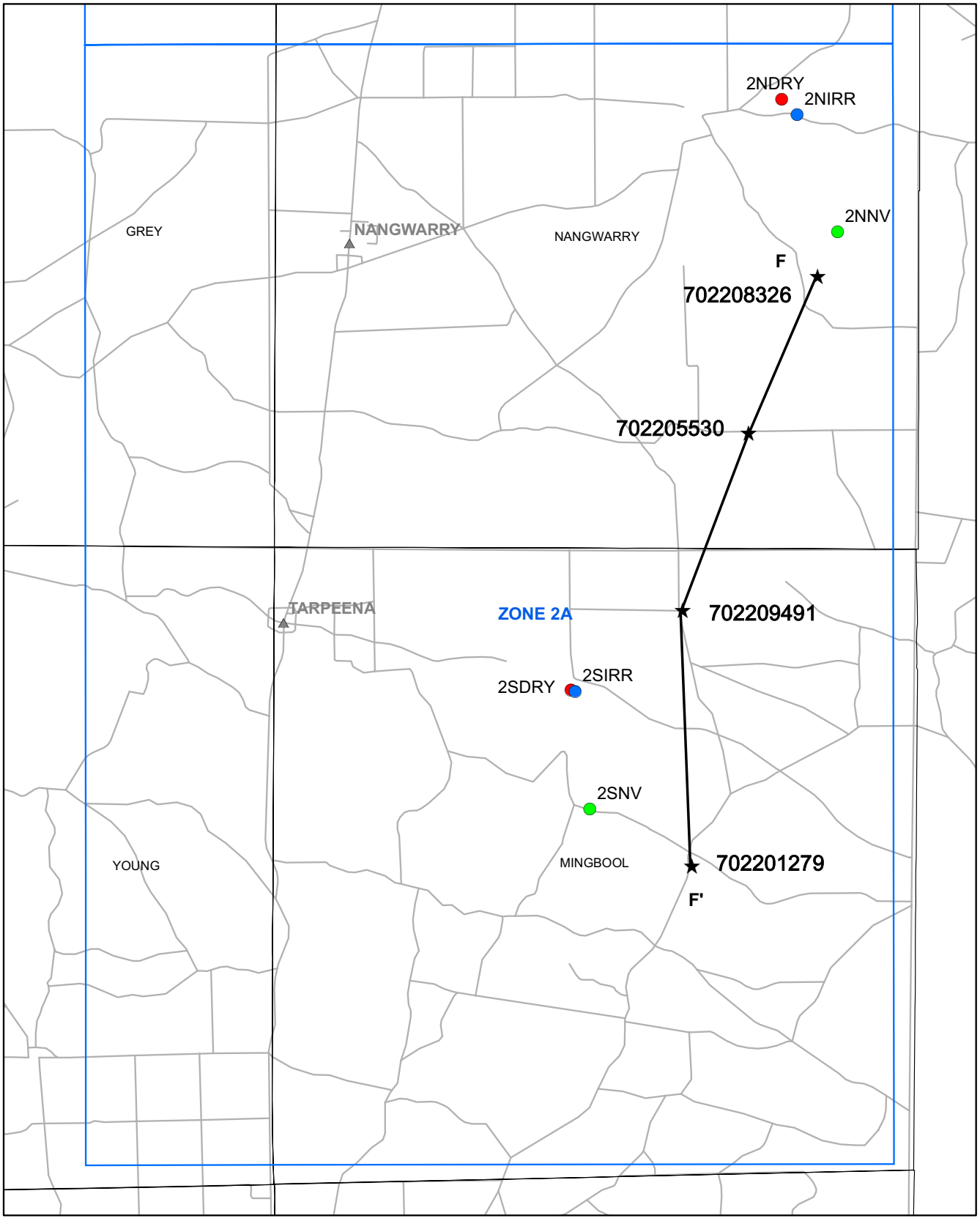

Figure 17
Hundred of Stirling and Border Designated Area Salt Accession
Cross Section F - F'

Borde Designated Area Coring Sites
- Dryland
- Irrigation
- Native Vegetation

Cross Section F - F'
Border Designated Area

Government of South Australia
Department of Water, Land and Biodiversity Conservation

0 1 2 4 6 8 10 Kilometers

B. GEOLOGICAL CROSS SECTIONS

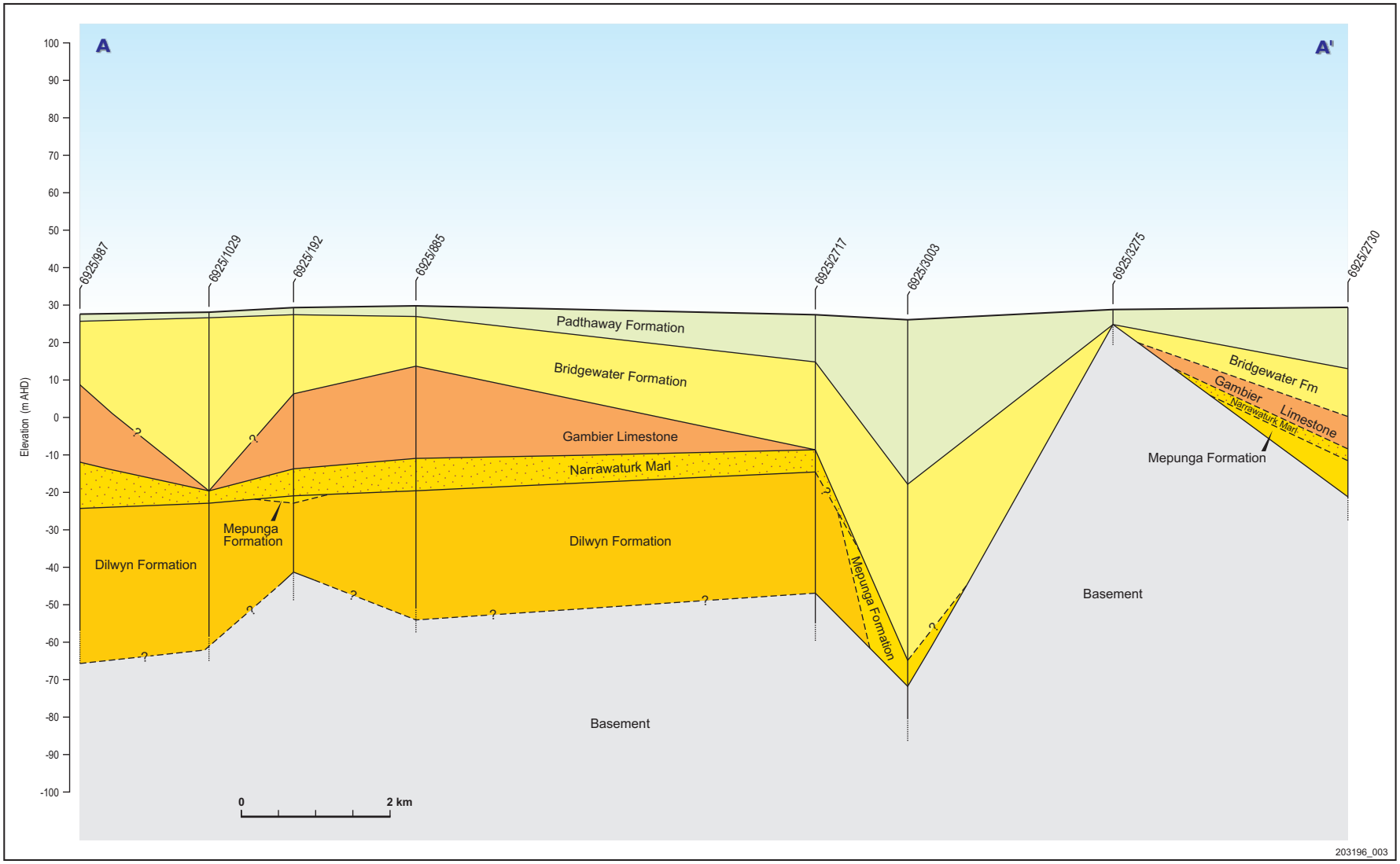

Figure 18. Geological Cross Section A–A'

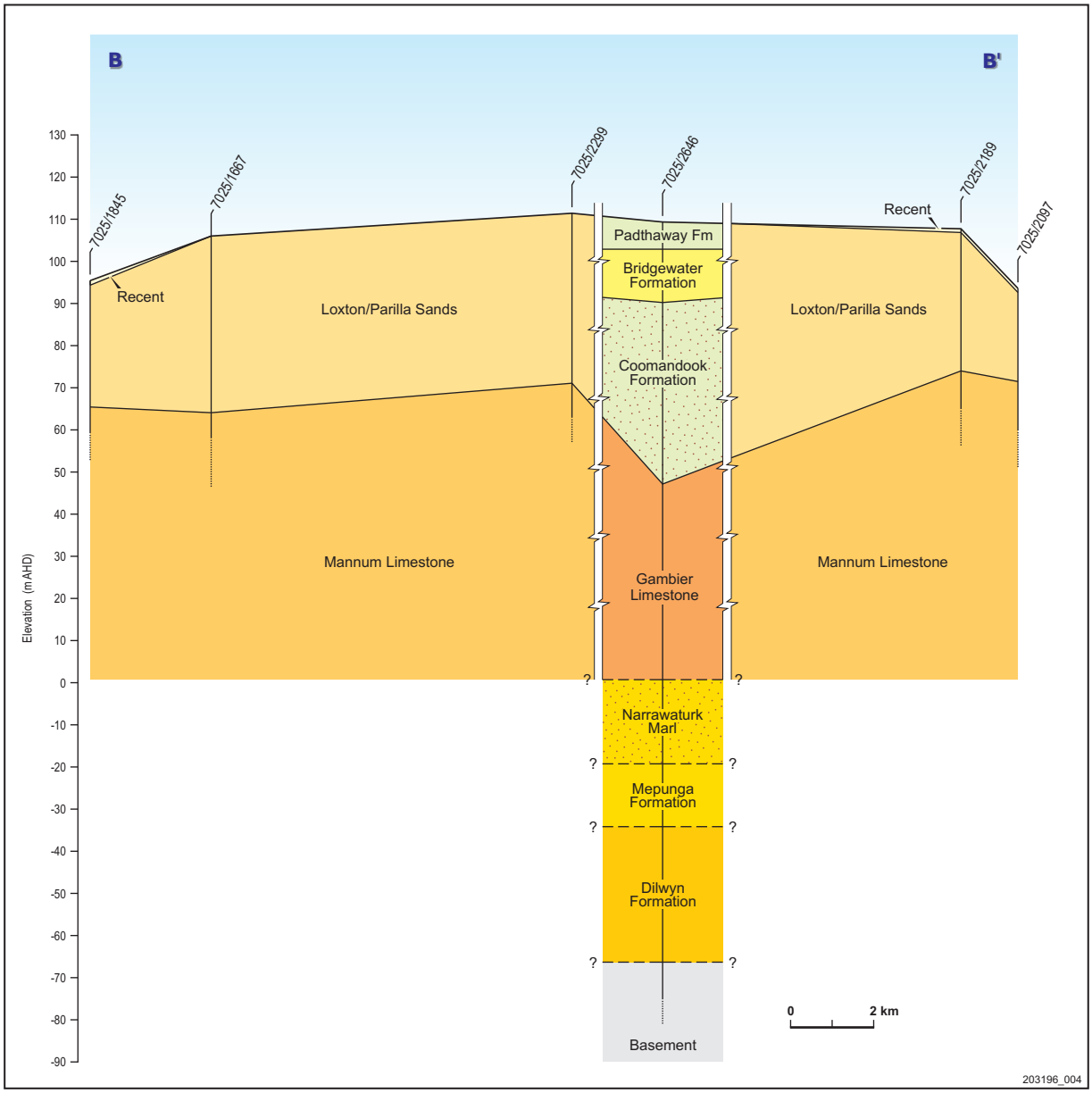

Figure 19. Geological Cross Section B–B'

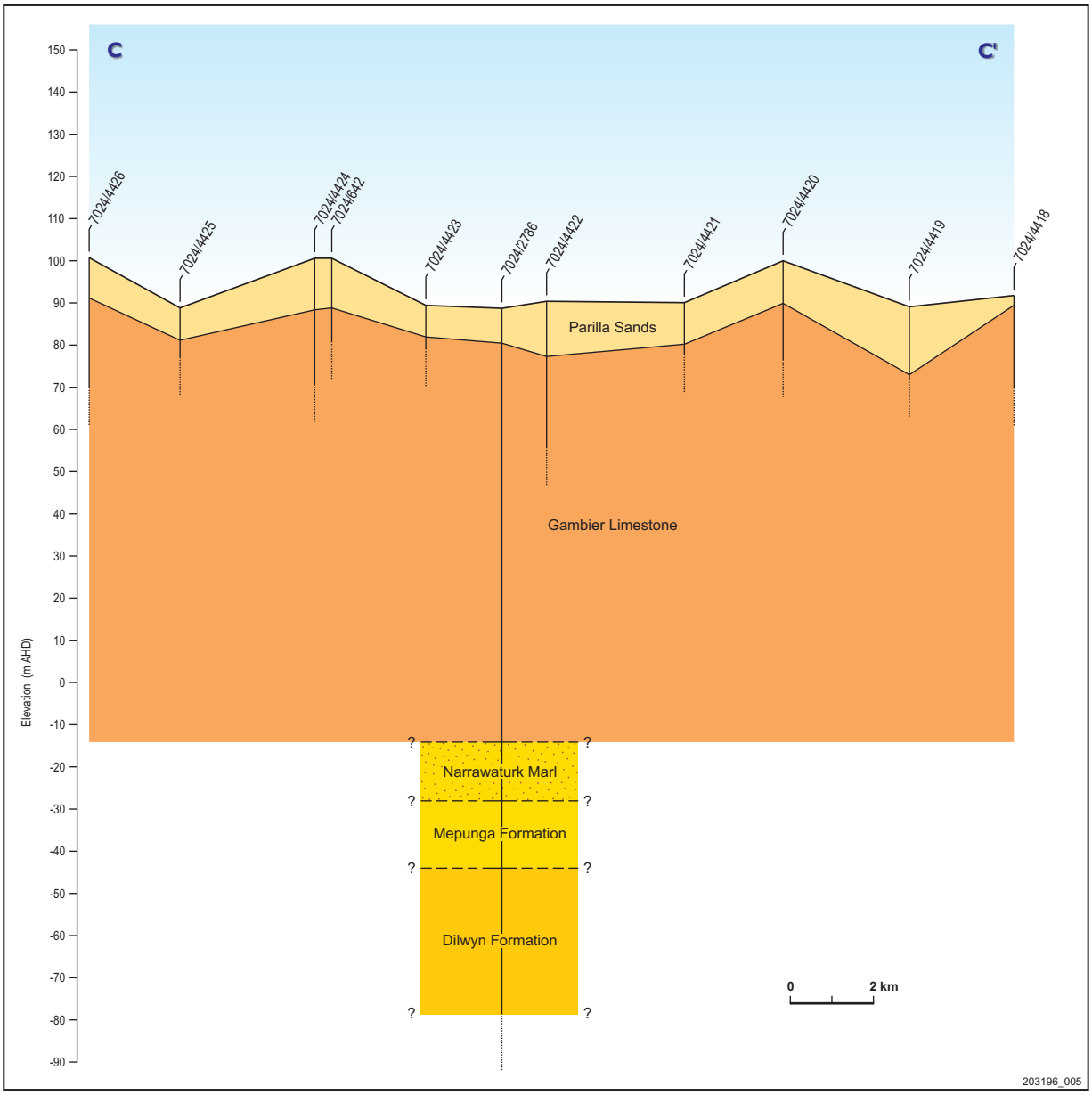

Figure 20. Geological Cross Section C–C'

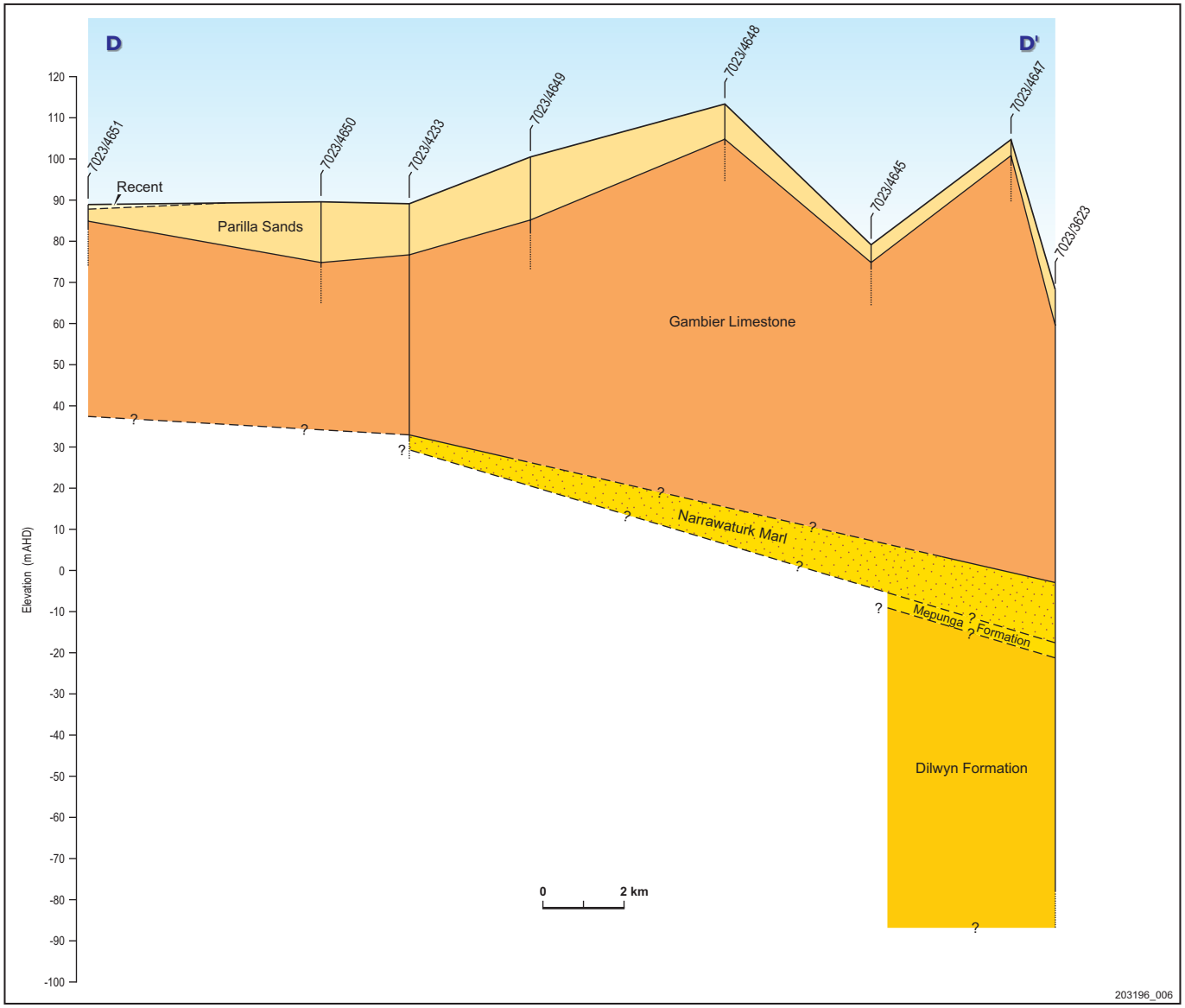

Figure 21. Geological Cross Section D–D'

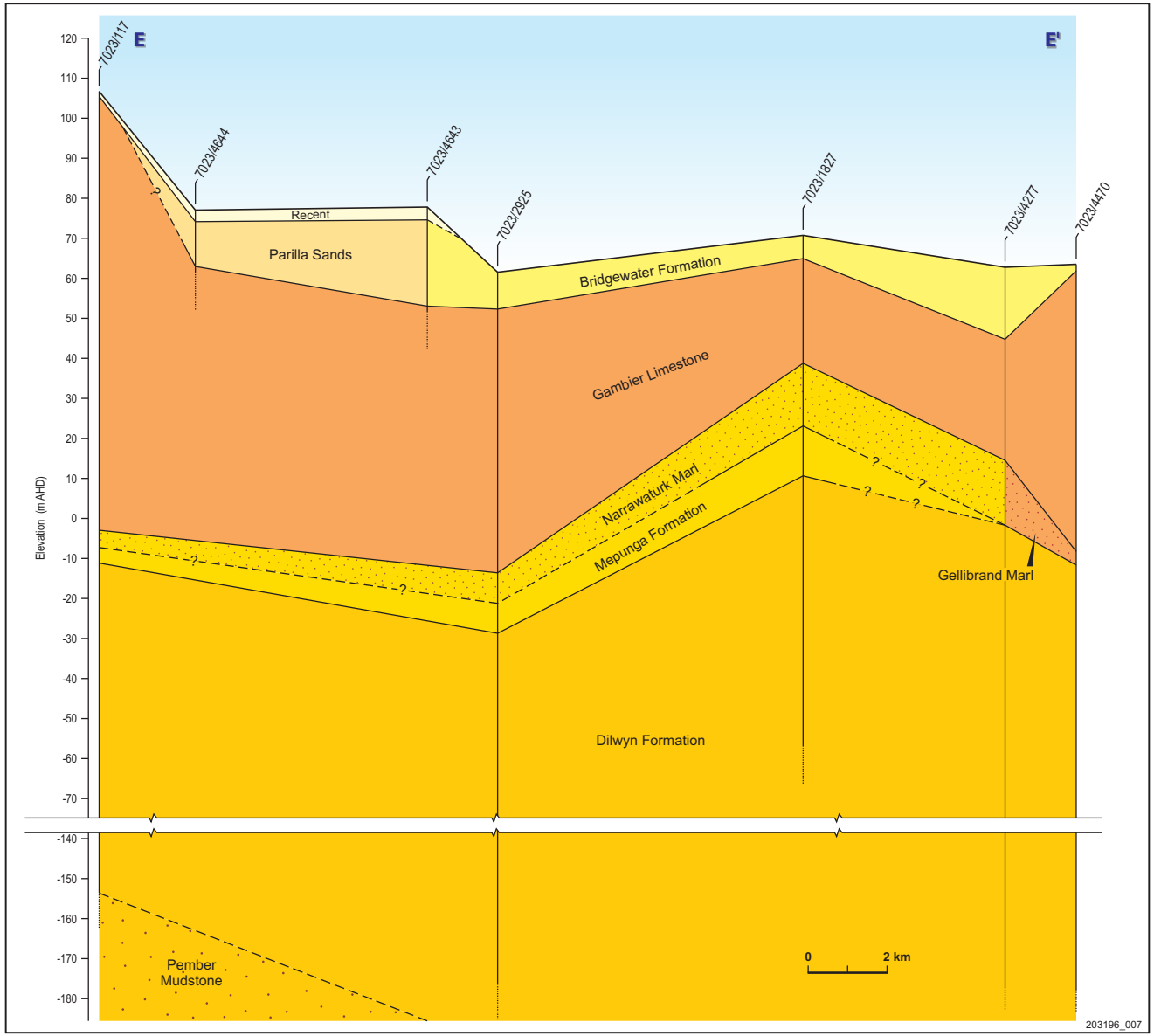

Figure 22. Geological Cross Section E–E'

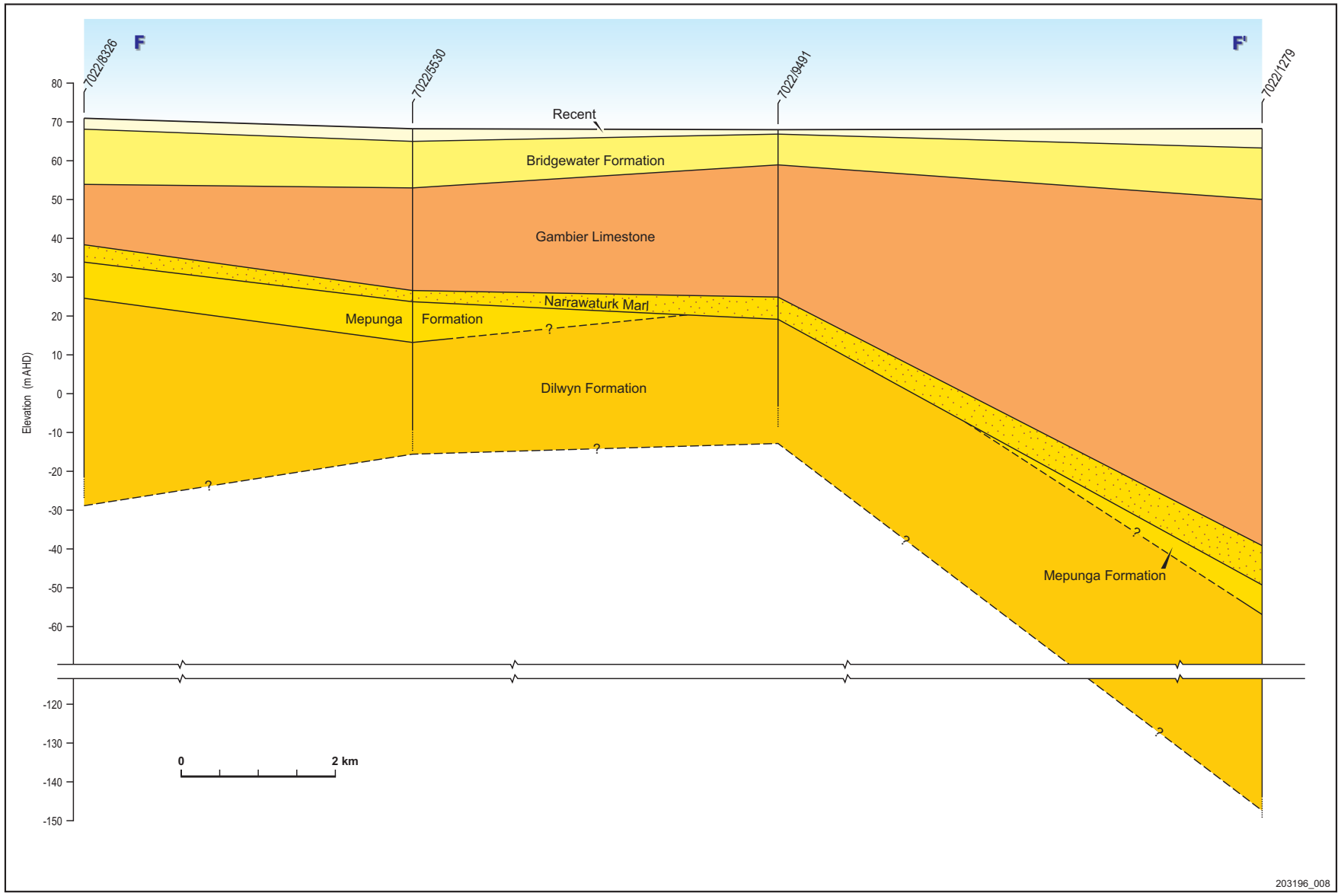

Figure 23. Geological Cross Section F–F'

C. WATER WELL LOGS

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 2N DRY

Coordinates: E 494470 N 5848280 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104219

UNIT No. (-)

Hundred: Nangwarry Sec: 95

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	7.5	8.57	5.9	11.9					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		SAND	Clear to frosted, subangular to well rounded. Minor organic silt. Fine			50	-0.7	11.9
0.5	1.5		SAND	Overall pale brown, close up clear, frosted to iron stained. Slightly finer than above					
1.5	2.5		SAND	Strong iron staining. Some fragments weakly cemented					
2.5	3.5		CLAY	Mottled brown grey. Stiff					
3.5	4		CLAY	Becoming calcareous with white carbonate material. Clay is rubbly, easily broken up					
4	5		CLAY/MARL	Off white to pale orange. Marly carbonate material					
5	5.6		CLAY/MARL	Brown marl, embedded with sand. Not as strongly calcareous. Clay becoming stiffer					
5.6	6		SAND	Clear, frosted mainly iron stained. Uncemented, sub rounded to well rounded. Fine to medium grained					
6	6.6		SANDY CLAY	Grey, fine sand embedded into a clay					
6.6	7		SAND	Strong iron stained. Medium to coarse grained					
7	7.5		CLAY	Grey, with fine sand embedded. Strong sticky clay.					
7.5	10.5		NO SAMPLE						
10.5	11		MARLY CLAY	Light grey. Clay/sand/carbonate mix					

REMARKS: Investigation hole. Completed as monitoring well.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 8 February 2005

COMPLETED: Yes

LOGGED BY: J Lawson

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 2N IRR

Coordinates: E 494615 N 5848035 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104218

UNIT No. (-)

Hundred: Nangwarry Sec: 95

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	8.5	9.05	5.9	11.9					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		SAND	Clear frosted, sub angular to sub rounded			50	-0.7	11.9
0.5	1		SAND	Iron staining now present					
1	1.5		CLAY	Mottled red brown, pale brown and pale grey clay. Stiff strongly bound					
1.5	2.5		CLAY	Pale brown to pale grey. Minor sand content					
2.5	3		CLAY	Mottled pale grey to pale brown. Addition of white carbonate material					
3	3.5		SANDSTONE	Off white to pale brown. Strong iron staining. Some fragments strongly cemented. Carbonate/sand mix. Uncemented to strongly cemented					
3.5	4		SANDSTONE	Mainly uncemented					
4	4.5		SANDSTONE	Becoming clayey again					
4.5	5		CLAY	Carbonate content rapidly declined, sand and slit content increased					
5	6		SANDSTONE	Off white to pale grey. Strongly cemented to uncemented					
6	8		SANDSTONE	Off white to pale orange. Iron content increasing					
8	8.5		SANDSTONE	Slightly higher moisture content close to water table. Uncemented to occasional strongly cemented chips. Undefined fossil remains and sand					
8.5	11.5		SANDSTONE	Marlier sandstone after the water table has been cut					

REMARKS: Investigation hole. Completed as monitoring well.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 8 February 2005

COMPLETED: Yes

LOGGED BY: J Lawson

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 2N NV

Coordinates: E 495616 N 5845161 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104824

UNIT No. (7022-9869)

Hundred: Nangwarry Sec: 255

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	-	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Grey topsoil					
0.5	1		SAND	Fine grey sand					
1	1.5		SAND	Fine brown sand					
1.5	2		SAND	Fine red/brown sand					
2	4		SAND	Fine pale orange/yellow sand with minor medium to coarse grains					
4	7		SAND	Fine to medium pale yellow to pale orange/brown sand					
7	13		SAND	Fine to medium pale yellow to orange sand					
13	14.7		SAND	Fine to medium pale yellow/orange to whitish sand					
14.7	15.2		SAND	Fine to medium orange/brown sand with bands of red/brown sand					
15.2	16.2		SAND	Fine to medium whitish to pale orange sand with bands of fine orange/red sand					
16.2	17		SAND	Fine red/orange/yellow sand tending slightly clayey towards base of sample					
17	18		CLAY	Sticky grey clay with bands of brown and orange sandy clay					
18	20		CLAY/ SANDSTONE	Rubbly grey clay with poorly to moderately cemented white and red sandstone with minor well cemented brown sandstone at base of sample					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 15 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 2S DRY

Coordinates: E 489021 N 5833825 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104820

UNIT No. (7022-9871)

Hundred: Mingbool Sec: Q4 D54694

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	5	4.46							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Fine brown topsoil					
0.5	1.5		CLAY	Brown clay with band of grey clay at base of sample					
1.5	2		SAND	Fine pale orange sand slightly clayey					
2	3		SAND	Fine orange sand					
3	3.5		SAND	Fine orange sand moderately cemented					
3.5	4.5		SAND	Fine pale orange/yellow sand moderately to well cemented					
4.5	5		SAND/ SANDSTONE	Fine pale yellow sand with bands of moderately to well cemented sandstone					
5	6.5		SANDSTONE	Fine pale yellow sandstone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 15 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 2S IRR

PROJECT: Border Zone Salt Accession

PERMIT No. 104817

UNIT No. (7022-9870)

Coordinates: E 489122 N 5833777 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

Hundred: Mingbool Sec: Q4 D54694

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	4.40	3.9							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Fine brown topsoil					
0.5	1		CLAY	Brown, orange and red bands of clay to sandy clay					
1	1.5		CLAY	Brown sandy clay to clayey sand					
1.5	2		SAND	Red/brown sand with minor clay					
2	4		SAND	Fine pale orange/brown to pale yellow sand with fine moderately to well cemented sandstone					
4	4.4		SAND/ SANDSTONE	Fine to medium pale yellow to pale grey sand/sandstone poor to well cemented					
4.4	5		SANDSTONE	Well to poorly cemented grey sandstone with brown/green poorly cemented sandstone and minor coral					
5	6.5		LIMESTONE	Pale grey sandy limestone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 15 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 2S NV

Coordinates: E 489479 N 5830867 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104816

UNIT No. (7022-9872)

Hundred: Mingbool Sec: Adj 269

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	4.45	3.55							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		SAND	Fine grey sand					
0.5	1		SAND	Fine orange/brown sand					
1	1.75		SAND	Fine orange to pale orange sand					
1.75	4		CLAY	Grey clay with bands of orange clay. Blue/grey clay towards end of sample					
4	4.5		SAND	Blue/grey clayey sand					
4.5	5		SAND	Fine grey sand					
5	5.5		SAND	Fine grey to pale grey sand					
5.5	6		SAND/ LIMESTONE	Whitish grey sand with well cemented fine grained limestone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 15 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 3N DRY

Coordinates: E 496379 N 5878936 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104829

UNIT No. (7023-6419)

Hundred: Comaum Sec: 307

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	-	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Topsoil					
0.5	1.5		CLAY	Red/brown sandy clay					
1.5	3.9		SANDSTONE	Light brown to pink sandstone					
3.9	5.5		SANDSTONE	Light brown/yellow sandstone					
5.5	8.3		LIMESTONE	Marly limestone					
8.3	11.4		LIMESTONE	Marly limestone with bands of well cemented sandstone					
11.4	15		LIMESTONE	Light brown limestone with bands of sand and cemented sandstone					
15	19.9		LIMESTONE	Marly limestone with bands of well cemented sandstone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 18 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 3N IRR

Coordinates: E 496408 N 5879441 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104830

UNIT No. (7023-6417)

Hundred: Comaum Sec: 307

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	-	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Topsoil					
0.5	1		CLAY	Brown sandy clay and sand with minor calcrete and sandstone at base of sample					
1	3		CLAY	Brown sandy clay with minor calcrete and sandstone					
3	5		SAND	Light brown sand with sandstone and calcrete					
5	9.5		LIMESTONE	Light brown sandy to marly limestone with minor fine sandstone					
9.5	11		CLAY	Brown sandy clay					
11	12		LIMESTONE	Medium light brown to brown sandy limestone with brown clay increasing towards base of sample					
12	14		LIMESTONE	Sandy limestone with bands of light brown sandstone					
14	15		LIMESTONE	Light brown to whitish consolidated limestone with sand and sandstone					
15	18		LIMESTONE	Light brown to white marly limestone with layers of hard well cemented sandstone					
18	20		LIMESTONE	Light brown marly limestone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 21 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 3N NV

Coordinates: E 497445 N 5880656 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104828

UNIT No. (7023-6418)

Hundred: Comaum Sec: 347

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	-	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	1.5		SAND	Fine pale yellow to grey sand					
1.5	2.5		SAND	Fine red/brown sand and ironstone					
2.5	3.5		SAND	Medium orange/brown to grey sand weakly cemented with minor clay					
3.5	4		SAND	Medium orange, light brown and red sand weakly cemented with minor clay					
4	5		SAND/ SANDSTONE	Light brown to orange sand and weakly cemented sandstone					
5	6		SANDSTONE	Fine to medium pink, grey, orange and light brown poorly cemented sandstone					
6	7		SANDSTONE	Pale yellow to whitish grey sandstone					
7	8		SANDSTONE	Pale yellow, grey to pink sandstone					
8	9.5		SANDSTONE	Fine pink, grey and orange sandstone					
9.5	13.4		SANDSTONE	Pink to whitish brown sandstone, more consolidated towards end of sample					
13.4	14		SANDSTONE/ SAND	Pink to whitish brown sandstone, with band of medium to coarse sand towards end of sample					
14	17		SANDSTONE	Fine pink to whitish brown sandstone					
17	18.2		CLAY	Brown clay					
18.2	20		LIMESTONE	Marly Limestone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 17 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 3S DRY

PROJECT: Border Zone Salt Accession

PERMIT No. 104826

UNIT No. (7023-6423)

Coordinates: E 490613 N 5862595 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

Hundred: Penola Sec: 531

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	3.90	3.60							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Topsoil					
0.5	1		SAND	Medium red/brown to brown sand					
1	3		CLAY	Layers of red, orange, grey and brown clay to sandy clay					
3	3.5		SAND	Medium brown to grey clayey sand					
3.5	5		SAND/ SANDSTONE	Layers of whitish sand and brown sandstone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 16 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 3S IRR

PROJECT: Border Zone Salt Accession

PERMIT No. 104827

UNIT No. (7023-6424)

Coordinates: E 490866 N 5862493 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

Hundred: Penola Sec: 531

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	4.40	4.30							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Topsoil					
0.5	1.5		CLAY	Brown clay to red/brown clayey sand					
1.5	2.4		CLAY/ SANDSTONE	Grey/brown clay with layers of poor to well cemented sandstone					
2.4	3		SANDSTONE	Poor to well cemented brown sandstone					
3	3.5		SANDSTONE	Layers of well cemented brown sandstone and brown clayey sand					
3.5	6		SANDSTONE/ SAND	White sandstone and pale brown/yellow sand					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 16 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 3S NV

PROJECT: Border Zone Salt Accession

PERMIT No. 104825

UNIT No. (7023-6425)

Coordinates: E 492416 N 5851978 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

Hundred: Penola Sec: 381

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	6	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Topsoil					
0.5	1		SAND	Fine grey to pale brown sand					
1	1.5		SAND	Fine to medium brown to red sand					
1.5	2		CLAY	Sticky red/brown clay with minor bands of red/brown sand					
2	3		CLAY	Interbedded layers of red, light brown, orange and grey sticky clay, with bands of clayey sand of same colour					
3	4		CLAY/ SANDSTONE	Interbedded brown/orange sandy clay and well cemented whitish grey sandstone					
4	4.9		SAND	Medium red/brown clayey sand					
4.9	5		SANDSTONE	Well cemented sandstone					
5	5.5		SAND	Light brown clayey sand					
5.5	6		SAND/ SANDSTONE	Medium grey sand with well cemented sandstone					
6	6.5		SAND/ SANDSTONE	Medium light brown to grey sand with brown well cemented sandstone					
6.5	7		SANDSTONE	Well cemented brown sandstone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 16 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 4N DRY

PROJECT: Border Zone Salt Accession

PERMIT No. 104835

UNIT No. (7023-6415)

Coordinates: E 490801 N 5898342 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

Hundred: Joanna **Sec: Q100 D57685**

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	13.5	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.8		TOPSOIL	Topsoil					
0.8	2.5		CLAY/SAND	Brown to red sandy clay to clayey sand					
2.5	6.8		CLAY	Red, grey and brown clay to sandy clay and clayey sand					
6.8	7		CLAY/ LIMESTONE	Brown clay to marly sandy limestone					
7	7.5		LIMESTONE	Marly sandy limestone with minor clay bands					
7.5	8.5		LIMESTONE	Marly sandy limestone with bands of hard well cemented limestone					
8.5	9		CLAY	Brown clay to sandy clay with minor bands of marly limestone					
9	9.5		LIMESTONE	Hard well cemented whitish limestone with bands of marly limestone					
9.5	10		CLAY	Brown to green/grey clay with band of hard limestone					
10	10.5		LIMESTONE	Whitish/grey limestone with bands of green/brown clay					
10.5	14		LIMESTONE	Whitish/grey to pale brown limestone, marly to well cemented					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 22 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 4N IRR

PROJECT: Border Zone Salt Accession

PERMIT No. 104834

UNIT No. (7023-6414)

Coordinates: E 491106 N 5899460 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

Hundred: Joanna Sec: Q91 F57685

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	9.5	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Fine dark grey topsoil					
0.5	1		SAND	Chocolate clayey sand					
1	2		CALCRETE/ SAND	Whitish calcrete and grey clayey sand					
2	3.5		SAND	Fine to medium grey to brown sand with bands of calcrete					
3.5	6		SAND	Medium whitish/grey sand with minor fine brown/orange sand and calcrete					
6	6.5		SAND	Fine whitish/grey sand					
6.5	7		SAND	Fine whitish/grey sand to clayey sand with calcrete bands					
7	8		SAND	Fine whitish/grey and orange/brown sand					
8	8.5		SAND	Medium whitish/grey and orange/brown sand					
8.5	9.5		SAND	Medium to large light brown to orange sand					
9.5	10.5		SAND	Fine to medium whitish/grey to pale brown sand					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 23 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 4N NV

PROJECT: Border Zone Salt Accession

PERMIT No. 104836

UNIT No. (7023-6416)

Coordinates: E 489526 N 5898185 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

Hundred: Joanna Sec: A12

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	26	25.25							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	1		SAND	Fine red/brown sand		PVC	50	-0.5	25
1	1.5		SAND	Brown sand and ironstone					
1.5	13.5		LIMESTONE	Hard white limestone		Slotted PVC	50	25	31
13.5	14			Cavity					
14	17.5		SAND	Fine light brown sand with bands of sandy clay					
17.5	18.5		CLAY	Plastic brown clay					
18.5	19		CLAY/ LIMESTONE	Layers of clay and whitish limestone					
19	24		LIMESTONE	Whitish to pale brown limestone					
24	24.5		LIMESTONE	Pale brown marly limestone					
24.5	33		No recovery	No recovery. Expected marly limestone to limestone					

REMARKS: Investigation hole. Completed as monitoring well.

DRILL TYPE: Rotary Auger

COMPLETED: YES

DRILL FLUID:

LOGGED BY: D. Wohling

DATE: 21 March 2005

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 4S DRY

PROJECT: Border Zone Salt Accession

PERMIT No. 104832

UNIT No. (7023-6421)

Coordinates: E 490187 N 5888441 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

Hundred: Joanna Sec: A371

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	16	16.26							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Topsoil					
0.5	2.2		SAND	Fine to medium red, brown and grey sand					
2.2	5.5		CLAY	Brown, grey and red clay to clayey sand					
5.5	6		SAND	Fine marly whitish sand					
6	10.9		SAND	Fine marly whitish, pale yellow to pale green/brown sand with bands of hard well cemented brown sandstone					
10.9	16		SAND	Fine marly whitish pale yellow to grey sand with bands of hard well cemented brown sandstone					
16	17		SAND	Fine greyish sand					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 16 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 4S IRR

Coordinates: E 490239 N 5888311 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104831

UNIT No. (7023-6422)

Hundred: Joanna Sec: A371

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	16	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Topsoil					
0.5	1		SAND	Fine grey sand to red/brown fine to medium sand towards end of sample					
1	4		CLAY	Plastic brown and grey clay, sandy clay in parts					
4	5		SAND	Fine whitish sand with a band of well cemented sandstone					
5	16.5		SAND/ SANDSTONE	Fine whitish to light brown sand with bands of fine hard well cemented sandstone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 16 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 4S NV

Coordinates: E 488227 N 5888433 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104833

UNIT No. (7023-6420)

Hundred: Joanna Sec: 476

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	19	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	1		TOPSOIL	Fine grey topsoil with organic matter					
1	2		SAND	Fine grey to brown sand					
2	10.2		SAND	Fine light brown, pale yellow, orange and pink sand					
10.2	11		CLAY	Plastic red/brown clay					
11	11.8		CLAY	Red/brown clay to sandy clay					
11.8	13.5		SAND	Fine whitish sand					
13.5	14.8		CLAY	Plastic red/brown clay, sandy clay in parts					
14.8	15.4		SANDSTONE/ CLAY	Well cemented sandstone with band of green/brown clay					
15.4	15.5		SAND	Fine to medium red/brown sand					
15.5	18		SAND/ SANDSTONE	Fine white sand and sandstone					
18	20		LIMESTONE	Moderately consolidated limestone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 17 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 5 DRY

PROJECT: Border Zone Salt Accession

PERMIT No. 104864

UNIT No. (7024-5634)

Coordinates: E 482927 N 5925904 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

Hundred: Binnum Sec: 442

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	13.5	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Topsoil					
0.5	1		CLAY	Red to brown/orange sandy clay with minor ironstone					
1	1.5		CLAY	Light brown sandy clay with minor ironstone					
1.5	3.5		CLAY	Light brown to greyish clay to sandy clay with minor calcrete					
3.5	4		CLAY	Grey and brown clay to sandy clay					
4	5		CLAY	Grey and brown clay to sandy clay with bands of calcrete					
5	7		CLAY	Brown sandy clay to clay					
7	7.5		LIMESTONE/ CLAY	Bands of whitish/grey fossiliferous limestone and brown to grey clay					
7.5	10		LIMESTONE	Whitish grey fossiliferous limestone					
10	13		LIMESTONE	Off white to pale brown fossiliferous limestone					
13	14.5		LIMESTONE	Pale brown/yellow fossiliferous limestone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 24 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 5 IRR

PROJECT: Border Zone Salt Accession

PERMIT No. 104865

UNIT No. (7024-5635)

Coordinates: E 482977 N 5925919 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

Hundred: Binnum Sec: 442

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	13.5	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Topsoil					
0.5	4		SAND	Grey to orange/brown sand to clayey sand with bands of calcrete					
4	6		SAND	Brown sand to clayey sand with bands of calcrete					
6	7.5		LIMESTONE	White to light brown sandy limestone					
7.5	8		LIMESTONE	White sandy limestone					
8	8.5		LIMESTONE	Off white fossiliferous to sandy limestone					
8.5	11.8		LIMESTONE	Off white fossiliferous limestone					
11.8	14.5		LIMESTONE	Off white to pale brown fossiliferous limestone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 23 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 5 NV

Coordinates: E 483040 N 5925557 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104837

UNIT No. (7024-5636)

Hundred: Binnum Sec: 623

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	15	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	1		TOPSOIL	Fine grey/brown sand and organic matter					
1	4		SAND	Grey to brown/orange sand to clayey sand, with bands of calcrete					
4	11.7		SAND	Fine grey sand with bands of fine orange/brown sand					
11.7	11.8		CLAY	Plastic grey clay					
11.8	13		SAND	Fine to medium grey to whitish/grey sand with minor bands of grey clay					
13	13.5		CLAY	Plastic grey to orange/brown clay					
13.5	15		CLAY/SAND	Grey clay to clayey sand with medium whitish/grey sand at base of sample					
15	16		SAND	No recovery. Fine sand					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 23 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 6 DRY

PROJECT: Border Zone Salt Accession

PERMIT No. 104870

UNIT No. (7024-5631)

Coordinates: E 484300 N 5946003 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

Hundred: Geegeela Sec: 32

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	18.5	18.0							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Grey topsoil					
0.5	3		SAND	Red, light brown, orange and grey sand					
3	3.5		CLAY	Grey clay					
3.5	5.2		CLAY	Grey to light brown clay					
5.2	7		SAND/ LIMESTONE	Red, grey and brown sand with layers of marly off white limestone, khaki green and grey clayey sand and calcrete					
7	9		LIMESTONE	Marly light brown limestone					
9	21		LIMESTONE	Off white to light brown fossiliferous limestone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 1 April 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 6 IRR

Coordinates: E 484298 N 5945846 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104871

UNIT No. (7024-5632)

Hundred: Geegeela Sec: 32

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	19	18.40							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Grey topsoil					
0.5	1		CLAY	Red/brown sandy clay					
1	3.5		SAND	Orange/brown with minor grey slightly clayey sand					
3.5	7		SAND	Fine grey with minor orange/brown sand, slightly clayey in parts					
7	7.5		SAND	Bands of fine grey, red, brown and orange sand					
7.5	8		SAND	Bands of light brown, red/orange and grey sand					
8	9.5		SAND	Bands of fine grey, pink, red, orange and light brown sand, clayey in parts					
9.5	11		CLAY	Light brown, grey and pink sandy clay to clay					
11	13		SAND	Fine grey, light brown to brown sand					
13	14		SAND/ LIMESTONE	Grey, light brown to brown clayey sand to clay in parts with bands of white limestone					
14	15		LIMESTONE	White limestone					
15	21		LIMESTONE	Off white fossiliferous limestone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 1 April 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 6 NV

PROJECT: Border Zone Salt Accession

PERMIT No. 104869

UNIT No. (7024-5633)

Coordinates: E 484625 N 5946737 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

Hundred: Geegeela Sec: 25

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	19	18.40							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		SAND	Grey sand					
0.5	4		SAND/CLAY	Bands of brown, red and grey slightly clayey sand to sandy clay and clay					
4	5.8		CLAY	Grey and red/brown clay					
5.8	7		LIMESTONE	Pale brown/yellow sandy limestone with calcrete nodules					
7	9		LIMESTONE	Pale brown/yellow sandy limestone with calcrete nodules and bands of well cemented sandstone					
9	10		LIMESTONE	Poor to well cemented whitish/yellow limestone with bands of brown sandy clay					
10	15		LIMESTONE	Whitish/yellow marly to fossiliferous limestone					
15	21		LIMESTONE	Pale orange/yellow marly to well cemented fossiliferous limestone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 31 March 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 7N DRY

Coordinates: E 481931 N 5987341 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104876

UNIT No. (7025-3639)

Hundred: Tatiara Sec: 444

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	26	25.35							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Grey topsoil and brown clayey sand					
0.5	4.5		SAND	Orange, brown and red medium sand with grey clay band at 4.3m					
4.5	9.5		SAND	Fine whitish, orange, grey, red and light brown sand					
9.5	10		SAND	Medium to coarse brown sand with minor clear/grey quartz sand					
10	16		SAND	Fine to coarse brown, orange and red sand					
16	21.5		SAND	Fine orange, light brown and grey sand					
21.5	22		SAND	White waxy sand					
22	23		CLAY/ LIMESTONE	Bands of red/brown clay and pale brown marly limestone					
23	24		LIMESTONE	Pale brown marly limestone					
24	25		LIMESTONE	Pale brown limestone					
25	26		LIMESTONE	Pale brown to off white fossiliferous limestone with minor band of red/brown marly clay					
26	27		LIMESTONE	Pale brown fossiliferous limestone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 2 April 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 7N IRR

Coordinates: E 482002 N 5987339 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104877

UNIT No. (7025-3640)

Hundred: Tatiara Sec: 444

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	25.5	26.12							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	1		CLAY	Brown sandy clay					
1	4		SAND	Fine red/orange sand					
4	7.5		SAND	Fine red, orange, brown and grey sand, slightly clayey in parts					
7.5	9		SAND	Bands of fine brown and grey sand					
9	9.5		SAND	Fine to medium brown sand					
9.5	13		SAND	Fine to coarse brown sand with bands of medium to coarse clear/grey quartz sand					
13	14		SAND	Brown clayey sand. Perched water					
14	17		SAND	Grey, orange and light brown marly sand					
17	20		SAND	Grey, pink, and light brown/orange marly sand					
20	23		SAND	Fine red, grey, light brown and orange marly sand					
23	24		LIMESTONE	Light brown marly limestone					
24	27		LIMESTONE	Off white fossiliferous limestone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 2 April 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 7N NV

PROJECT: Border Zone Salt Accession

PERMIT No. 104875

UNIT No. (7025-3638)

Hundred: Tatiara Sec: 448

Coordinates: E 484880 N 5988088 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	-	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Topsoil and fine whitish sand					
0.5	2		SAND	Fine orange sand					
2	4.5		SAND	Fine orange to red/brown sand					
4.5	5.5		SAND	Fine orange, red, light brown and grey sand					
5.5	7		SAND	Fine light brown, orange, pink and grey sand					
7	9		SAND	Fine to medium light brown/orange and grey sand					
9	11		SAND	Medium to coarse brown to red/orange and grey sand					
11	12		SAND	Fine to medium orange/brown and pink sand					
12	14		SAND	Fine to coarse brown sand					
14	15		SAND	Fine grey, orange and medium brown sand					
15	16		SAND	Fine orange/brown sand with some coarse clear quartz sand					
16	17		SAND	Fine grey to orange sand with medium brown sand					
17	20		SAND	Fine orange/light brown sand					
20	21		SAND	Fine whitish brown sand					
21	25		SAND	Fine orange/brown sand					
25	26			No sample recovery					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 2 April 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 7S DRY

Coordinates: E 491092 N 5965853 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104873

UNIT No. (7025-3648)

Hundred: Tatiara Sec: 408

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY L/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/L	TOTAL DISSOLVED SOLIDS Analysis No.
	-	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Grey topsoil					
0.5	1.5		SANDY CLAY	Light brown sandy clay to clay sand					
1.5	4		SAND	Bands of light brown, pale red brown and grey sand to sandy clay					
4	5		CLAY	Grey with bands of red brown clay and clayey sand					
5	5.5		SAND	Red to grey sand to sandy clay					
5.5	6		CLAY	Grey to yellow grey clay					
6	6.5		CLAY	Darker grey and yellow clay					
6.5	7		CLAY	Dark grey to black clay					
7	7.5		SAND	Grey to pale yellow sand					
7.5	12		SAND	Orange yellow fine sand					
12	13.3		SAND	Fine pale orange to light brown sand					
13.3	15		SAND	Fine pale brown to grey sand					
15	16.5		SAND	Fine grey whitish sand					
16.5	18		SAND	Fine grey, light brown orange sand					
18	20		SAND	Medium to coarse brown, orange grey sand					
20	21		SAND	Fine grey light brown sand					
21	26		SAND	Fine to medium orange brown sand					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 25 July 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 7S IRR

Coordinates: E 491173 N 5965796 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Zone Salt Accession

PERMIT No. 104874

UNIT No. (7025-3649)

Hundred: Tatiara Sec: 408

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	-	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		CLAY	Dark grey clay					
0.5	1		CLAY	Grey crumbly clay, slightly sandy					
1	1.5		CLAY	Grey to whitish grey sandy clay					
1.5	2.5		CLAY	Brown sandy clay					
2.5	4		SAND	Brown, light brown, grey, red clayey sand to sandy clay					
4	5.5		SAND	Light brown, grey, red clayey sand. Medium grained sands.					
5.5	6		CLAY	Grey clay (Perched water at 6m)					
6	8.5		CLAY	Grey clay					
8.5	9		CLAY	Darker grey crumbly clay					
9	10		CLAY	Dark grey to black and yellow orange crumbly clay					
10	11		CLAY	Dark grey to black, clay to clayey sand to orange brown fine sand					
11	14		SAND	Fine brown to light brown sand					
14	16		SAND	Fine light brown to pale whitish brown sand					
16	21		SAND	Fine light brown, pale yellow, light grey sand					
21	22		SAND	Fine to coarse light brown to orange and light grey sand					
22	24		SAND	Coarse, minor fine, sand grey, red, orange, light brown					
24	26		SAND	Fine with some coarse sand. Light brown, red orange					

REMARKS: Investigation hole. Backfilled to surface. Cement/bentonite plug 6-10m.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 26 July 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – 7S NV

PROJECT: Border Zone Salt Accession

PERMIT No. 104872

UNIT No. (7025-3647)

Coordinates: E 491173 N 5965796 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

Hundred: Tatiara Sec: 903

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	-	-							

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		SAND	Dark brown sand					
0.5	2		SAND	Light brown sand, slightly clayey, minor calcrete					
2	2.5		SAND	Red brown sandy clay, minor calcrete					
2.5	3.5		SAND	Red brown sand, slightly clayey					
3.5	4		CLAY	Grey to light brown sandy clay to clay					
4	5		SAND	Grey, light brown to red brown clayey sand to sandy clay					
5	6		SAND	Red, orange, light brown and grey sand, slightly clayey in parts					
6	7		SAND	Light brown and pale grey sands					
7	7.5		SANDSTONE	Brown to red brown sandstone					
7.5	10.5		SANDSTONE	Red brown to red, grey and pink bands of sandstone					
10.5	15		SAND	Light brown, orange, pale yellow and grey sand					
15	19.5		SAND	Pale yellow to orange sand					
19.5	23		SAND	Fine to coarse sand, brown, light brown, pale yellow/orange. Hard calcrete bar 22.4-22.6					
23	24.5		SAND	Brown/orange sand, bands of limestone					

REMARKS: Investigation hole. Backfilled to surface.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 27 July 2005

COMPLETED:

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – BDA DRY 1

Coordinates: E 491363 N 5917019 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Designated Area Salt Accession

PERMIT No. BDA 01

UNIT No. ()

Hundred: Binnum Sec: Adj. Sec 528

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	20.5	20.00	21	24					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Grey-brown topsoil to chocolate clay.			50	-0.6	21
0.5	1		CLAY	Chocolate brown sandy clay to pale brown calcareous sand.					
1	1.5		SAND	Light brown clayey sand.					
1.5	2.5		SAND	Light brown, red, orange, grey slightly clayey medium grained sand.					
2.5	3		SAND	Light brown/orange to grey/purple medium grained sand, minor clay.					
3	3.5		SAND	Grey to purple/red medium grained clayey sand, increasing clay content.					
3.5	4		SAND	Purple/red to pink/grey medium grained clayey sand, minor grey stone.					
4	4.5		CLAY	Light brown sandy clay, minor grey sandy clay and increasing stone content.					
4.5	5.5		CLAY	Light brown to grey sandy clay.					
5.5	6		SAND	Light brown, grey and red medium grained sand, minor clay.					
6	6.5		SAND	Orange to light brown and red medium-fine grained sand.					
6.5	7		SAND	Pale brown/orange fine-medium grained sand.					
7	8		SAND	Pale brown/orange, red/orange fine-medium grained sand.					
8	9.5		SAND	Pale orange/brown fine medium sand.					
9.5	10		SAND	Brown to light brown fine sand.					
10	11		SAND	Orange/brown fine sand, with minor limestone.					
11	12		SAND	Pale grey fine sand, layers of whitish grey to orange limestone.					
12	15		LIMESTONE	Fine powdery pale orange/white limestone.					
15	20.5		LIMESTONE	White/pale orange limestone.					
20.5	21		LIMESTONE	White limestone.					

REMARKS: Drilled from 21-25m with solid centre, i.e. no core samples taken. Slotted casing 21-24m.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 22 November 2006

COMPLETED: Yes

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – BDA DRY 3

Coordinates: E 489671 N 5937944 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Designated Area Salt Accession

PERMIT No. BDA 02

UNIT No. ()

Hundred: Binnum Sec: Adj. Sec 334

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	21	20.65	22	25					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Grey topsoil, minor brown clay.			50	-0.6	22
0.5	1		CLAY	Brown clay, minor white calcareous sand.					
1	1.5		SAND	Whitish grey calcareous sand.					
1.5	2.5		SAND	Grey, red, orange, brown fine-medium sand, minor clay.					
2.5	3		CLAY	Grey sandy clay to brown/red clayey sand.					
3	3.5		CLAY	Grey clay to sandy clay.					
3.5	4		CLAY	Brown to grey sandy clay.					
4	4.5		SAND	Orange/brown to grey clayey sand to sand.					
4.5	5		SAND	Brown, pale grey, pale orange/brown fine-medium sand.					
5	6.5		SAND	Pale grey fine-medium sand to brown/orange slightly clayey sand.					
6.5	7		CLAY	Grey clay to grey/light brown sandy clay.					
7	7.5		CLAY	Grey to light orange/brown clay.					
8.5	9		CLAY	Orange/brown to grey sandy clay.					
9	9.5		SAND	Grey/orange brown clayey sand to grey clay, minor limestone.					
9.5	10		SAND	Pale grey calcareous sand.					
10	11		LIMESTONE	Whitish grey limestone, minor brown/grey clay.					
11	13		LIMESTONE	Whitish limestone to fine orange sand and brown/grey clayey sand.					
13	15		LIMESTONE	Pale orange fine sand and limestone.					
15	21.5		LIMESTONE	Whitish/pale orange limestone.					

REMARKS: Drilled from 21.5-26m with solid centre, i.e. no core samples taken. Slotted casing 22-25m.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 22 November 2006

COMPLETED: Yes

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – BDA DRY 4

Coordinates: E 486067 N 5955842 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Designated Area Salt Accession

PERMIT No. BDA 04

UNIT No. ()

Hundred: Geegeela Sec: Adj. A14 D29600

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	19.5	21.35	20.5	23.5					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Grey topsoil to orange/brown sand.			50	-0.6	20.5
0.5	1		SAND	Orange/brown sand, slightly clayey.					
1	1.5		SAND	Light brown/orange sandy clay.					
1.5	3		SAND	Light brown/orange medium grained sand, slightly clayey.					
3	3.5		SAND	Pale pink/grey and light brown fine-medium sand, slightly clayey.					
3.5	4		SAND	Brown grey pink orange clayey sand.					
4	6		SAND	Pink/grey/light brown/orange sand.					
6	7		SAND	Layers of pale grey fine sand and brown to light brown clay.					
7	7.5		CLAY	Light brown clay.					
7.5	8		CLAY	Light brown sandy clay to pale grey clayey sand.					
8	8.5		SAND	Pale grey/yellow to pale brown/orange fine-medium sand, slightly clayey.					
8.5	9		SAND	Pale brown/yellow clayey sand.					
9	9.5		SAND	Pale grey sand to pale grey and light brown clay.					
9.5	10		CLAY	Light brown/orange clay.					
10	11		CLAY	Light brown to red/brown and grey clay.					
11	12		CLAY	Brown clay.					
12	13		SAND	Pale yellow/grey sand.					
13	14		SAND	Pale yellow/ brown sand, slightly clayey.					
14	15		SAND	Brown clayey sand.					
15	20.5		LIMESTONE	Off white/pale orange limestone.					

REMARKS: Drilled from 20.5-24.5m with solid centre, i.e. no core samples taken. Slotted casing 20.5-23.5m.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 23 November 2006

COMPLETED: Yes

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – BDA NV 2

Coordinates: E 490481 N 5955995 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Border Designated Area Salt Accession

PERMIT No. BDA 03

UNIT No. ()

Hundred: Geegeela Sec: 97

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	22	21.28	22	25					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Grey topsoil.			50	-0.6	22
0.5	1		SAND	Pale yellow/brown fine sand.					
1	1.5		SAND	Orange to red/ brown fine-medium sand					
1.5	2.5		SAND	White/pale yellow to orange/brown fine sand.					
2.5	3		SAND	Pale grey/pale yellow/red/orange medium-fine sand.					
3	3.5		SAND	Light brown/grey clayey sand.					
3.5	4		SAND	Pink/grey medium sand to grey yellow sandy clay.					
4	4.5		SAND	Light brown/yellow clayey sand.					
4.5	5.5		SAND	Brown to orange/brown and grey clayey sand.					
5.5	7.5		SAND	Grey to orange sand, slightly clayey.					
7.5	8		SAND	Grey to pinkish grey medium sand, to grey and orange sandy clay.					
8	8.5		SAND	Orange sand.					
8.5	9		CLAY	Orange clay to fine grey and orange sand.					
9	9.5		SAND	Pale brown/orange sand, slightly clayey.					
9.5	10		SAND	Pale yellow/orange to grey fine-medium sand, slightly clayey.					
10	12		SAND	Orange to light brown sand.					
12	13		SNAD	Dark orange/brown sand.					
13	18		LIMESTONE	Pale yellow/orange/whitish/brown fine sand.					
18	20		LIMESTONE	Off white marly limestone and fine light brown to brown sand.					
20	22.5		LIMESTONE	Off white limestone.					

REMARKS: Drilled from 22.5-26m with solid centre, i.e. no core samples taken. Slotted casing 22-25m.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 23 November 2006

COMPLETED: Yes

LOGGED BY: D. Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – PEN DRY

Coordinates: E 449710 N 5989221 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Hundred of Stirling Salt Accession

PERMIT No. 107814

UNIT No. (-)

Hundred: Pendleton Allot: 2 DP: 43797

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	8-9	7.26	5.2	11.2					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	1		SAND	Orange sand, calcrete nodules, minor clay (< 5%)			50	-0.8	11.2
1	8		SAND	Pale brown to off white sand and limestone. Water cut between 8-9m					
8	12.5		SANDSTONE	Pale brown/orange sandstone					

REMARKS: Completed as monitoring well. Bottom 1.3m of hole collapsed during installation.

DRILL TYPE: Air Hammer

DRILL FLUID:

DATE: 16 August 2005

COMPLETED: Yes

LOGGED BY: D Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – PEN IRR

Coordinates: E 449406 N 5989370 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Hundred of Stirling Salt Accession

PERMIT No. 107815

UNIT No. (-)

Hundred: Pendleton Allot: 2 DP: 43797

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	9		5.4	11.4					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	1		SAND	Off white sand with calcrete			50	-0.6	11.4
1	9		SANDSTONE	Orange/brown sandstone and sand with calcrete					
9	12		SANDSTONE	Light brown/orange sandstone more consolidated than above. Water cut @ 9m					

REMARKS: Completed as monitoring well. Bottom 0.6m of hole collapsed during installation.

DRILL TYPE: Air Hammer

DRILL FLUID:

DATE: 16 August 2005

COMPLETED: Yes

LOGGED BY: D Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – STR NTH DRY

Coordinates: E 441224 N 6007788 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Hundred of Stirling Salt Accession

PERMIT No. 107811

UNIT No. (-)

Hundred: Stirling Sec: 130

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	11	6.6	6	12					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	2		LIMESTONE	Whitish yellow limestone and sand			50	-0.7	12
2	3		SAND	Light brown clayey sand. Fine to medium					
3	4		SAND	Orange/brown clayey sand and whitish calcareous sand					
4	6		CLAY	Grey brown sandy clay and limestone and calcrete bands					
6	11		CLAY	Grey sandy clay to clay (Keppoch clay??)					
11	12		LIMESTONE	Cavernous limestone??					

REMARKS: Completed as monitoring well.

DRILL TYPE: Air Hammer

DRILL FLUID:

DATE: 22 September 2005

COMPLETED: Yes

LOGGED BY: D Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – STR MID DRY (PREV IRR)

Coordinates: E 436854 N 6002612 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Hundred of Stirling Salt Accession

PERMIT No. 107812

UNIT No. (-)

Hundred: Stirling Sec: 87

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	7		6	12					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	1		TOPSOIL	Topsoil, rubbly limestone and calcrete			50	-0.5	12
1	5		LIMESTONE	Rubbly limestone slightly marly with calcrete					
5	11		CALCRETE	Calcrete with some limestone. Water cut @ 7m					
11	12.5		CALCRETE/ SANDSTONE	Calcrete, well cemented sandstone and limestone					

REMARKS: Completed as monitoring well. Bottom 0.5m of hole collapsed during installation.

DRILL TYPE: Air Hammer

DRILL FLUID:

DATE: 17 August 2005

COMPLETED: Yes

LOGGED BY: D Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – STR NTH IRR

Coordinates: E 440819 N 6008609 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Hundred of Stirling Salt Accession

PERMIT No. 107809

UNIT No. (-)

Hundred: Stirling Sec: 126

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	8.8	6.6	5.8	11.8					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Brown topsoil			50	-0.7	11.8
0.5	1		LIMESTONE	Limestone with calcrete bands					
1	2.5		CALCRETE	Hard whitish calcrete					
2.5	4		SANDSTONE	Sandstone and sand, pale yellow to grey					
4	5		SAND	Fine to medium orange sand. Very minor clay. Slightly moist @ 5m					
5	6		SANDSTONE	Light brown to red sandstone and clay					
6	7		SAND	White to light brown clayey sand and marly limestone					
7	8		SANDSTONE	Light brown sandstone with sandy clay. Hard bar 7.8-8m					
8	9		LIMESTONE	Light brown limestone. Water cut @ 8.8m					
9	12		SAND/ LIMESTONE	Sand and limestone layers					

REMARKS: Completed as monitoring well. Bottom 0.2m of hole collapsed during installation.

DRILL TYPE: Air Hammer

DRILL FLUID:

DATE: 22 September 2005

COMPLETED: Yes

LOGGED BY: D Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – WIR DRY 1

Coordinates: E 450894 N 5985702 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Hundred of Stirling Salt Accession

PERMIT No. 110062

UNIT No. (-)

Hundred: Wirrega **Part Sec: 611**

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	7.5	6.3	4.5	10.5					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	2		SAND	Sand			50	-0.4	10.5
2	4.5		LIMESTONE	Limestone					
4.5	7.5		CLAY	Clay					
7.5	9		MARL	Orange marl. Water cut @ 7.5m					
9	13		SANDSTONE	Sandstone					

REMARKS: Completed as monitoring well. Bottom 2.5m of hole collapsed during installation.

DRILL TYPE: Air Hammer

DRILL FLUID:

DATE: 15 August 2005

COMPLETED: Yes

LOGGED BY: D Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – WIR DRY 2

Coordinates: E 450898 N 5985572 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Hundred of Stirling Salt Accession

PERMIT No. 107817

UNIT No. (-)

Hundred: Wirrega **Part Sec: 611**

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	9	5.82	6.5	12.5					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	2.5		SAND	Sand, minor clay			50	-0.5	12.5
2.5	4.5		SAND	Pale brown sand, minor clay (up to 40%)					
4.5	6.5		SAND	Orange/brown sand, ~2% clay, minor calcrete fragments					
6.5	9		CLAY	Mottled grey brown sandy clay, minor sand. Moist at 8.5-9m					
9	13		SANDSTONE	Sandstone					

REMARKS: Completed as monitoring well. Bottom 0.5m of hole collapsed during installation.

DRILL TYPE: Air Hammer

DRILL FLUID:

DATE: 15 August 2005

COMPLETED: Yes

LOGGED BY: D Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – PEN SUB-SURF

Coordinates: E 449700 N 5988957 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Hundred of Stirling Salt Accession

PERMIT No. 107816

UNIT No. (-)

Hundred: Pendleton **Part Sec:123**

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	9	6.56	6	12					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	1		SAND	Cream to off white sand and sandstone, with some limestone fragments			50	-0.5	12
1	6		SAND	Orange/brown sand with limestone fragments					
6	9		SANDSTONE	Orange/brown sandstone with minor limestone					
9	13		SANDSTONE/ LIMESTONE	Sandstone/limestone					

REMARKS: Completed as monitoring well. Bottom 1m of hole collapsed during installation.

DRILL TYPE: Air Hammer

DRILL FLUID:

DATE: 16 August 2005

COMPLETED: Yes

LOGGED BY: D Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – STR STH DRY

Coordinates: E 437482 N 5993829 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Hundred of Stirling Salt Accession

PERMIT No. 107813

UNIT No. (-)

Hundred: Stirling Allot: 2 FP: 16720

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	7		5.5	11.5					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Grey brown topsoil			50	-0.5	11.5
0.5	5		LIMESTONE	Off white to grey sandy limestone with calcrete, minor (<2%) clay					
5	7		LIMESTONE	Off white sandy limestone and calcrete					
7	9		LIMESTONE	Grey to light grey limestone. Water cut @ 7m					
9	10.5		SANDSTONE	Brown sandstone and grey limestone					
10.5	12		SANDSTONE	Brown sandstone					

REMARKS: Completed as monitoring well. Bottom 0.5m of hole collapsed during installation.

DRILL TYPE: Air Hammer

DRILL FLUID:

DATE: 16 August 2005

COMPLETED: Yes

LOGGED BY: D Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – ARC DT IRR

Coordinates: E 434375 N 6017133 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Hundred of Stirling Salt Accession

PERMIT No. 118769

UNIT No. (-)

Hundred: Archibald Section: 1

AQUIFER	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
SUMMARY	9		9	15					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Fine grey to pale brown sand			50	-0.6	15
0.5	1.5		SAND	Fine pale brown sand. Minor calcrete					
1.5	2.5		SANDSTONE	Fine pale brown sandstone with well cemented limestone at base of sample					
2.5	3		SANDSTONE	Pale brown to orange sandstone with layers of pale brown to whitish limestone					
3	4		SAND	Pale brown to whitish sand and sandstone					
4	5		SAND	Pale brown to orange sand. Minor pale brown to white limestone					
5	6		SAND	Pale brown to orange sand. Slightly clayey					
6	6.5		CLAY	Pale brown, orange to grey sandy clay to clayey sand					
6.5	7		CLAY	Grey sandy clay yo clayey sand. Layers of whitish grey limestone					
7	8		SAND	Orange, grey to pale brown clayey sand. Layers of pale grey limestone and sandstone					
8	8.5		SAND	Grey clayey sand with layers of limestone and grey well cemented calcrete					
8.5	9		LIMESTONE	Grey limestone with layers of well cemented calcrete					
9	9.5		LIMESTONE	Grey limestone and sandstone with grey clayey sand layers					
9.5	10.5		CLAY	Grey sandy clay and layers of grey limestone and sandstone					
10.5	15		SAND	Pale grey sand					

REMARKS: Completed as monitoring well.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 8 May 2006

COMPLETED: Yes

LOGGED BY: D Wohling

SHEET 1 OF 1

The Department of Water, Land and Biodiversity Conservation

GROUNDWATER PROGRAM

WATER WELL LOG – ARC DRY

Coordinates: E 434154 N 6017272 El. Surface (m) El. Ref. Point (m) Datum: WGS 84

PROJECT: Hundred of Stirling Salt Accession

PERMIT No. 118770

UNIT No. (-)

Hundred: Archibald Section: 1

AQUIFER SUMMARY	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m)		SUPPLY			TOTAL DISSOLVED SOLIDS	
			From	To	L/sec	Test length	Method	mg/L	Analysis No.
	9		9	15					

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE	Depth Core Sample	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	0.5		TOPSOIL	Grey, dark grey to pale brown fine sand. Minor organic matter			50	-0.8	15
0.5	1		SAND	Poorly cemented white sand and sandstone					
1	3		SAND	Pale brown, orange to white sand with minor clay					
3	3.5		SAND	Pale orange, brown to grey sand. Slightly clayey					
3.5	4.5		SAND	Pale grey to brown sand. Some clay					
4.5	5		SAND	Pale brown sand					
5	5.5		SAND	Pale yellow to brown sand					
5.5	6		SAND	Pale greenish grey to orange sand. Minor clay and limestone					
6	6.5		SAND	Pale greenish grey sand. Minor clay					
6.5	7		SAND	Pale greenish grey, orange and whitish sand with minor clay					
7	7.5		SAND	Whitish grey sand to sandy clay. Minor clay					
7.5	8		SAND	Greenish grey to orange clayey sand to sandy clay					
8	8.5		CLAY	Chocolate brown sandy clay to clayey sand					
8.5	9		SAND	Chocolate brown, orange to grey clayey sand and sandy clay. Water cut 9m					
9	9.5		CLAY	Greenish grey sandy clay. Minor limestone					
9.5	10		LIMESTONE	Whitish grey limestone and sandstone and greenish grey sandy clay					
10	10.5		CLAY	Greenish grey clay. Minor limestone					
10.5	15		LIMESTONE	Whitish grey limestone and sand					

REMARKS: Completed as monitoring well. Bottom 0.2m of hole collapsed during installation.

DRILL TYPE: Rotary Auger

DRILL FLUID:

DATE: 9 May 2006

COMPLETED: Yes

LOGGED BY: D Wohling

SHEET 1 OF 1

UNITS OF MEASUREMENT

Units of measurement commonly used (SI and non-SI Australian legal)

Name of unit	Symbol	Definition in terms of other metric units	Quantity
day	d	24 h	time interval
gigalitre	GL	10^6 m^3	volume
gram	g	10^{-3} kg	mass
hectare	ha	10^4 m^2	area
hour	h	60 min	time interval
kilogram	kg	base unit	mass
kilolitre	kL	1 m^3	volume
kilometre	km	10^3 m	length
litre	L	10^{-3} m^3	volume
megalitre	ML	10^3 m^3	volume
metre	m	base unit	length
microgram	μg	10^{-6} g	mass
microlitre	μL	10^{-9} m^3	volume
milligram	mg	10^{-3} g	mass
millilitre	mL	10^{-6} m^3	volume
millimetre	mm	10^{-3} m	length
minute	min	60 s	time interval
second	s	base unit	time interval
tonne	t	1000 kg	mass
year	y	356 or 366 days	time interval

δD	hydrogen isotope composition
$\delta^{18}O$	oxygen isotope composition
EC	electrical conductivity (μS/cm)
TDS	total dissolved solids (mg/L)

GLOSSARY

Aquifer. An underground layer of rock or sediment which holds water and allows water to percolate through.

Aquifer, confined. Aquifer in which the upper surface is impervious and the water is held at greater than atmospheric pressure. Water in a penetrating well will rise above the surface of the aquifer.

Aquifer, unconfined. Aquifer in which the upper surface has free connection to the ground surface and the water surface is at atmospheric pressure.

Basin. The area drained by a major river and its tributaries.

Bore. *See well.*

Buffer zone. A neutral area that separates and minimises interactions between zones whose management objectives are significantly different or in conflict (e.g. a vegetated riparian zone can act as a buffer to protect the water quality and streams from adjacent land uses).

Catchment. A catchment is that area of land determined by topographic features within which rainfall will contribute to runoff at a particular point.

Catchment water management board. A statutory body established under Part 6, Division 3, s. 53 of the Act whose prime function under Division 2, s. 61 is to implement a catchment water management plan for its area.

Catchment water management plan. The plan prepared by a CWMB and adopted by the Minister in accordance with Part 7, Division 2 of the Water Resources Act 1997.

CWMB. Catchment Water Management Board.

Domestic purpose. The taking of water for ordinary household purposes and includes the watering of land in conjunction with a dwelling not exceeding 0.4 hectares.

DWLBC. Department of Water, Land and Biodiversity Conservation. Government of South Australia.

EC. Abbreviation for electrical conductivity. 1 EC unit = 1 micro-Siemen per centimetre (µS/cm) measured at 25 degrees Celsius. Commonly used to indicate the salinity of water.

Environmental water requirements. The water regimes needed to sustain the ecological values of aquatic ecosystems, including their processes and biological diversity, at a low level of risk.

Evapotranspiration. The total loss of water as a result of transpiration from plants and evaporation from land, and surface waterbodies.

GIS (geographic information system). Computer software allows for the linking of geographic data (for example land parcels) to textual data (soil type, land value, ownership). It allows for a range of features, from simple map production to complex data analysis.

Geological features. Include geological monuments, landscape amenity and the substrate of land systems and ecosystems.

Groundwater. *See underground water.*

Hydrogeology. The study of groundwater, which includes its occurrence, recharge and discharge processes and the properties of aquifers. *(See hydrology.)*

Irrigation. Watering land by any means for the purpose of growing plants.

Irrigation season. The period in which major irrigation diversions occur, usually starting in August–September and ending in April–May.

Land. Whether under water or not and includes an interest in land and any building or structure fixed to the land.

Leaching. Removal of material in solution such as minerals, nutrients and salts through soil.

Megalitre (ML). One million litres (1 000 000).

ML. *See megalitre.*

Model. A conceptual or mathematical means of understanding elements of the real world which allows for predictions of outcomes given certain conditions. Examples include estimating storm runoff, assessing the impacts of dams or predicting ecological response to environmental change.

Natural recharge. The infiltration of water into an aquifer from the surface (rainfall, streamflow, irrigation etc.) *(See recharge area, artificial recharge.)*

Pasture. Grassland used for the production of grazing animals such as sheep and cattle.

Potentiometric head. The potentiometric head or surface is the level to which water rises in a well due to water pressure in the aquifer.

Prescribed water resource. A water resource declared by the Governor to be prescribed under the Act, and includes underground water to which access is obtained by prescribed wells. Prescription of a water resource requires that future management of the resource be regulated via a licensing system.

Prescribed well. A well declared to be a prescribed well under the Water Resources Act 1997.

PWA. Prescribed Wells Area.

Recharge area. The area of land from which water from the surface (rainfall, streamflow, irrigation, etc.) infiltrates into an aquifer. *(See artificial recharge, natural recharge.)*

Stock Use. The taking of water to provide drinking water for stock other than stock subject to intensive farming (as defined by the Act).

Underground water (groundwater). Water occurring naturally below ground level or water pumped, diverted or released into a well for storage underground.

Volumetric allocation. An allocation of water expressed on a water licence as a volume (e.g. kilolitres) to be used over a specified period of time, usually per water use year (as distinct from any other sort of allocation).

Water allocation. (a) in respect of a water licence means the quantity of water that the licensee is entitled to take and use pursuant to the licence; (b) in respect of water taken pursuant to an authorisation under s. 11 means the maximum quantity of water that can be taken and used pursuant to the authorisation.

Water allocation, area based. An allocation of water that entitles the licensee to irrigate a specified area of land for a specified period of time usually per water use year.

Water allocation plan (WAP). A plan prepared by a CWMB or water resources planning committee and adopted by the Minister in accordance with Division 3 of Part 7 of the Act.

Water licence. A licence granted under the Act entitling the holder to take water from a prescribed watercourse, lake or well or to take surface water from a surface water prescribed area. This grants the licensee a right to take an allocation of water specified on the licence, which may also include conditions on the taking and use of that water. A water licence confers a property right on the holder of the licence and this right is separate from land title.

Water plans. The State Water Plan, catchment water management plans, water allocation plans and local water management plans prepared under Part 7 of the Act.

Well. (a) an opening in the ground excavated for the purpose of obtaining access to underground water; (b) an opening in the ground excavated for some other purpose but that gives access to underground water; (c) a natural opening in the ground that gives access to underground water.

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