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Barossa Infrastructure Limited (BIL)

BIL Expansion (2017)

Environmental Assessment Report

27 September 2017

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BIL Expansion (2017)

Environmental Assessment Report

Prepared for:

Barossa Infrastructure Pty Ltd

by:

Seed Consulting Services Pty Ltd

106 Gilles Street, Adelaide, South Australia 5000

P. +61 8 8232 4823

W. www.seedcs.com.au

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Executive Summary

Barossa Infrastructure Limited (BIL) provides reticulated irrigation water to customers connected to its pipeline network in the Barossa Valley, South Australia. BIL proposes to increase the volume of water delivered to 12 Gigalitres (GL) per year. Current (2017) use by BIL customers is approximately 9 GL per year, with approval for up to 10 GL.

This report presents an environmental assessment to consider any impacts of this increase and is the third environmental assessment following BIL's inception in 2001. Previous environmental assessments in 2001 and 2015 (Eco Management Services Pty Ltd) identified no likely environmental impacts as a consequence of BIL water use in the Barossa Valley.

A key aspect of BIL's operation since its inception is that it has enabled vineyard growers to replace marginal (1500 mg/L average) saline groundwater with River Murray water averaging approximately 300 mg/L, thereby substantially reducing the amount of surface salt loading associated with irrigation.

This report summarises the results of the investigations undertaken by Seed Consulting Services in 2017 to consider any environmental impact of the proposed increase to 12 GL. It is recommended that this report be read in conjunction with the 2001 and 2015 Eco Management Services (EMS) environmental assessment reports. Seed has focused this report primarily on salinity aspects. The 2001 and 2017 reports include assessment of wider environmental issues such as water dependent ecosystems and native vegetation. Seed considers that the assessment by EMS in 2001 and 2017, that there would be little or no impact on these factors, remains unchanged.

Seed reviewed current data for 18 shallow water table monitoring wells located within the Barossa Valley, previously reviewed by EMS and WaterSearch (2014). Data from these wells indicate little or no evidence of either raising (perched) water tables or increasing water table salinity.

Seed also reviewed groundwater and surfacewater status reports prepared by the Department of Environment, Water and Natural Resources (DEWNR) in 2014 and 2015 and historical groundwater consumption records dating back to prescription of water resources (1991) in the Barossa Valley floor, to assist in understanding the relationship between historical use of marginal groundwater (~1500 mg/L) for irrigation of vineyard and the advent of better quality (~300 mg/L) BIL water in 2001.

This assessment determined that the projected surface salt loading (Barossa Valley floor) based on the use of 9,000 ML (9 GL) of BIL water (noting 3GL to northern and western Barossa areas, outside of the valley floor) and 2.8 GL of groundwater (recent average over last 10 years) would result in approximately 6,900 Tonnes/annum (T/a) of surface salt load. The maximum groundwater use (1995), prior to BIL commencing operation was 4,700 ML, resulting in surface salt load of approximately 7,050 T/a salt.

In the period since 2001, and the commencement of the BIL scheme, regional shallow monitoring wells have not exhibited adverse response (water level or salinity increases) to the

surface salt loads resulting from saline groundwater use. Whilst current BIL usage is lower than that proposed (increase to 12 GL, 9 GL to be used in the valley floor) the much reduced salinity of BIL water will have an improved land management impact compared to long term use of marginal (1,500 mg/L) borewater.

Review of long term salt discharge through the Yaldara gauging station does not suggest current practices of using BIL water are having a negative impact, however DEWNR and Regional Development Australia (RDA Barossa) regional climate change reporting has highlighted the influence of climate change on regional rainfall and stream flows. These flows are clearly important in enabling discharge of accumulated salt from the Barossa Valley floor landscape. Under a projected changing climate with reduced rainfall and stream flows the important need for ongoing measurement and monitoring of soils and the water table (depth to water and salinity) is highlighted.

The proposed BIL expansion to 12 GL (9 GL use Barossa Valley floor) is not expected to create adverse salinity impact in the medium term, however under a changing climate scenario there is less longer term certainty.

Consequently, this report recommends that:

- BIL customers continue to manage water within an irrigation water management plan framework, and
- BIL review the shallow water table monitoring network at least every three years (next in 2020) and that this review considers DEWNR's annual groundwater and surfacewater status reports.

These actions will be important in continuing to demonstrate the environmental, economic and social, sustainable use of BIL water in the Barossa Valley.

1 Introduction

1.1 Background

Barossa Infrastructure Limited (BIL) propose to increase the volume of water taken from the River Murray and used in the Barossa Valley for supplementary viticulture irrigation.

The increase will be achieved through investment in additional infrastructure (pumps and pipes) to enable a total of 12,000 Megalitres (ML) per annum to be available to BIL customers. This proposed increase expands the BIL system to the maximum capacity as proposed when constructed in 2001. A series of incremental increases has occurred since BIL's inception in 2001, increasing from its original 7,000 ML capacity to 10,000 ML in 2015 and 12,000 ML in 2017.

Environmental assessments of the impact of these increases have occurred at each stage. The function of this report is to consider the low impacts identified in previous environmental assessments in the context of the latest increase to 12,000 ML total use and consider if this increase presents any long term adverse outcomes for the Barossa Region.

1.2 Brief Description of the Project

As identified in previous environmental assessment reports (Eco Management Services 2001 & 2015), the delivery of River Murray water involves the following key structural elements:

(a) The use of existing SA Water Infrastructure, including:

- The Mannum/Adelaide Pipeline;
- The Warren transfer main between the Mannum/Adelaide pipeline and the Warren Reservoir;
- The Warren Reservoir for storage; and
- A section of the Warren trunk main from the Warren Reservoir into the Barossa Valley.

(b) The use of BIL pipeline infrastructure which reticulates water throughout the valley for delivery to BIL customers at specified pressure and flow rates.

BIL is progressing (2017) with expanded infrastructure in the northern part of the Valley (Moppa region) to facilitate improved delivery in this region.

BIL's agreement with SA Water requires that all of the subject water be sourced from the River Murray by way of water entitlements held by BIL. SA Water transports the water to the Warren Reservoir and then to the agreed offtake point on the Warren trunk main. The Warren Reservoir has a total capacity of about 5,080 ML. The Warren transfer main initially had a capacity of 14 ML/day, which controlled the rate of transfer and the continuous annual capacity of this transfer

main to 5,110 ML. Upgrades to the transfer system now enable greater daily capacity (>70 ML/day) and in 2015/16 BIL a total of 9,047 ML, including 268 ML from the Nuriootpa Community Wastewater Management Scheme (CWMS).

As reported previously by Eco Management Services (2015) there is no compulsion for BIL's customers to take their water. If their allocation cannot be taken, either in whole or in part, then BIL's charges to the customer are reduced to reflect the reduction in BIL's costs. Whilst the customer will still be required to pay a reduced price for water not taken, this has been accepted by customers as the cost of ensuring access to water during dry periods which have previously had a significant negative impact on their revenues.

Furthermore, Eco Management Services (2001 and 215) noted that it is important to appreciate that many growers are using relatively high salinity groundwater for irrigation and there is a negative correlation between both yield and quality with increasing salinities. It is obviously desirable that a low salinity water resource be available on a reliable basis. In addition, the extraction of deep aquifer saline groundwater also leads to the importation of salt to the surface soils. It is desirable for sustainable land management purposes that, as far as practical, this saline water be replaced with low salinity water to achieve a net reduction in land salt load.

As part of the increase to 12 Gigalitres (GL) delivery, BIL has commissioned Seed Consulting Services Pty Ltd to undertake an environmental assessment of this increase, review previous environmental assessments and consider the increase in the context of any current and/or future regional impacts, in particular on regional shallow water tables.

This report summarises the results of the investigations undertaken. It is recommended that this report be read in conjunction with the 2001 and 2015 Eco Management Services (EMS) environmental assessment reports.

1.3 Main Environmental Issues Examined

The key environmental issues examined in the previous studies (2001 & 2015) were:

- the potential for the use of BIL water to result in a rise in regional water tables;
- the effects on the salt budget and the potential for increases in the salt load entering surface drainage as base flow;
- the potential for the creation of perched water tables, with adverse effects on plant growth and for migration off- site; and
- the effects of any changes in salinity and chlorine residuals on ecosystems and the implications of inter-basin transfer of water.

This review (2017) considers the same aspects but also further considers, through trend analysis, the shallow water table monitoring network to highlight any sub-regional trends in groundwater levels and salinity.

This report has not re-examined or updated the physical environment as it is considered this has been completed thoroughly in the previous environmental assessments.

2 Summary of previous reports

The following sections summarise two previous reports (2001 & 2015) that provide relevant background to consideration of the environmental impact of a further increase in water transferred from the Warren Reservoir-River Murray to the BIL Scheme.

2.1 Barossa Pipeline Project – Environmental Assessment report

In 2001 the *Barossa Pipeline Project – Environmental Assessment* report was prepared for Barossa Infrastructure Ltd (BIL) by Eco Management Services Pty Ltd. The report documented findings from an environmental assessment undertaken to determine potential impacts of the proposed transfer by BIL of 7,000 ML/annum of Warren Reservoir-River Murray Water to supplement viticulture irrigation in the region; the transfer was predicted to amount to 5,000 ML/yr in 2001/02 and up to 7,000 ML/yr by 2006/07. The environmental assessment focused on four main potential impacts of the proposed transfer as well as monitoring and corrective actions:

Potential impact 1. Water budget and a rise in regional water tables

Although acknowledged that poor water management (i.e. excessive overwatering) may lead to increases in the regional water table, efficient irrigation management was considered to result in negligible impact from imported water due to the evapotranspiration component of the water budget compensating for the imported water. Accordingly, the report concluded that even at the highest end of the proposed irrigation application rate in summer (i.e. 70-100 mm/ha/yr), there would be no impact on regional water tables other than naturally occurring seasonal fluctuations.

Potential impact 2. Salt budget and potential for increased salt loads in surface drainage as base flow

It was reported that "…*each megalitre of groundwater replaced by imported water results in an average reduction of one tonne of salt reaching the land surface*…". The proposed BIL water was found to have variable impacts on salt budget across the region, depending on whether the water was to be used for new irrigation, or as a replacement (and to what extent) for existing saline groundwater use. Within the Barossa Valley Floor and Lyndoch Valley Area, a net decrease in salt load was expected, with a net increase expected in the Greenock Creek Area. This was expected to result in an overall redistribution of salt accessions to the land surface in the North Para River catchment

Potential impact 3. Creation of perched water tables, with negative impacts on plant growth and for migration off-site

Three of 10 general soil classifications mapped in the region were considered susceptible to developing a perched water table if over irrigation was to result in greater accession to the water table. These general soil classifications were: (1) sand over clay group, (2) sand over clay and transitional red-brown earth, and (3) alluvial soils. These soils occur primarily in the Barossa Valley Floor. Regardless, it was concluded that effective irrigation management in all areas would negate any potential negative effects on water tables and plant growth. To facilitate effective irrigation management, all BIL customers were to be required to prepare irrigation management plans and annual returns.

Potential impact 4. Changes in salinity and chlorine residuals on ecosystems

The assessments concluded there would be no negative impacts on remnant native vegetation or aquatic fauna in the region as a consequence of salinity or chlorine.

Monitoring and corrective action

Fourteen shallow monitoring wells located in the soil associations susceptible to perched water table formation were established. It was suggested that monthly monitoring of water and salinity levels at these wells could provide early warnings of potential problems and allow for appropriate corrective actions to be implemented. The frequency of monitoring was to be reviewed annually and additional monitoring wells may be required depending on locations of future requests for imported water (see also Section 2.2).

2.2 Groundwater Monitoring 2014 Barossa Valley report

In 2014, the *Groundwater (Water Table) Monitoring 2014 Barossa Valley* report was prepared for Barossa Infrastructure Ltd (BIL) by Water Search Pty Ltd. This report documented the monitoring results between 2001 and 2014 of the 14 shallow monitoring wells (See 2014 report for well details) established following the 2001 report, together with some longer-term monitoring results and average monthly rainfall records for comparison purposes.

Water levels at the monitoring wells had generally been measured by DEWNR every 3 months since February 2002, with salinity samples taken roughly twice a year at the end of summer and end of winter. The key trends reported were as follows:

- water levels from the monitoring wells tended to track rainfall patterns and subsequent recharge rates, with patterns of stable or slowly rising levels from 2002 to 2006, followed by downward trends to 2009. Subsequent rises to 2012 were reported to be correlated with 2-3 years of enhanced winter recharge with a further general decline over 2012;
- patterns in water levels tracking long-term rainfall and recharge trends were found to also be reflected in longer-term (non-BIL) monitoring wells in the region;

- salinity trends were much more variable both within wells (across years) and between wells (within years). It was considered to be difficult to disentangle whether observed changes over time were real or an artefact (either partially or in entirety) of sampling methods and/or the immediate hydrogeology surrounding the well;
- all but one well showed slow increases or plateaus since 2002; with the one well showing a declining salinity trend;
- ongoing monitoring over time was recommended, particularly given projected altered weather conditions due to climate change; and
- the next review of collected data was recommended for the end of 2016.

2.3 Environmental Effects of Increasing the Volume of Imported Water to 10 Gigalitres

In 2015 the *Barossa Pipeline Project – Barossa Pipeline Project, Report on Environmental Effects of Increasing the Volume of Imported Water to 10 Gigalitres* was prepared for Barossa Infrastructure Ltd (BIL) by Eco Management Services Pty Ltd. The report documented findings from an environmental assessment undertaken to determine potential impacts of the proposed transfer by BIL of 10,000 ML/annum of Warren Reservoir-River Murray Water to the Barossa Region through BIL's pipeline network.

The following summary findings have been extracted from this report (Eco Management Services Pty Ltd, 2015) as follows:

The BIL water contributes to the sustainability of the Barossa as a wine producing area of high quality, by providing:

- *Additional good quality water (low salinity) to meet the demand of the Barossa wine industry, in particular:*
    - *Enable existing supplies of high salinity irrigation water to be replaced or mixed with low salinity water, which is important for quality.*
    - *Supplementing additional limited supplies, enabling new plantings, including in areas where groundwater is too saline for use.*
    - *Providing a reliable water supply to sustain production in times of climate variability (drought) and change.*
- *From a horticultural perspective the continued use of BIL water is also sustainable. It will be applied at a low rate of approximately 100 mm per year, which is about 20-25% of the requirement for vines. Even with this low rate, ongoing management of irrigation is required to ensure there are no issues with soil salinity, waterlogging or excess water moving below the root zone. There are a number of important drivers which will ensure its efficient use, and are:*
    - *The need to provide a quality product, including for overseas markets;*
    - *A strong negative correlation between salinity and quality, therefore involving careful salinity management;*

- *A strong negative correlation between yield and quality, therefore requiring management of application rates; and*
- *The high cost of BIL water.*

In addition:

- *BIL customers are required to prepare irrigation management plans, which takes into account location, soils, use of cover crops, mulch etc. BIL is currently upgrading its technology to enable real time monitoring with web based flowmeters, weather information and soil moisture readings.*

- *For the existing BIL water use and proposed increase to 10,000 ML, it is very unlikely that there will be any change in the regional water table, apart from naturally occurring seasonal variation. This is supported by data from the 14 monitoring wells established in 2001 to monitor the water table and salinity (2014 WaterSearch report). Variations observed, due to rainfall patterns, are the same as those occurring regionally, irrespective of soil types.*
- *Monitoring indicates that no perched water tables have developed. With the proposed increase the risk continues to be very low, because of the low application rate of the BIL water of 100 mm/year, irrigation in summer usually starting in December, and with efficient management resulting in very little water moving past the root zone.*

Assuming a conservative 50% replacement of saline irrigation water (average 1,500 mg/L TDS) in the Barossa Valley Floor and Lyndoch Valley, but all new water in the Greenock Creek and Gomersal Creek Catchments, there is a net average annual reduction in load to the surface of approximately 522 tonnes per year. There is however a salt load redistribution with a large decrease in the average annual load on the Barossa Valley Floor and Lyndoch Valley of 2,034 tonnes per year, but an increase in the Greenock Catchment of 1,512 tonnes per year. For the purpose of this assessment this assumes 5,400 ML used in the Greenock Creek Catchment, 2,200 ML in the Barossa Valley Floor and 1,400 ML in the Lyndoch Valley. The large reduction in the Barossa Valley Floor and Lyndoch Valley is particularly significant as these areas have the most soils with high risks of salinization and water logging. There should be no adverse effects on any remnant terrestrial vegetation.

The reduction in salt load will benefit aquatic ecosystems in the North Para River and tributaries where salinity has increased in the study area, particularly improving water quality in refugia pools. There may be a small increase in the longer-term in watercourses in the Greenock Creek Catchment, but which are already saline. Below the confluence of Greenock Creek there is the net average decrease of 520 tonnes per year.

In addition to the DEWNR monitoring network for ground and surface water, monitoring should continue, with periodic data review and reporting at:

- *The 14 wells established for BIL monitoring.*
- *New gauging station on Greenock Creek (salinity).*

At this stage no additional sites are considered necessary.

3 Groundwater Monitoring Results

Following the initial environmental impact report in 2001, the subsequent groundwater monitoring report in 2014, and the 2015 assessment of expansion to 10 GL/a, this report (2017) provides additional findings from water level and salinity monitoring from the monitoring wells previously reported within the Barossa region.

3.1 Approach and Methods

The approach applied for this report involved a desktop review of previous reports and monitoring data available online. The results are presented in a manner to provide consistency between this report and the 2014 monitoring report.

For each well, water levels and salinity records were downloaded from the SA Water Connect website[1], and average monthly rainfall data was downloaded from the BOM website[2]. Rainfall data was taken from the weather station most relevant to each well and for the time period covering the available well data.

3.2 Results

Of the 20 wells reported in the 2014 report, two of the BIL monitoring wells (BRS023 and MOR272) had no data available (2014-2017) and so have been excluded from this report. Of the remaining 18 wells (Table 1 and Figures 8 to 25), 12 are dedicated BIL monitoring wells, and six are existing DEWNR observation wells. Wells are referred to in this report primarily by their Observation Well number, though Table 1 also shows the associated Unit Number for each well.

Data availability and key trends

The frequency and duration of data records varied among wells, with some missing data in one or more years (Figures 8 to 25). Where there is little and/or sporadic data, trends in changes over time are difficult to confirm; this was particularly problematic for salinity records.

Water level data was available to April 2017 (end summer) for all but one well (BRS024). For well BRS024, only one recent data record, taken in 2015 was available. Water level records show slowly decreasing trends to 2017 in 13 wells, slow to rapid increasing trends in three wells, and relatively stable trends in two wells (Table 1).

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[1] SA Water Connect https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[2] Data source: http://www.bom.gov.au/climate/data/

There was no salinity data more recent than 2014 available for any of the wells, meaning that it is not possible to determine whether trends in salinity patterns have varied or remained the same from the patterns discussed in the 2014 report (Table 1).

Relationship between water level and salinity

The relationship between water level and salinity showed high variability. Of the 13 wells with decreasing water level trends, six showed a decrease in salinity over time, six showed an increase in salinity, and one (MOR010) has a distinct lack of records making it difficult to clarify a specific trend (Table 1, Attachment A). For the three wells with increasing water level trends, one showed a decreasing salinity trend and the other two an increasing trend (Table 1, Attachment A). For the two wells with relative stable water levels, one increased in salinity and the other decreased (Table 1, Attachment A).

Table 1. Observation Well codes and related Unit Numbers for each well. Also shown are comments on water level and salinity data (graphically represented in Attachment A.

Observation Well	Unit Number	Data comments	
		Water Level	Salinity
BLV008	6729-1672	• Slow decreasing trend • 67 data points, ranging October 2001 to April 2017	• Slow decreasing trend – no recent records • 27 data points, ranging November 2001 to October 2014
BLV009	6729-1673	• Slow decreasing trend • 62 data points, ranging October 2001 to April 2017	• Rapid increasing trend – no recent records • 28 data points, ranging November 2001 to October 2014
BLV010	6729-1674	• Slow decreasing trend • 62 data points, ranging October 2001 to April 2017	• Stable to slight increasing trend – no recent records • 27 data points, ranging November 2001 to October 2014
NTP008	6629-1811	• Stable trend • 62 data points, ranging October 2001 to April 2017	• Rapid increasing trend – no recent records • 24 data points, ranging November 2001 to October 2014
NTP009	6629-1812	• Stable trend • 63 data points, ranging October 2001 to April 2017	• Slow decreasing trend – no recent records • 30 data points, ranging November 2001 to October 2014
NTP010	6629-1813	• Slow decreasing trend • 62 data points, ranging October 2001 to April 2017	• Rapid decreasing trend • 29 data points, ranging November 2001 to October 2014

Observation Well	Unit Number	Data comments	
		Water Level	Salinity
NTP011	6629-1814	• Stable to slow decreasing trend • 62 data points, ranging October 2001 to April 2017	• Stable to slow increasing trend • 27 data points, ranging November 2001 to October 2014
MOR010	6629-4	• Stable to slow decreasing trend • 391 data points, ranging August 1961 to April 2017	• Trend not clearly defined due to lack of data points and no recent records • 10 data points, ranging May 1961 to June 1978 • 3 earlier data points are not shown on the graph: June 1939 (2122), February 1940 (2137), and May 1951 (2391)
MOR084	6629-73	• Rapid increasing trend • 78 data points, ranging October 1974 to April 2017	• Slow decreasing trend – no recent records • 25 data points ranging, October 1974 to August 2010
MOR204	6628-15398	• Slow decreasing trend • 261 data points, ranging November 1990 to April 2017	• Slow increasing trend – no recent records • 24 data points, ranging November 1990 to March 2011
MOR212	6729-1448	• Slow decreasing trend • 241 data points, ranging October 1991 to April 2017	• Slow decreasing trend – no recent records • 19 data points, ranging October 1991 to March 2011
MOR213	6628-16133	• Stable to slow increasing trend • 227 data points, ranging March 1993 to April 2017	• Rapid increasing trend – difficult to clearly define due to lack of points and recent records • 14 data points, ranging September 1994 to May 2011
MOR273	6729-1671	• Stable to slow decreasing trend • 64 data points, ranging October 2001 to April 2017	• Slow increasing trend – no recent records • 24 data points, ranging November 2001 to October 2014
MOR274	6628-20695	• Slow increasing trend • 59 data points, ranging February 2002 to April 2017 • Some years missing data	• Slow increasing trend – difficult to clearly define due to lack of data points and no recent records • 8 data points, ranging November 2001 to May 2013 • Some years missing data

Observation Well	Unit Number	Data comments	
		Water Level	Salinity
BRS009	6628-13342	• Slow decreasing trend • 270 data points, ranging June 1985 to April 2017	• Slow decreasing trend – difficult to clearly define due to lack of recent records • 55 data points, ranging February 1987 to December 2010
BRS022	6628-20690	• Slow decreasing trend • 62 data points, ranging October 2001 to April 2017	• Rapid decreasing trend – no recent records • 27 data points, ranging November 2001 to October 2014
BRS024	6628-20693	• Stable to slow decreasing trend – difficult to clearly define due to lack of data points and only 1 record after 2014 • 51 data points, ranging October 2001 to January 2015 • Some years missing data	• Slow increasing trend – difficult to clearly define due to lack of data points and no recent records • 6 data points, ranging November 2001 to May 2006
BRS025	6628-20694	• Stable to slow decreasing trend • 61 data points, ranging October 2001 to April 2017	• Stable to slow increasing trend – difficult to clearly define due to lack of recent records • 28 data points, ranging November 2001 to October 2014

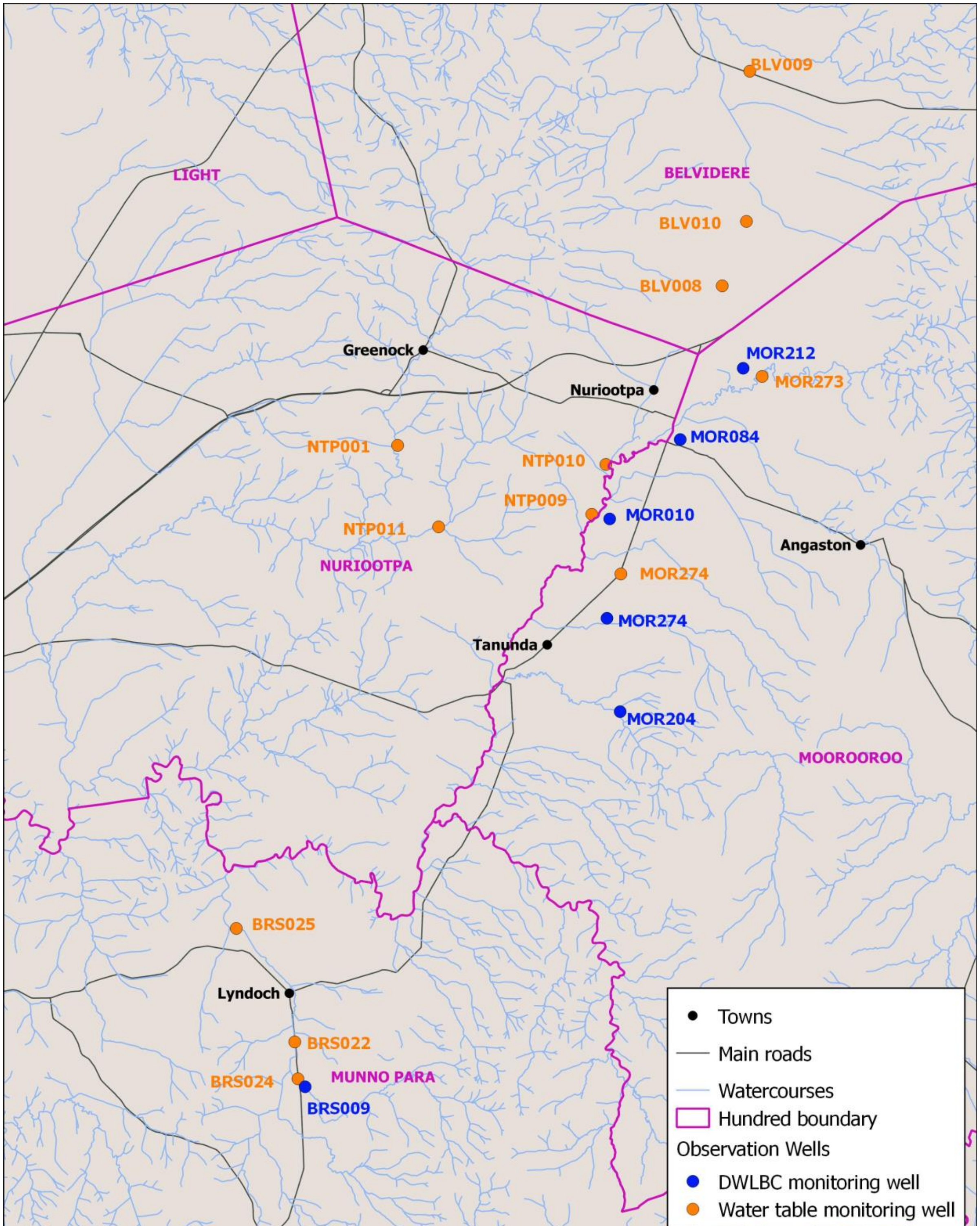

Figure 1. Water table monitoring well location plan

Important note: (i) This map is not guaranteed to be free from error or omissions, and has been produced for the exclusive use of the Client and Seed Consulting Services; (ii) Any contours are suitable only for the purpose of this plan; their accuracy has not been verified and no reliance should be placed upon them for any purpose other than the original purpose of this map; (iii) Aerial photos and imagery have been overlaid as best fit on the boundaries shown and precision is approximate only; (iv) Scale shown s correct for original plan and any copies of this plan should be verified by checking against the scale bar; (v) This figure may not be copied unless this not is included.

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4 Water & Salt Balance

The *Barossa Pipeline Project – Environmental Assessment* report prepared by Eco Management Services Pty Ltd in 2001 included a regional water and salt balance, with reference to work by Cobb (1986) who prepared a regional water budget for the period February 1979 to February 1980. Cobb estimated that the groundwater extraction in the valley floor was approximately 1,591 ML/a (not including Lyndoch Valley).

Subsequent groundwater reviews (Sibenaler, 1991) and the commencement of water metering (wells) in the early 1990's, development of a Barossa Valley Water Allocation Plan (WAP) in 1992, and regional investigations and reporting by the Department of Environment, Water & Natural Resources (DENWR) has resulted in greater understanding of groundwater extraction and recharge patterns.

The EMS (2001 & 2015) studies provide further summary water balance data based on consumption history (metered use), and DEWNR groundwater status reports (2014) and surfacewater (2015) provide further information regarding regional salinity trends.

4.1 Water balance

Historical Groundwater Usage

In the lead up to the 1991 Proclamation (Prescription) of groundwater in the Barossa Valley, Siebenaler (July 1991) noted that the groundwater withdrawal for irrigation was of the order of 4,100 ML for 1990/91. Prior to that, the estimated groundwater withdrawals in 1979, 1986 and 1989 were assumed to be of the order of 1,600, 2,300 and 2,700 ML, respectively.

Pugh (1995) noted that metered groundwater extractions were:

- 1990/1991 3,300 ML[3]
- 1991/1992 3,113 ML
- 1992/1993 1,770 ML
- 1993/1994 3,600 ML
- 1994/1995 4,687 ML

The December 2000 *Barossa Prescribed Water Resources Area WAP* noted that approximately 5,000 ML of underground water was allocated and "…the level of use over the last few years has averaged only 4,400 ML per year".

The 2007/08 Barossa WAP District *Irrigation Annual Report* estimated that groundwater use was approximately 3,900 ML, which was significantly less than the allocated volume (5,500 ML) at that time. This figure should be treated with caution however, as not every extraction was

[3] Incomplete metering

accounted for in the reporting mechanisms to the (then) Adelaide and Mount Lofty Ranges Natural Resources Management Board.

The 2009 WAP suggested groundwater allocations were around 6,100 ML, including Lyndoch, Valley Floor and Flaxman's Valley catchments, with groundwater use around 2,000 ML (based on 2004/05 irrigation reporting data).

Revision 2045 (AWE, 2010) noted approximately 7,200 ML of allocated groundwater in the Barossa region, which included the Lyndoch, Flaxman's Valley and Greenock Creek sub-catchments.

Reporting by DEWNR (2014) identified the groundwater use from the three main Barossa Valley aquifers as follows:

2014 DEWNR review (Fractured Rock, Upper & Lower Aquifers)

In the Barossa PWRA, groundwater is primarily used for the irrigation of vineyards and the Fractured Rock Aquifers are the main source of extraction, supplying 58% of groundwater extracted during 2014. Metered extractions from the fractured rock aquifers totalled **1,602 ML** in 2013–14, a 19% decrease from the previous water-use year (Figure 2).

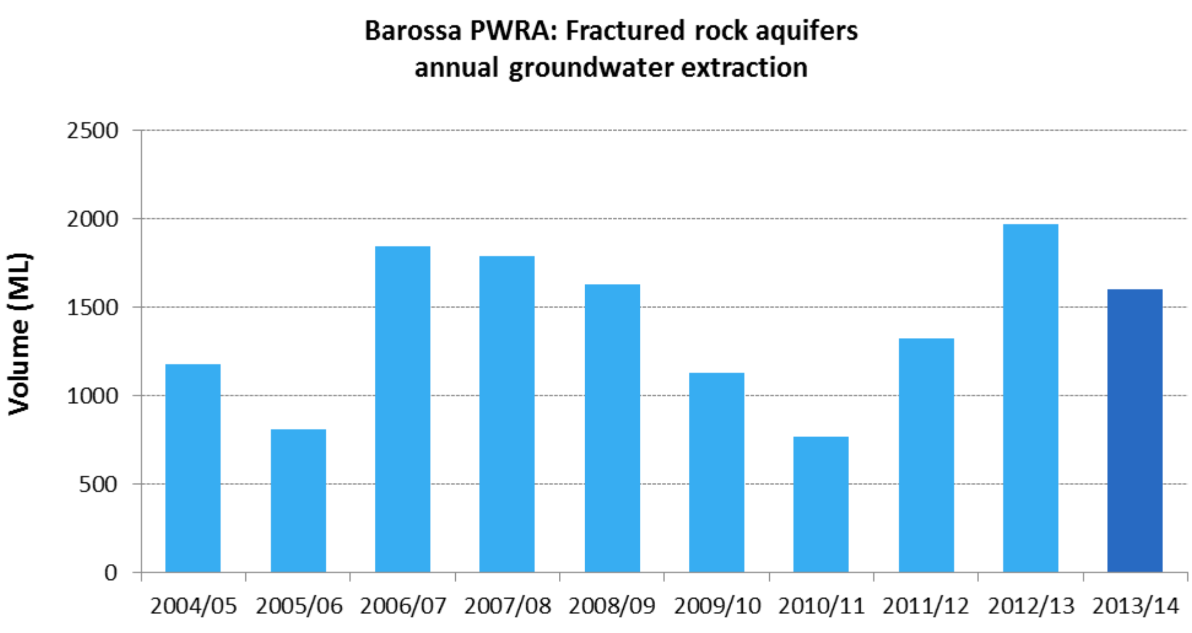

Figure 2. Annual metered use from the Fractured rock aquifers, Barossa PWRA. DENWR 2015.

Metered extractions from the Upper Aquifer totalled **389 ML** in 2013–14, which represents a 17% decrease compared with the previous water-use year (Figure 3) and totals 14% of the total extraction from the Barossa PWRA.

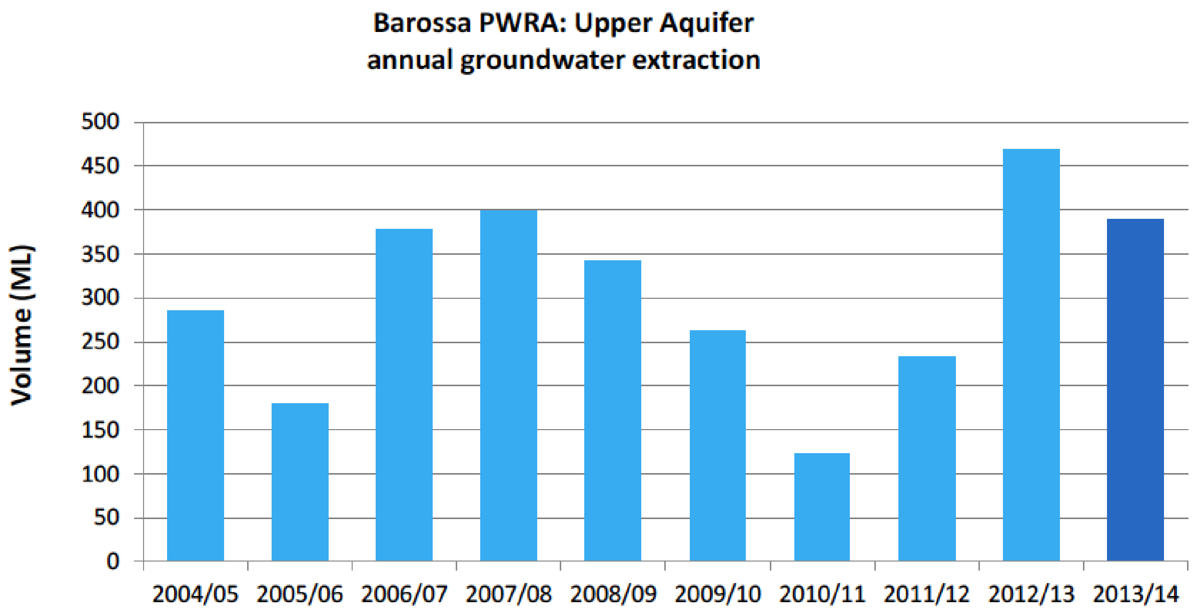

Figure 3. Annual metered use from the Upper aquifer, Barossa PWRA. DENWR 2015.

Metered extractions from the Lower Aquifer totalled **789 ML** for 2013–14, which is a 16% decrease compared to the previous water-use year (Figure 4). This volume forms 28% of the total extraction from the Barossa PWRA.

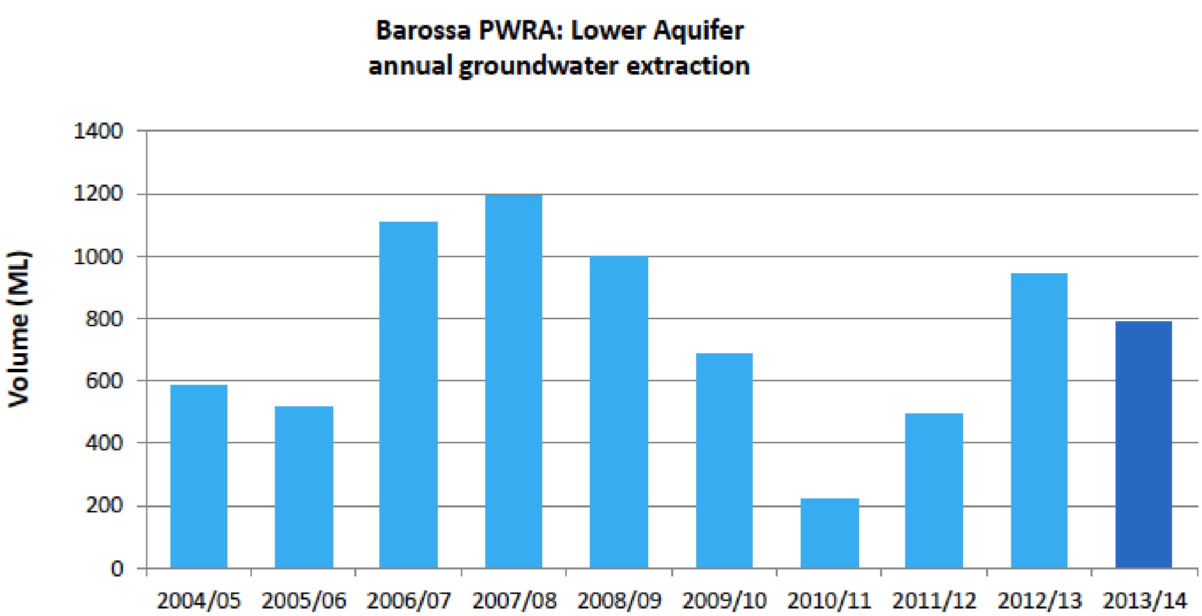

Figure 4. Annual metered use from the lower aquifer, Barossa PWRA. DENWR 2015.

The combined extraction of groundwater in the Barossa Prescribed Water Resources Area for 2013/14 was **2,780 ML.**

DEWNR noted the following status for the three main Barossa Valley floor aquifers in 2014:

The fractured rock aquifers of the Barossa PWRA have been assigned a green status for 2014:

2014 Status

"No adverse change, indicating negligible risk to the resource"

This means that the groundwater status was observed to be stable (i.e. no significant change) or improving over the 12-month reporting period. If these conditions were to continue, there is a very low likelihood of negative impacts on the beneficial uses of the resource (e.g. drinking water, irrigation or stock watering).

The 2014 status for the fractured rock aquifers is supported by:

- an overall rise in the maximum recovered groundwater level when compared to 2013 water level data
- an overall decline in groundwater salinity when compared to 2013 salinity data, albeit from limited data.

The Upper Aquifer of the Barossa PWRA has been assigned a green status for 2014:

2014 Status

"No adverse change, indicating negligible risk to the resource"

This means that the groundwater status was observed to be stable (i.e. no significant change) or improving over the 12-month reporting period. If these conditions were to continue, there is a very low likelihood of negative impacts on the beneficial uses of the resource (e.g. drinking water, irrigation or stock watering).

The 2014 status for the Upper Aquifer is supported by:

- most wells recorded either an increase or negligible change in the maximum recovered groundwater level when compared to 2013 water level data
- most wells recorded a decrease in or stable salinity levels in 2014 when compared to 2013.

While most wells recorded stable or improving water levels, the decline in groundwater level in the areas of intensive irrigation around Lyndoch and Angaston should not be overlooked.

The Lower Aquifer of the Barossa PWRA has been assigned a yellow status for 2014:

2014 Status

"Gradual adverse changes, indicating a low risk to the resource in the medium term"

This means that minor adverse changes in the resource status have been observed over the 12-month reporting period. If these conditions were to continue, they are unlikely to negatively impact the beneficial uses of the resource (e.g. drinking water, irrigation or stock watering) for at least 15 years.

The 2014 status for the Lower Aquifer is supported by:

- an overall decline in the maximum recovered groundwater level when compared to 2013 water level data.

Summary (Groundwater) extractions

When compared to historical data (estimated and metered records) of groundwater extractions dating back to 2001 (as described by Green Ochre, AMLR report 2010, figure 5), there appears to be consistent groundwater use of approximately 2,500 to 3,000 ML/a in the valley floor. This is also supported by the 2014 total of 2,780 ML (total region including Valley Floor, Lyndoch, Greenock and Flaxman's Valley).

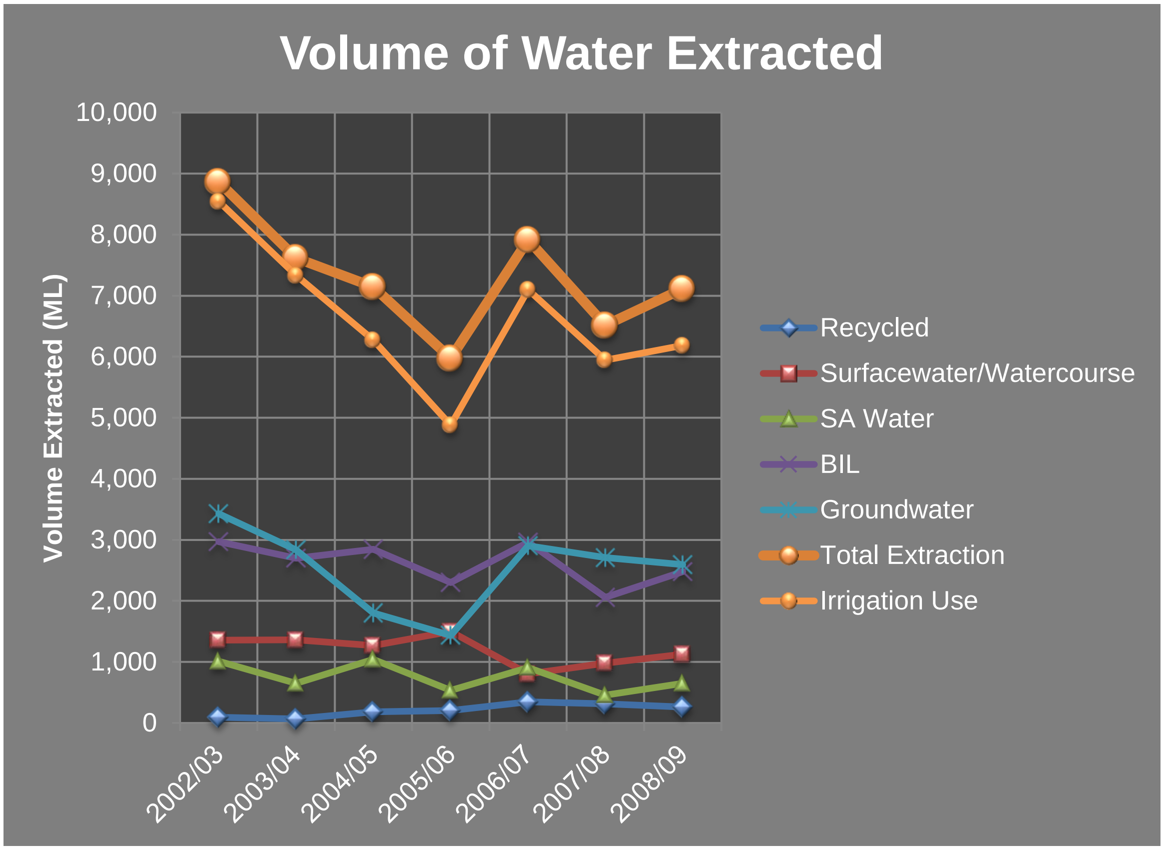

Figure 5. Volumes of water extraction between 2002 and 2009. Taken from: Green Ochre report to Adelaide and Mount Lofty Ranges NRM Barossa Irrigation Annual Reporting, 7 Year Trend Analysis (2002/03 – 2008/09)

It would appear from the records available that groundwater extraction from the Barossa Valley floor aquifers peaked in the mid to late 1990's at around 4,700 ML (1994/95) prior to the commencement of the BIL scheme.

4.2 Salt balance

2001 & 2015 EMS Reviews

In 2001, the maximum anticipated salinity for the imported water (BIL) was 500 mg/L, about a third of the typical groundwater used for irrigation during and preceding the 1990's and early 2000's. It was determined that if there was no replacement of existing more saline groundwater use, this would result in an overall importation of salt into the catchment of the order of 2,500 tonnes/annum with 5,000 ML/a of imported water, rising to 3,500 tonnes/annum with 7,000 ML/annum imported water. However, there was expected to be replacement of groundwater accounting for approximately 50% of use at that time. Prior to the commencement of the BIL scheme (i.e. late 1990's), groundwater use in the Barossa Valley Proclaimed Wells Area was around 4,700 ML/annum.

EMS reported that this salt would eventually reach the regional water table and discharge as base flow in the catchment streams. However, the net effects are variable depending on whether the imported water is for new irrigation, replacement of current groundwater use or a mixture. Annual fluctuations in rainfall and run-off also influence the salt load discharging the region (*sensu* Yaldara gauging station).

Historical BIL Usage & Salinity

Review of historical BIL water quality (TDS) data suggests an average TDS of approximately 300 mg/L. 12,000 ML of imported water would result in a total regional import of approximately 3,600 Tonnes/a of salt. By comparison using (2001) TDS of 500 mg/L would result in 6,000 Tonnes/a of salt. This assumes no replacement of existing groundwater, which was the premise for BIL commencing operations in 2001 and has, as expected, resulted in reduction in use of groundwater.

Analysis of Regional Data

Of the 12,000 ML total BIL capacity proposed, approximately 25% of the water will be applied to catchments outside of the Barossa Prescribed Water Resources Area (BIL, *pers. com.* 2017; BIL network and customer data) or areas not draining to the North Para River. This is a result of additional BIL water being utilised in the north of the Valley floor and west (i.e. Seppeltsfield, Gomersal Creek and Greenock catchment areas) and will equate to:

- up to ~ 9,000 ML utilized across the Valley floor from north of the Sturt Highway to (and including) the Lyndoch Valley; and
- ~ 2,700 Tonnes/a of total salt imported to the region (based on a salinity of 300 mg/L – BIL consistently achieves this or lower).

Considering a base (pre-BIL) year where approximately 4,700 ML (1994/5) of groundwater was extracted from the Barossa Valley floor aquifer systems, this would have resulted in approximately 7,050 Tonnes/a of surface salt load. Assuming that groundwater consumption has now reduced to around 2,800 ML/a (as reported by DEWNR, 2014), this represents a

reduction of some 1,900 ML consumption, or 2,850 Tonnes/a reduced salt load (based on 1,500 mg/L average salinity).

The total salt load under a regime of 9,000 ML/a (2,700 T/a salt[4]) of BIL water use and 2,800 ML/a (4,200 T/a salt) groundwater use would be a total of 6,900 T/a surface salt load.

As stated above, based on pre-BIL Barossa Valley Floor groundwater use records supported by regional reporting (AMLR 1991-2014), approximately 7,050 T/a salt was being applied (1995).

The proposed future mix of BIL and groundwater (Total 11,800 ML and 6,900 T/a salt) would represent a net reduction of approximately 150 T/a surface salt load. This is consistent with EMS findings (2001 & 2015) on net reductions in cyclical salt and also appear consistent with current trend analysis of shallow monitoring wells that, on the whole, do not appear to demonstrate evidence of raising or perched water tables or groundwater salinity.

However, it should be noted that these groundwater monitoring trends are based on current BIL usage (7,000 to 9,000 ML, 2013-16) across the whole region of supply which has included approximately 2,000 ML west and north of the Valley floor, neither of which influence the North Para River catchment.

This broad water and salinity balance analysis suggests that the expanded use of BIL (to 9,000 ML) in the Barossa Valley floor will result in a marginally lower total surface salt load when compared to irrigation activities utilizing marginal salinity groundwater prior to the commencement of BIL (1995). Regional monitoring does not suggest any adverse trends in shallow water table salinity. This should not be construed to mean that this long-term salt load is not detrimental (longer term) to some soil types within the region. For these reasons recommendations in the previous EMS environmental studies should continue to be followed. This is discussed further in the Conclusions and Recommendations section (Section 5).

A review of stream gauging data for the Yaldara weir (A5050502) identifies a slight reduction trend in corrected EC (uS/cm) from 1994 to 2017 (Figure 6). However, the long-term trend is not certain and is influenced by peak flow years where stream EC reduces in high rainfall years but total salt load increases as a result of the greater total volume (ML) of discharge (Figure 7).

4 based on BIL utilising water at 300 mg/L

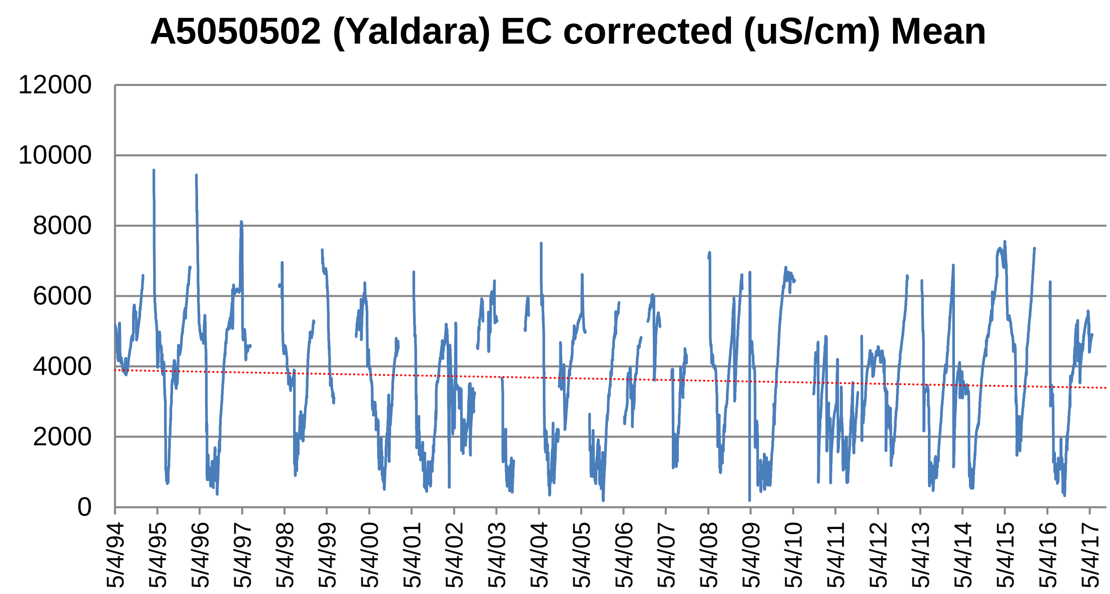

Figure 6. 23 year (1994-2017) water quality (EC) data for Yaldara gauging station, will slight downward trend in corrected mean EC.

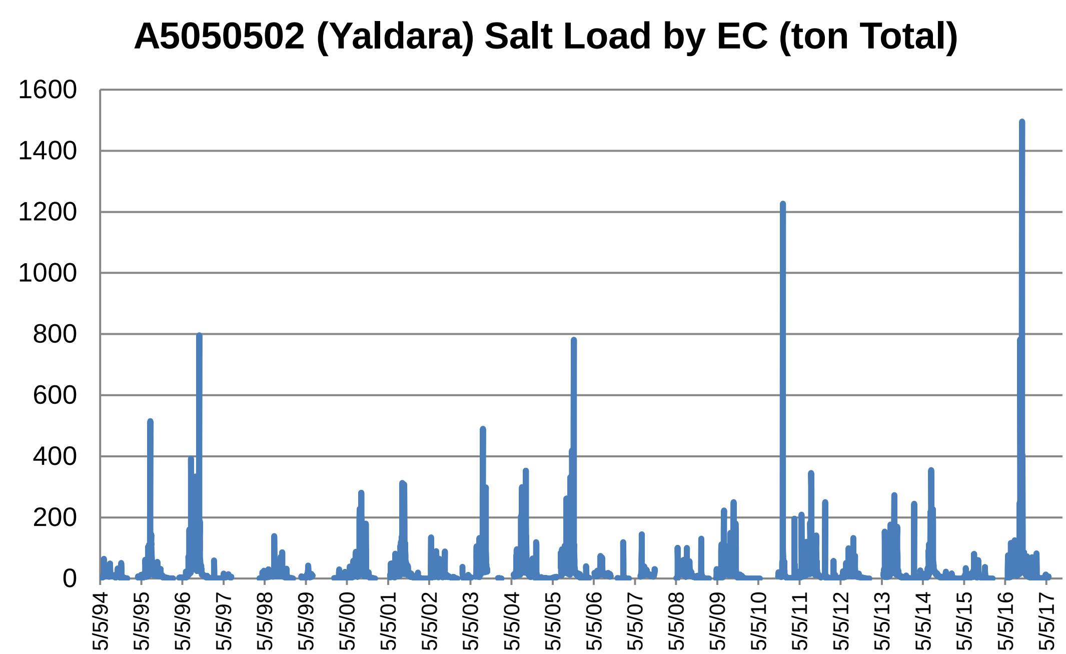

Figure 7. Daily accumulated salt load (Total Tonnes) based on EC for Yaldara gauging station, noting that peak loads are a function of large inflows due to high rainfall years.

In DEWNR's 2015 regional surfacewater summary report it was noted that there was a clear pattern of increasing salinity in the spring and summer months and decreasing salinity in the autumn months, highlighting the climatic influences. Under a changing climate, this pattern significantly could influence future regional salinity discharge and management of salt in the landscape and so highlights the need for ongoing monitoring, as suggested in this report and previous regional water studies (e.g. *Revision 2045*, DEWNR annual surfacewater status reports, and EMS 2001 and 2015 reports).

Areas outside of the Barossa Valley floor

Approximately 3,000 ML of BIL water is proposed to be used in the Greenock, Seppeltsfield and Gomersal areas. This will largely be continuing use of BIL water, with some new or expanded use in these areas, where BIL has replaced surfacewater, watercourse and some groundwater use. The surface salt load (900 T/a) across these regions, based on the projected irrigation rates, regional soils and hydrogeology (fractured rock) of these areas is not expected to result in adverse effects of BIL water use. This is supported by monitoring of the Gomersal area (Seed 2010-2017) as part of ongoing Health SA requirements relating to use of community wastewater management scheme (CWMS) recycled water from The Barossa Council, Nuriootpa CWMS.

5 Conclusions & Recommendations

Water and salt balance analysis for use of up to 12,000 ML of BIL from 2017 is considered to result in a slightly better surface salt load (6,900 T/a) when compared to pre-BIL use of saline groundwater. This is based on up to 9,000 ML of BIL water use and 2,800 ML groundwater use across the Barossa Valley Floor, and compared to the peak of groundwater use (4,700 ML & 7,050 T/a) in 1995, pre-development of the BIL scheme.

Salt discharge from the region can be seen to have increased slightly in the period 1994 – 2017 (Figure 7), but this has been influenced by a number of high rainfall years during that period, which have resulted in corresponding higher annual (winter/spring) total (T/a) salinity discharge. By comparison, the monitored groundwater wells (Figures 8-25, Attachment A) generally show little or no adverse change in either salinity or depth to water, supporting a notion that at current levels of surface salinity load, the region is able to discharge any potential adverse salt accumulation load through an interaction of soil, rainfall and water table drainage to the stream network, as was suggested by EMS (2001 and 2015). It should be noted though that this may not continue to be the case under a future drier climate, with decreasing rainfall and subsequent projected decreases in stream flows. There is therefore a clear need for monitoring and identification of any "early warning" signs to continue.

EMS (2001) recommended that Water Management Plans should form part of BIL customers' use of BIL water. This is technically a requirement of DEWNR imported water permit activities.

Water Management Plans

EMS (2001) concluded that a Water Management Plan should include the following:

1. Water application in a controlled way, i.e. a water meter is the simplest and most basic measurement device;

2. That soil types have been taken into account;

3. An appropriate method of application – drippers, (rate), under vine sprinklers;

4. The correct rate of water used on a per Ha basis;

5. Any under vine mulching on shallow soils;

6. Source of the water – wells, dams, mains;

7. Water quality (TDS mg/L) and whether or not the supplies are mixed in order to achieve a quality standard (<1500 mg/L);

8. Whether or not BIL water will replace existing supplies that are salty or used to facilitate "new" plantings;

9. Method of storage of mains water – well recharge, dams, lined or not;

10. Soil moisture monitoring systems employed;

11. When and how water applied – growth stage, frequency, amount, on advice from wine industry viticulturist; and

12. The location of the vineyard – Section, Hundred etc.

In Seed's experience, most vineyard growers in the region currently address these irrigation management aspects through:

- the general cost of water and desire to be as efficient as possible;
- advice from winemaker or winery to produce fruit to specification; and
- a desire to sustainably manage their land.

Never-the-less, it is strongly recommended that all landholders irrigating vines in the Barossa Valley region regularly monitor and review soil conditions to determine any potential adverse soil conditions such as soil salinity or sodicity, and plan for remedial activities as needed. This will be particularly important into the future under a changing climate where reduced rainfall and regional stream flows may reduce the important flushing of salt. It is not currently possible to determine if there is likely to be any long-term impact under climate change, however climate change projections (RDA Barossa, 2015) suggest:

> "*The Region is likely to experience a drying trend under future climate change, although there is more confidence in modelled projections of temperature than rainfall. By 2030, the best estimate under a medium emissions scenario is that annual rainfall will decline on average by 2 to 5% and by 10 to 20% by 2070, with a more pronounced reduction in winter (10 to 20% reduction) compared to summer (5 to 10% reduction).*"

This further highlights the need for ongoing measurement and monitoring of water and salinity trends in the region to assist in identification of any potential early warning signs of detrimental salt load impacts.

Water Table Monitoring

In 2001 EMS concluded and recommended that regional water table monitoring should be undertaken to determine any trends in raising (perched) water table/s or salinity potentially associated with irrigation related increased surface salt load. A shallow water table monitoring network was created in 2001 and subsequently continues to be periodically monitored. Water Search (2014) completed a review of the network as part of the 2015 EMS BIL expansion report and Seed has completed an additional review in 2017 as part of this report.

It is recommended that a review be completed again in three years' time, following completion of the BIL expansion and three years additional operation of the BIL scheme. It is recommended that the network receive ongoing reviews every three years.

Reporting (DEWNR) & Surface Flow Monitoring

EMS (2015) suggested that ongoing DEWNR surfacewater reporting could be complemented by further gauging in the Greenock Creek catchment. DEWNR complete annual reporting for the three aquifer systems in the Barossa and future reviews of the shallow well monitoring network should review all DEWNR annual groundwater and surfacewater status reports to ensure regional resource trends are also considered.

EMS Observations

EMS concluded in 2015 that "*BIL water contributes to the sustainability of the Barossa as a wine producing area of high quality, by:*

- *Providing additional good quality water (low salinity) to meet the demand of the Barossa wine industry, in particular.*
- *Enabling existing supplies of high salinity irrigation water to be replaced or mixed with low salinity water, which is important for quality.*
- *Supplementing additional limited supplies, enabling new plantings, including in areas where groundwater is too saline for use, and*
- *Providing a reliable water supply to sustain production in times of climate variability (drought) and change.*"

Seed concurs with these observations and these factors are equally important in 2017 regarding the expansion of BIL to 12 GL, including into areas of the Barossa Valley Region where existing water supplies are either minimal, unreliable or saline.

EMS further concluded (2015) that *"…from a horticultural perspective the continued use of BIL water is also sustainable. It will be applied at a low rate of approximately 100 mm per year, which is about 20-25% of the requirement for vines. Even with this low rate, ongoing management of irrigation is required to ensure there are no issues with soil salinity, waterlogging or excess water moving below the root zone."*

Seed also concurs with these observations. Particular attention should be given to new areas of vineyard development, where knowledge of soils may be less (particularly under impacts of irrigation) and irrigation management, including soil remedial activities, may be required.

EMS noted in 2015 that *"…for the existing BIL water use and proposed increase to 10,000 ML, it is very unlikely that there will be any change in the regional water table, apart from naturally occurring seasonal variation."*

Seed does not expect that this will change in the short to medium term, even with the proposed increase to 12,000 ML of BIL, on the basis of the water and salt balance analysis by Seed and the existing well monitoring and irrigation management practices.

Summary Recommendations

In summary, Seed considers that the expansion of the BIL network to 12,000 ML should not result in any immediate or medium term adverse salinity impacts. The regional shallow water table monitoring network does not indicate any current adverse trends in increased water levels or salinity, based on the current level of BIL water use (7-9 GL).

It is evident that rainfall and stream flows in the North Para River catchment have an important function in assisting soils and the catchment to discharge any soil accumulated salinity resulting from irrigation activity. It is currently not possible to fully determine if there will be any adverse impact under a changing climate, though projected reduced rainfall and run-off could lead to an accumulation of salt in the soil profile, or in the shallow water table. Based on current evidence there is unlikely to be an increase in shallow water table levels (e.g. increase in perched water tables) due to the use of BIL water as any decrease in rainfall will most likely result in a total reduction in water input, unless significant additional irrigation water was found. Consequently, under a drying climate, salinity presents the greatest future risk.

It is therefore recommended that:

- BIL customers continue to manage water for irrigation within an irrigation Water Management Plan context, including attention to aspects such as soil assessment and analysis and irrigation scheduling;
- BIL reviews the shallow water table monitoring network at least every three years to review water level and salinity data for any adverse trends; and
- this three yearly review also considers the annual DEWNR groundwater and surface water status reports.

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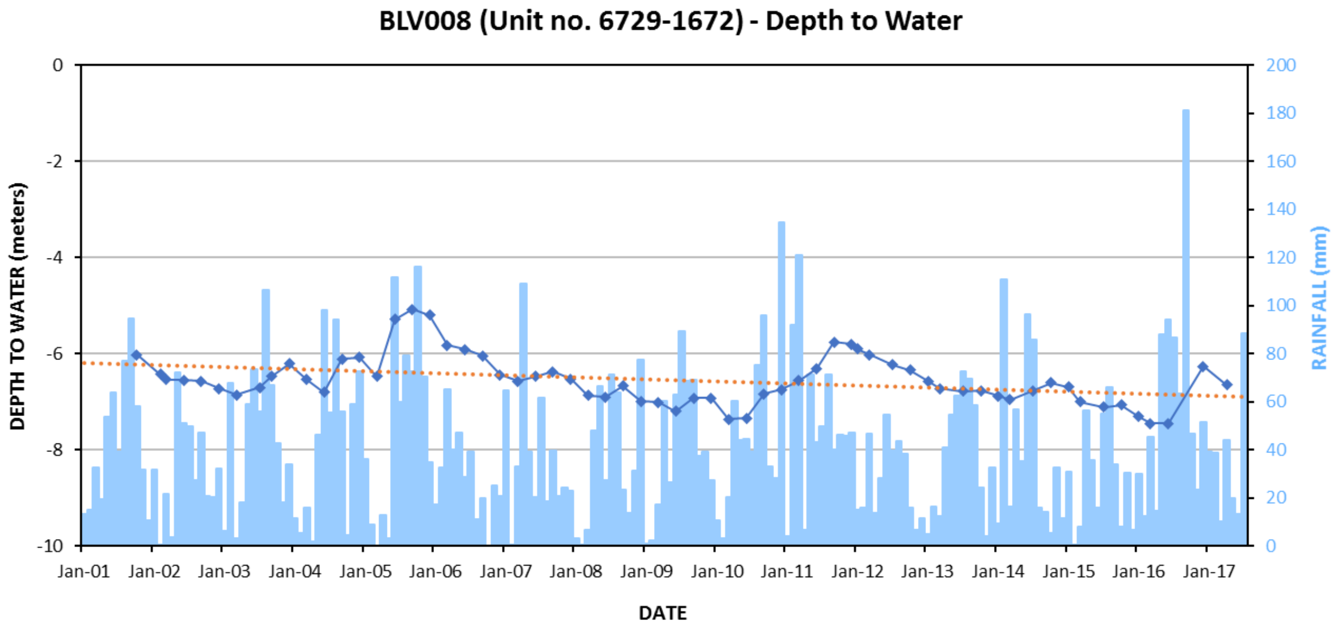
Attachments

Attachment A. Trends in depth to water and salinity for 18 wells shown in Figures 8 to 25.

For each well, the first graph shows the available monitoring data for depth to water and the second graph shows the available monitoring data for salinity. These monitoring data records (dark blue points and line) are overlaid on average monthly rainfall data (light blue bars). A linear trend line for the monitoring data is also shown (orange dotted line), though it should be noted that this trend line does not indicate: significance or any interaction with rainfall data or time.



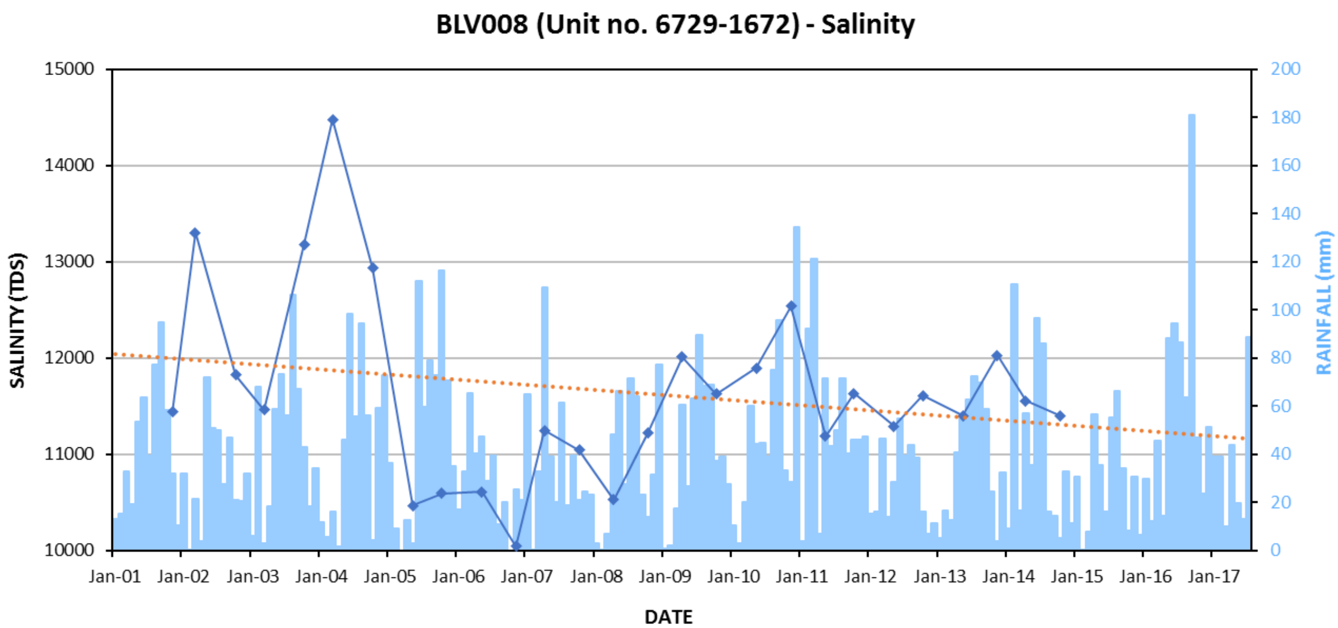
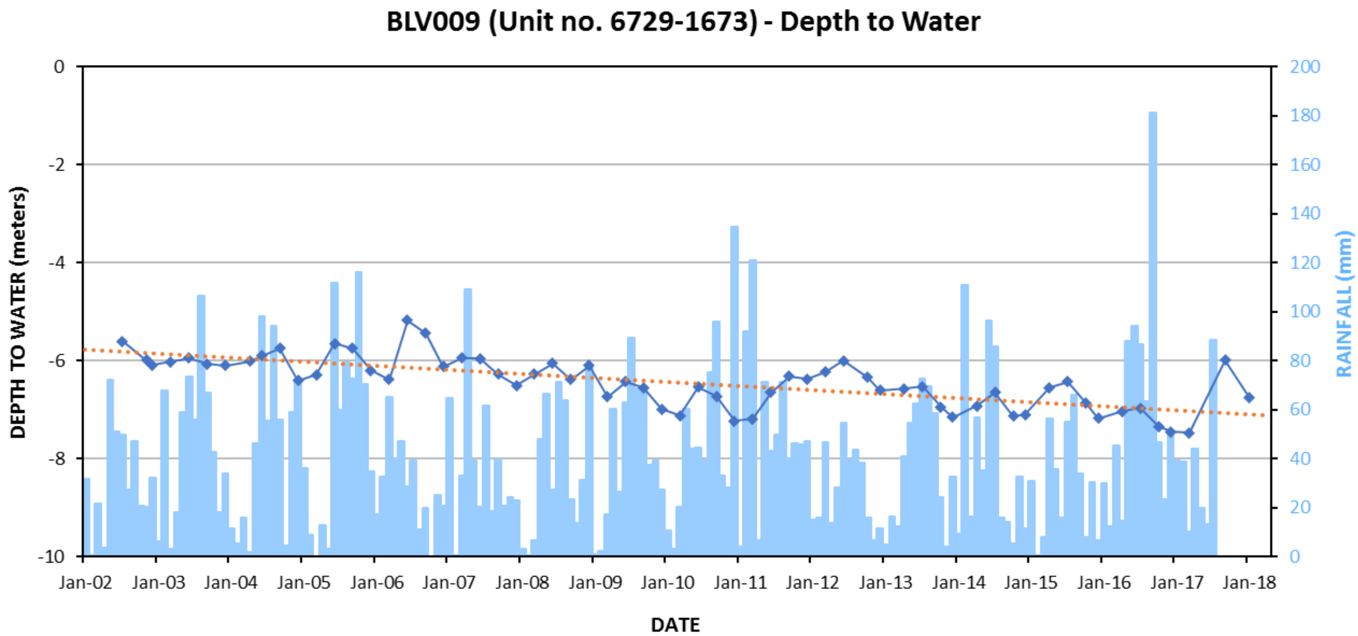


Figure 8. Depth to Water and Salinity for Observation Well BLV008 (Unit no. 6729-1672)[5]. Background rainfall is monthly total precipitation for Nuriootpa[6]. A trend line for the data points is shown by an orange dotted line.

[5] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[6] Data source: http://www.bom.gov.au/climate/data/



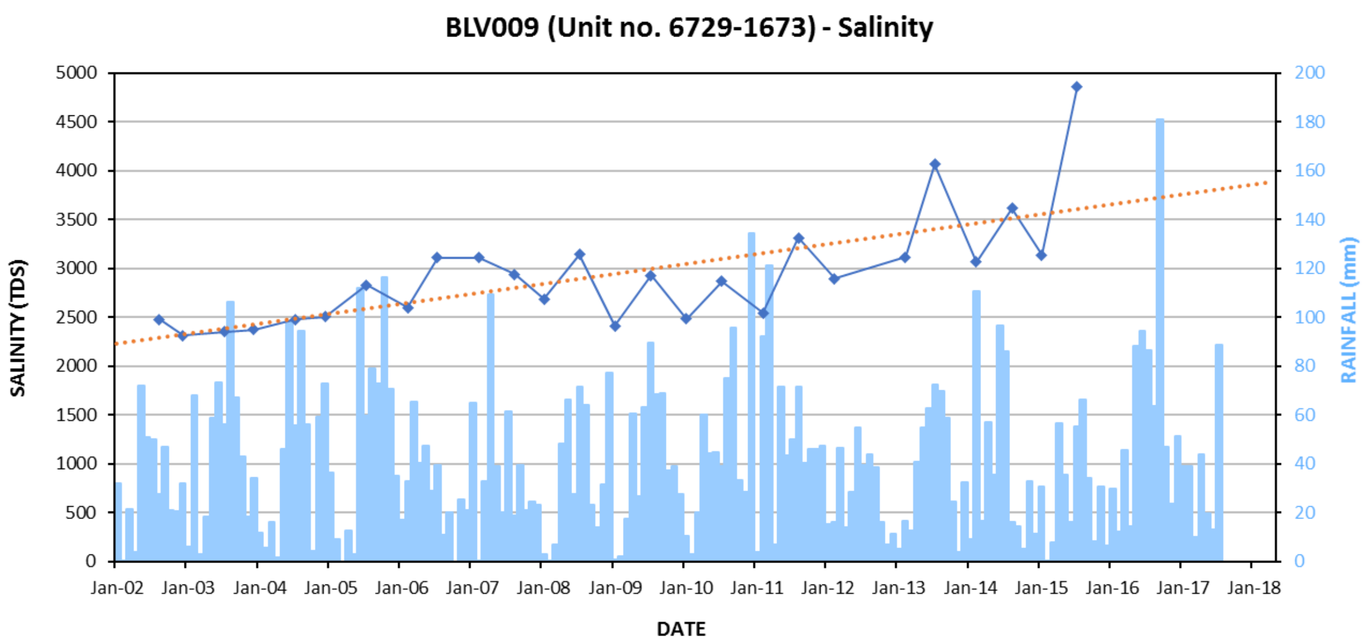


Figure 9. Depth to Water and Salinity for Observation Well BLV009 (Unit no. 6729-1673)[7]. Background rainfall is monthly total precipitation for Nuriootpa[8]. A trend line for the data points is shown by an orange dotted line.

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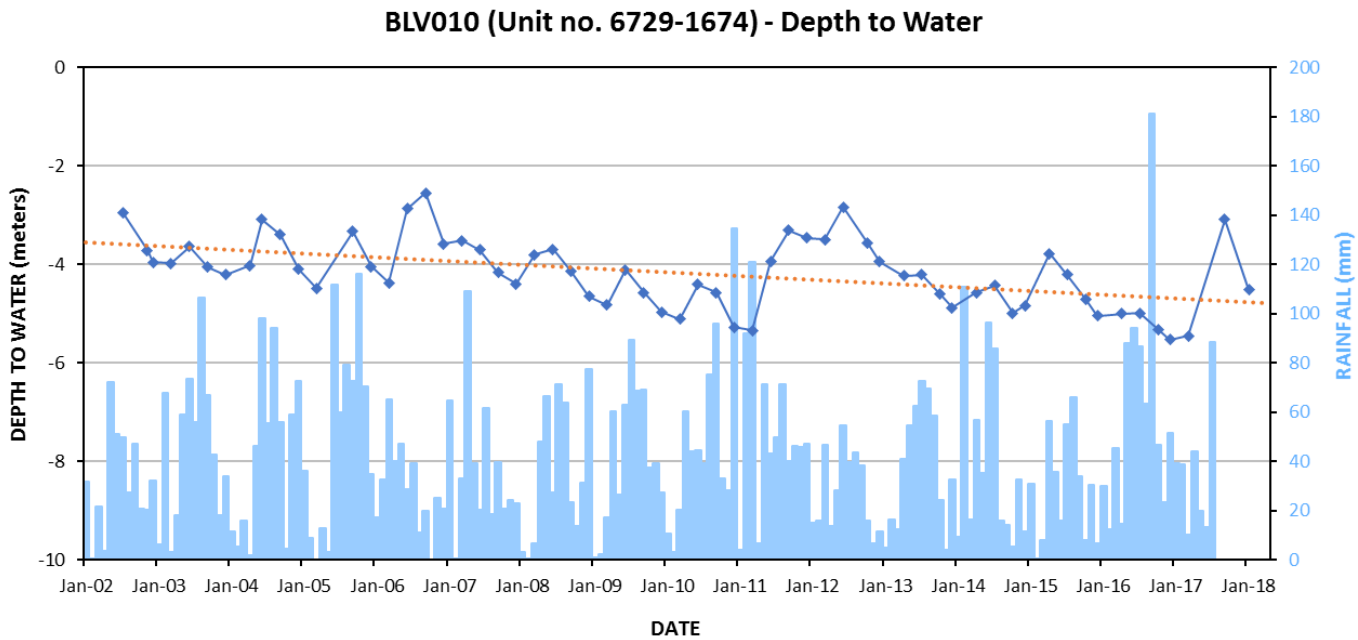
[7] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[8] Data source: http://www.bom.gov.au/climate/data/



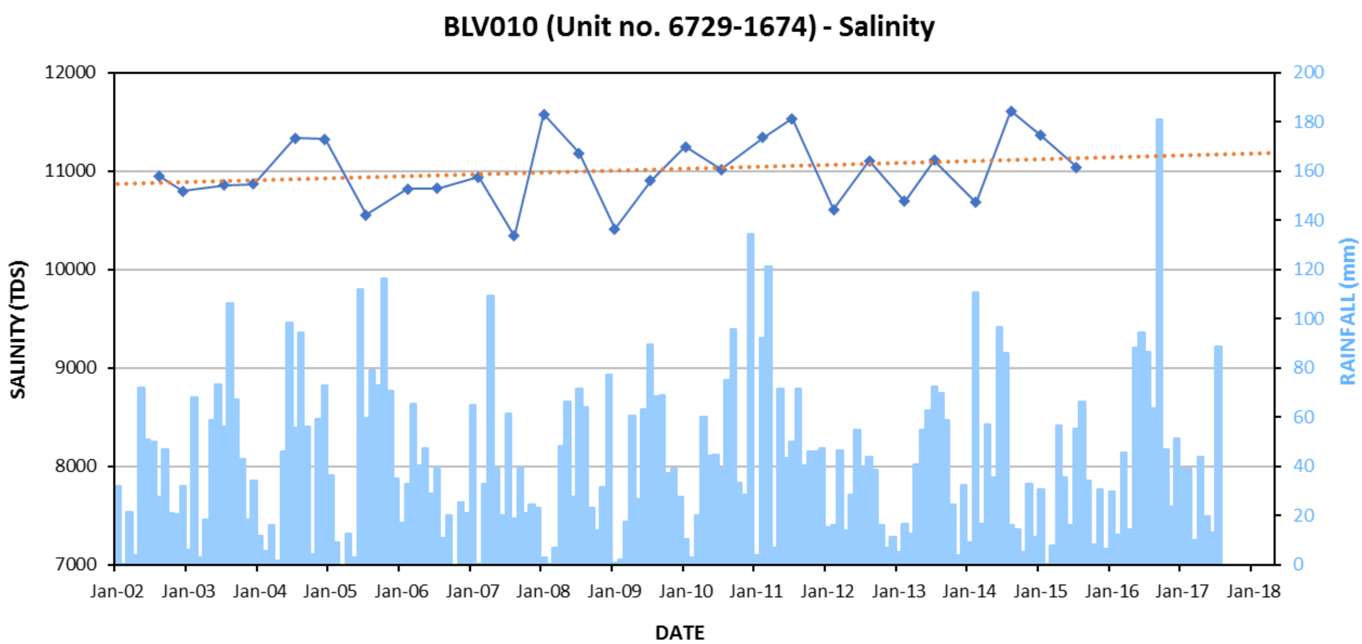


Figure 10. Depth to Water and Salinity for Observation Well BLV010 (Unit no. 6729-1674)[9]. Background rainfall is monthly total precipitation for Nuriootpa[10]. A trend line for the data points is shown by an orange dotted line.

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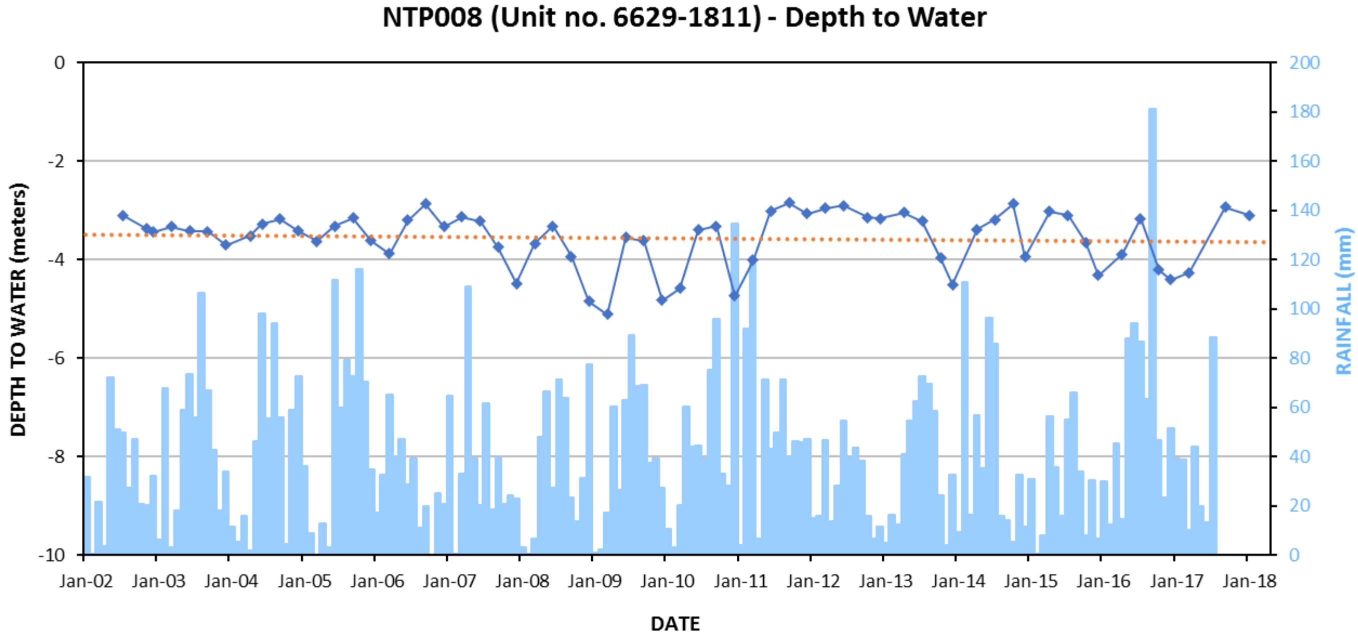
[9] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[10] Data source: http://www.bom.gov.au/climate/data/



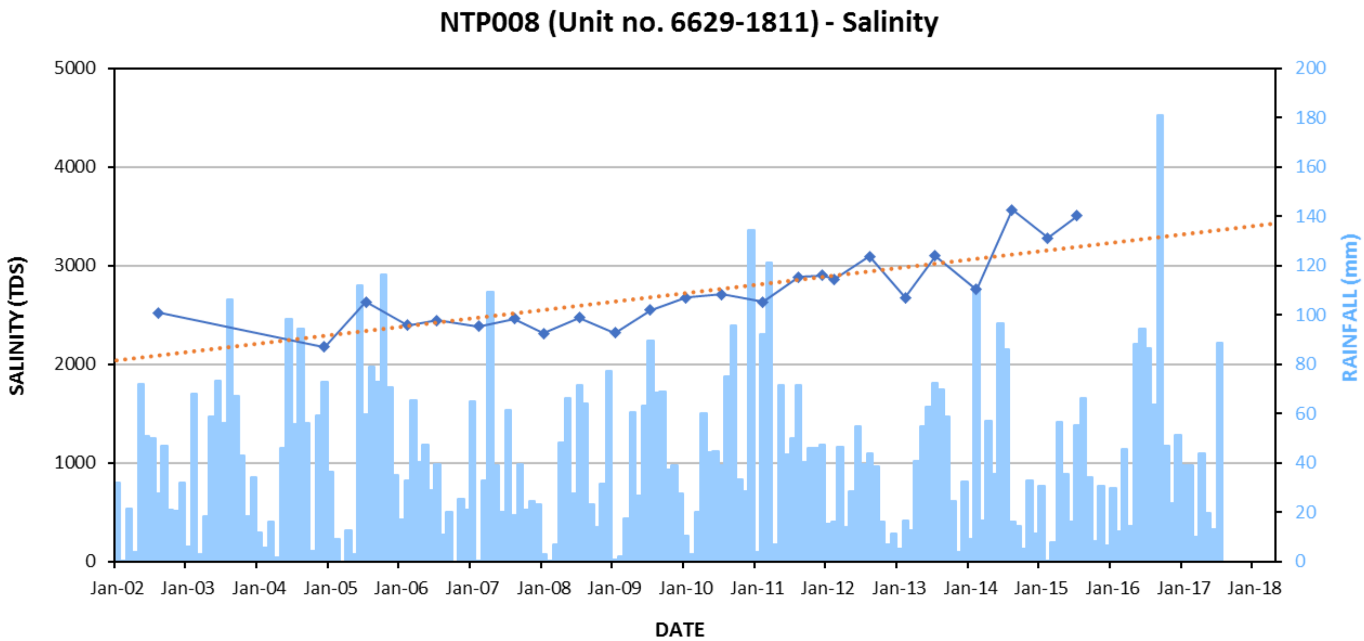


Figure 11. Depth to Water and Salinity for Observation Well NTP008 (Unit no. 6629-1811)[11]. Background rainfall is monthly total precipitation for Nuriootpa[12]. A trend line for the data points is shown by an orange dotted line.

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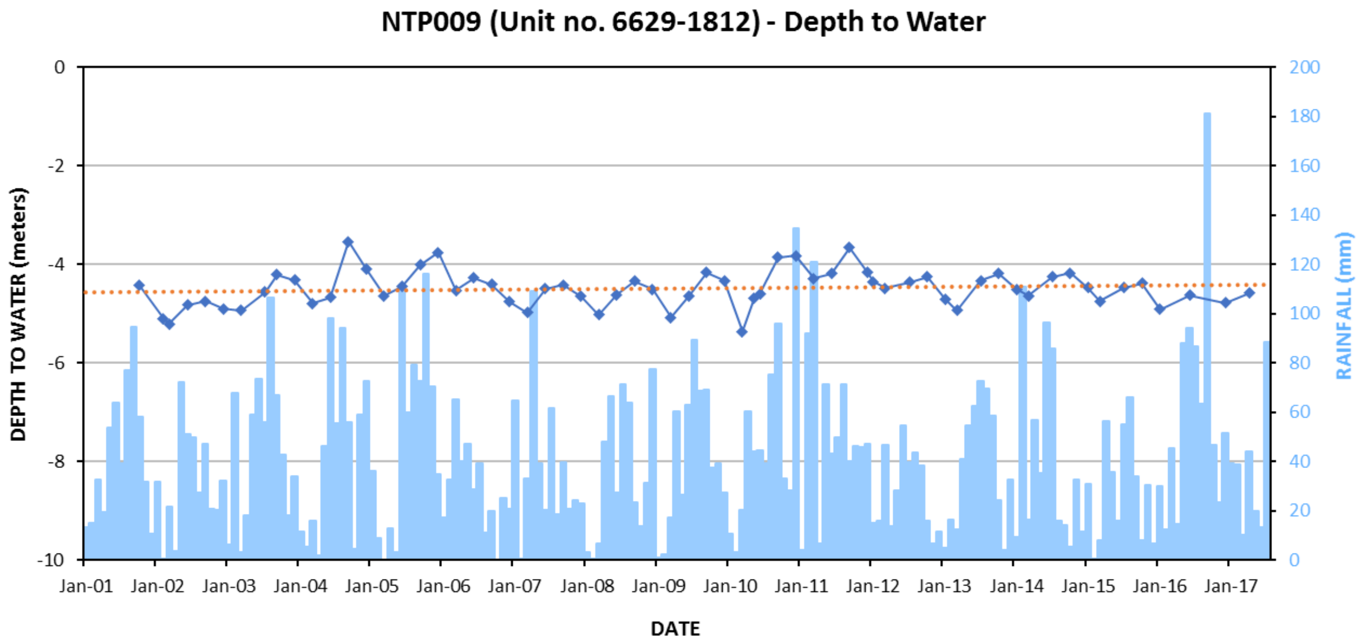
[11] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[12] Data source: http://www.bom.gov.au/climate/data/



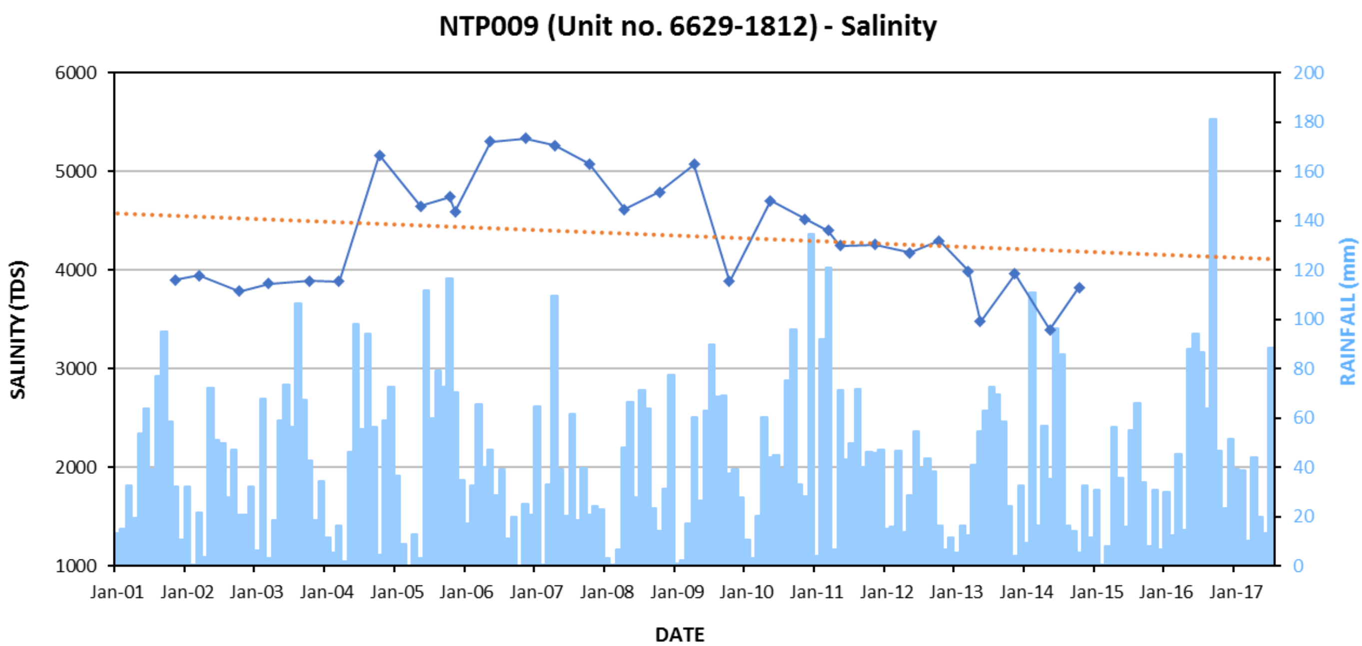
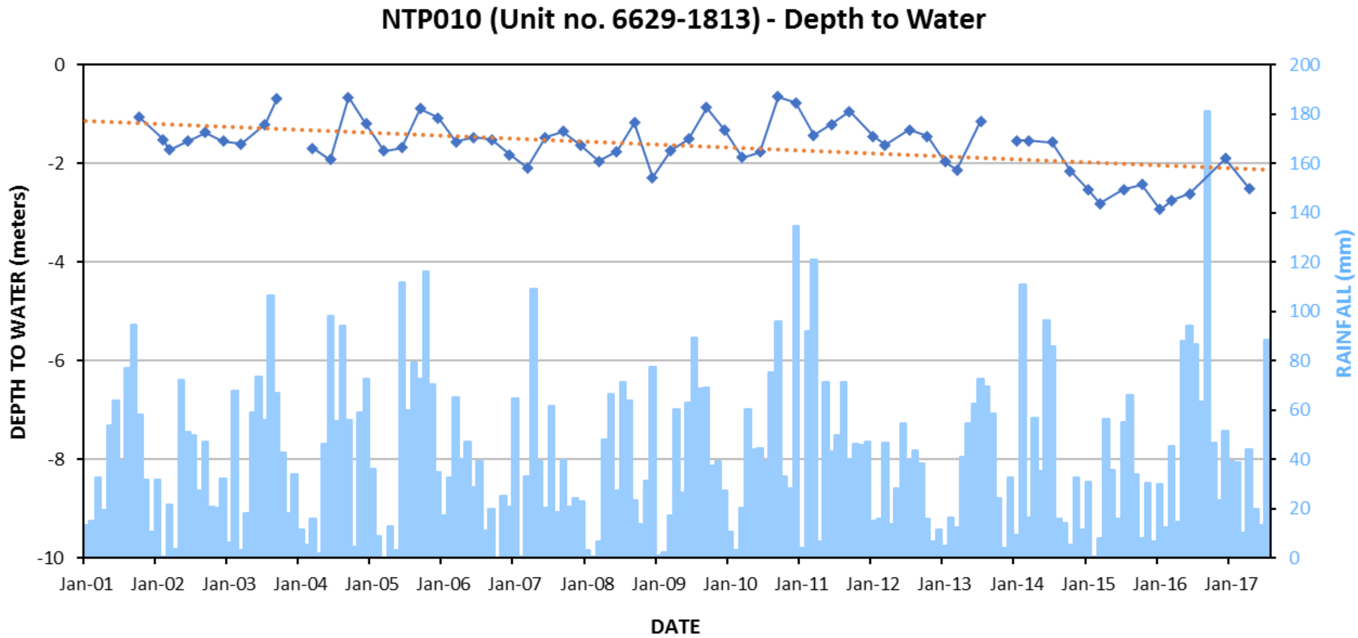


Figure 12. Depth to Water and Salinity for Observation Well NTP009 (Unit no. 6629-1812)[13]. Background rainfall is monthly total precipitation for Nuriootpa[14]. A trend line for the data points is shown by an orange dotted line.

[13] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[14] Data source: http://www.bom.gov.au/climate/data/



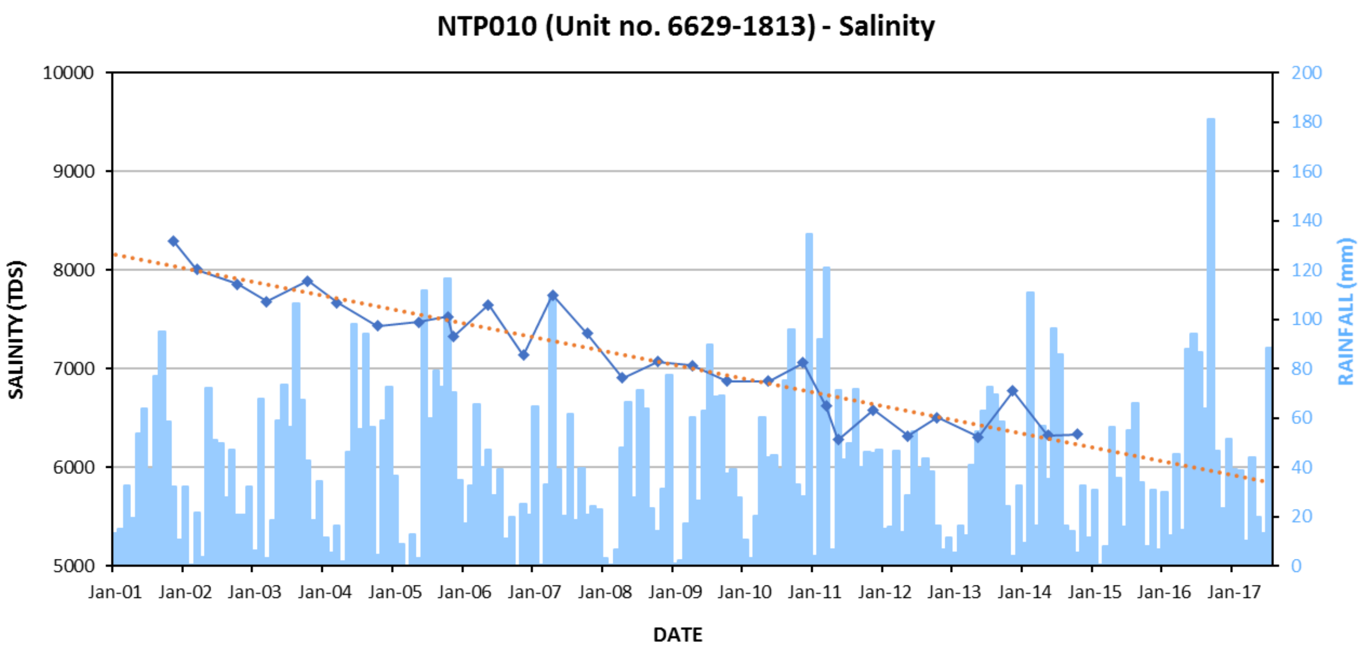


Figure 13. Depth to Water and Salinity for Observation Well NTP010 (Unit no. 6629-1813)[15]. Background rainfall is monthly total precipitation for Nuriootpa[16]. A trend line for the data points is shown by an orange dotted line.

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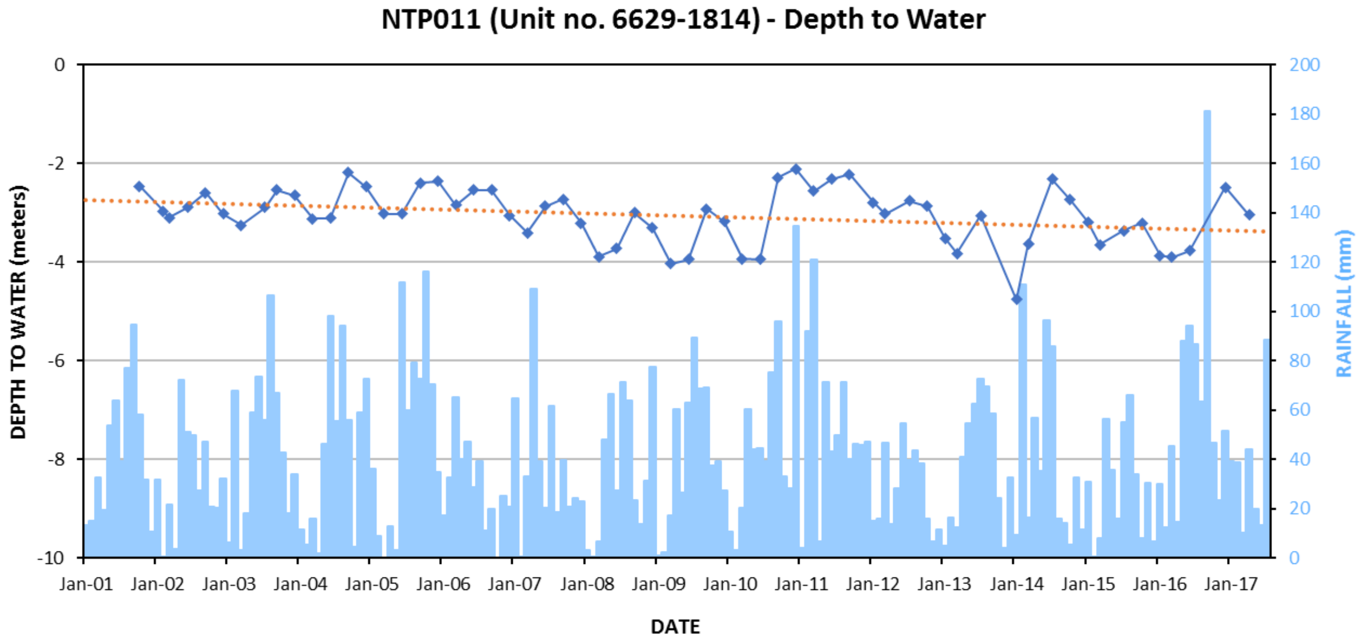
[15] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[16] Data source: http://www.bom.gov.au/climate/data/



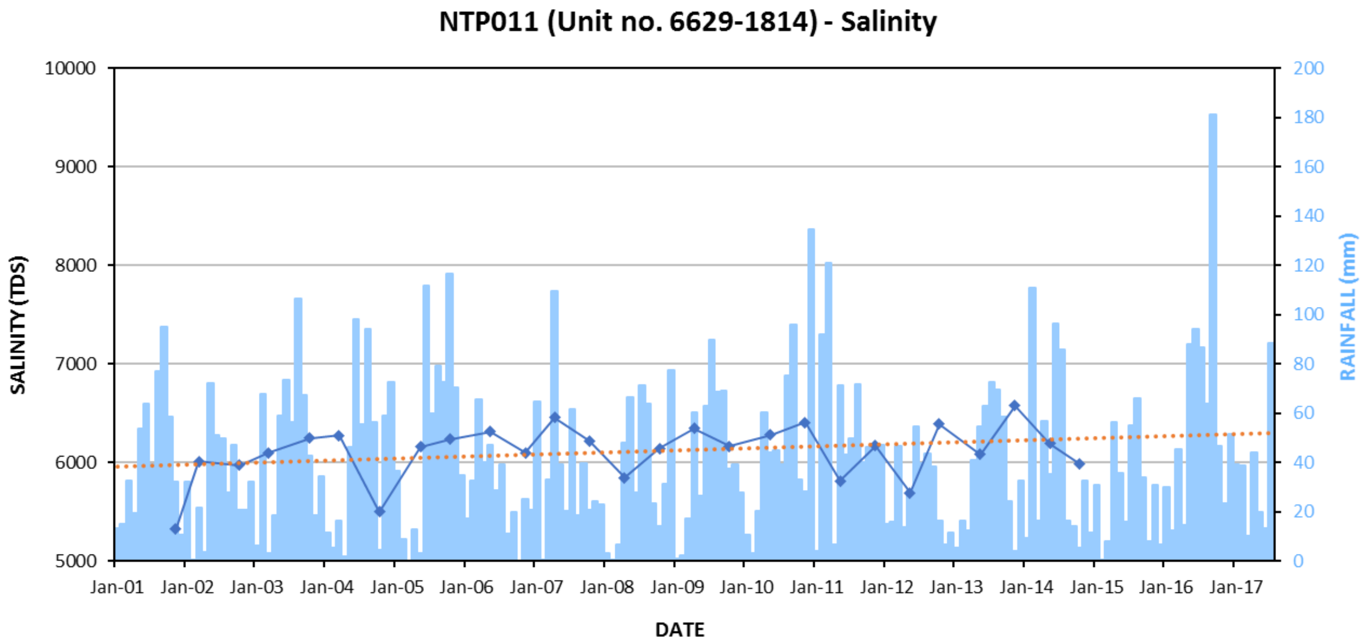
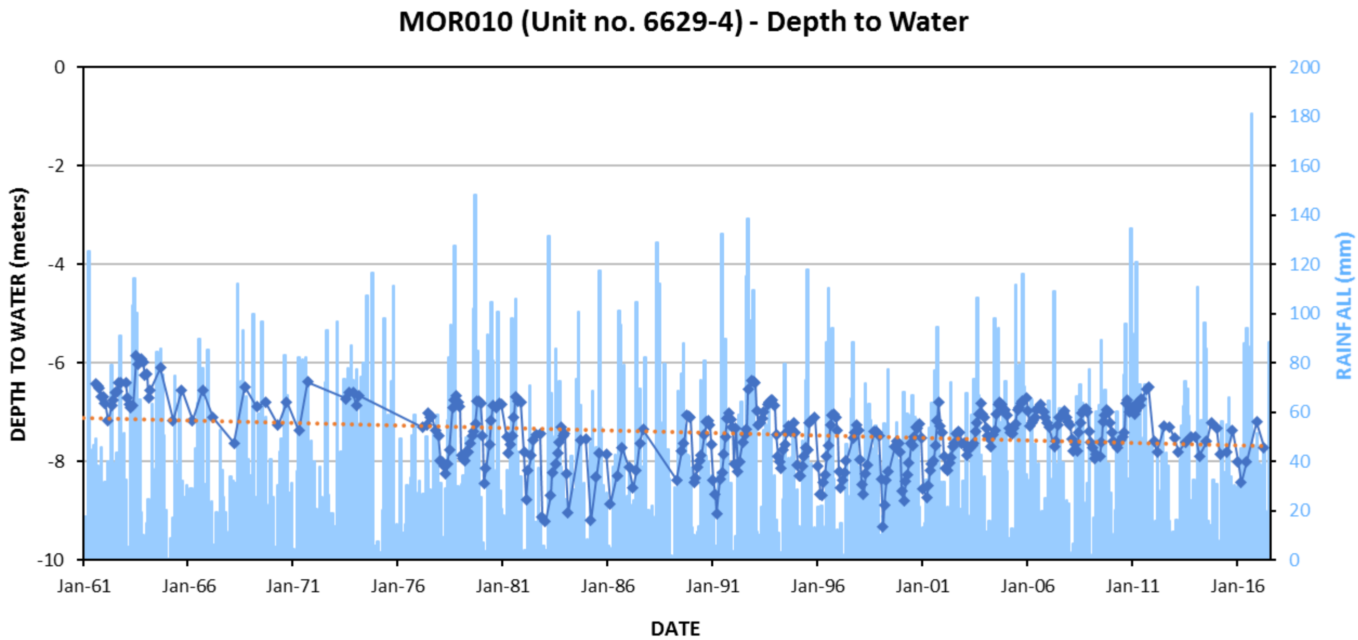


Figure 14. Depth to Water and Salinity for Observation Well NTP011 (Unit no. 6629-1814)[17]. Background rainfall is monthly total precipitation for Nuriootpa[18]. A trend line for the data points is shown by an orange dotted line.

[17] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[18] Data source: http://www.bom.gov.au/climate/data/



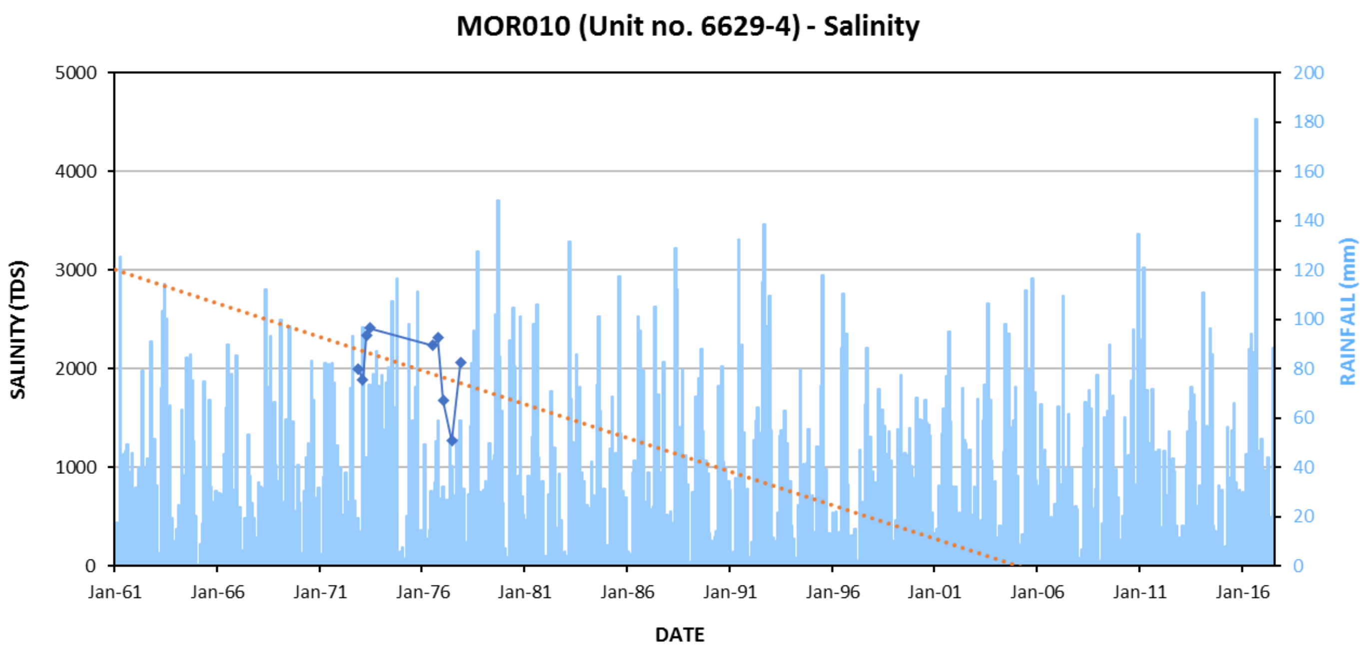
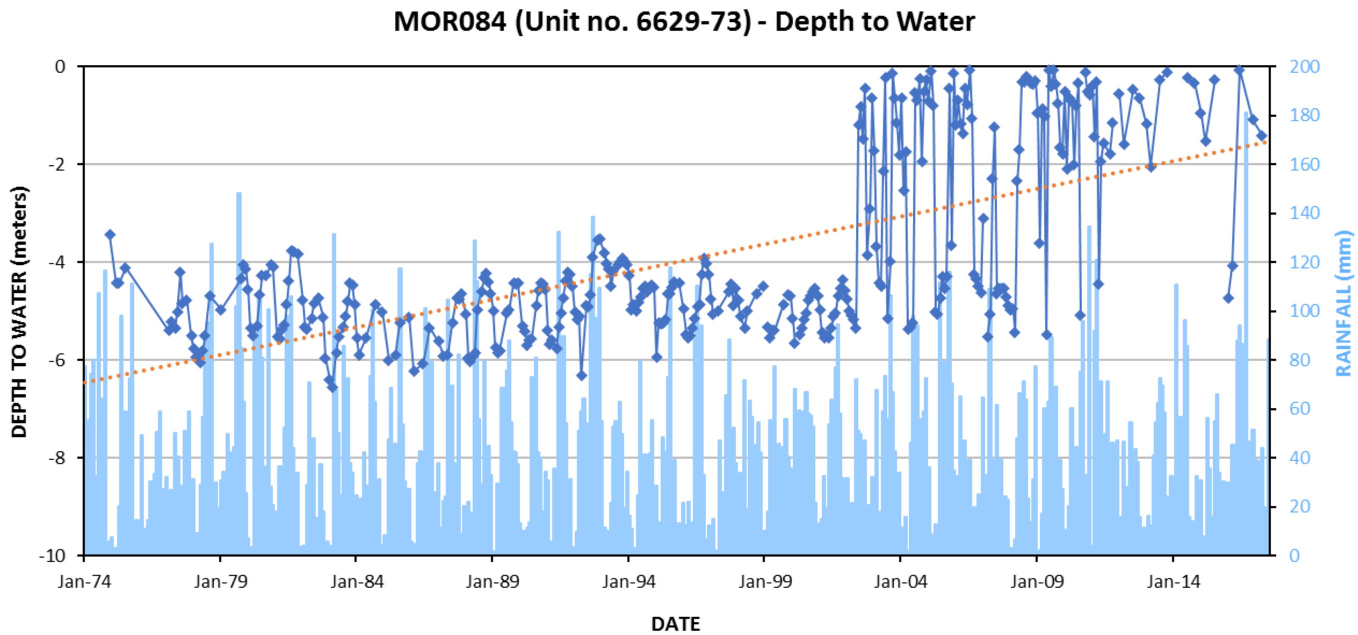


Figure 15. Depth to Water and Salinity for Observation Well MOR010 (Unit no. 6629-4)[19]. Background rainfall is monthly total precipitation for Nuriootpa[20]. A trend line for the data points is shown by an orange dotted line.

[19] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[20] Data source: http://www.bom.gov.au/climate/data/



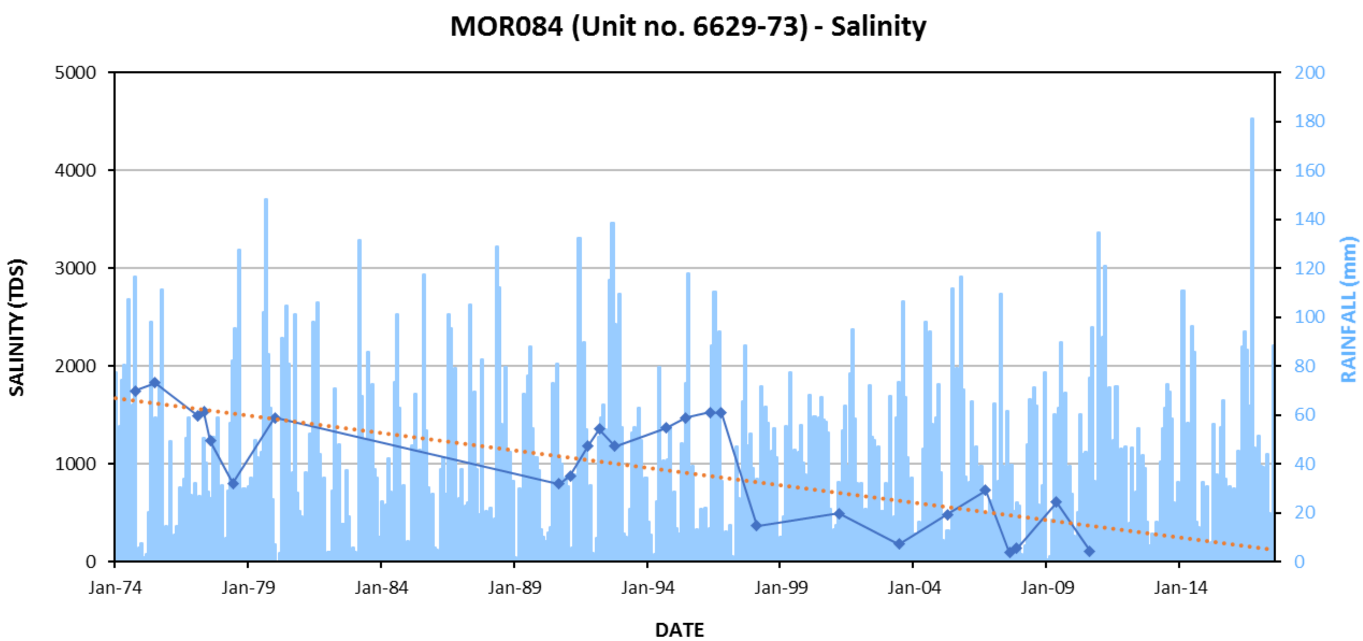


Figure 16. Depth to Water and Salinity for Observation Well MOR084 (Unit no. 6629-73)[21]. Background rainfall is monthly total precipitation for Nuriootpa[22]. A trend line for the data points is shown by an orange dotted line.

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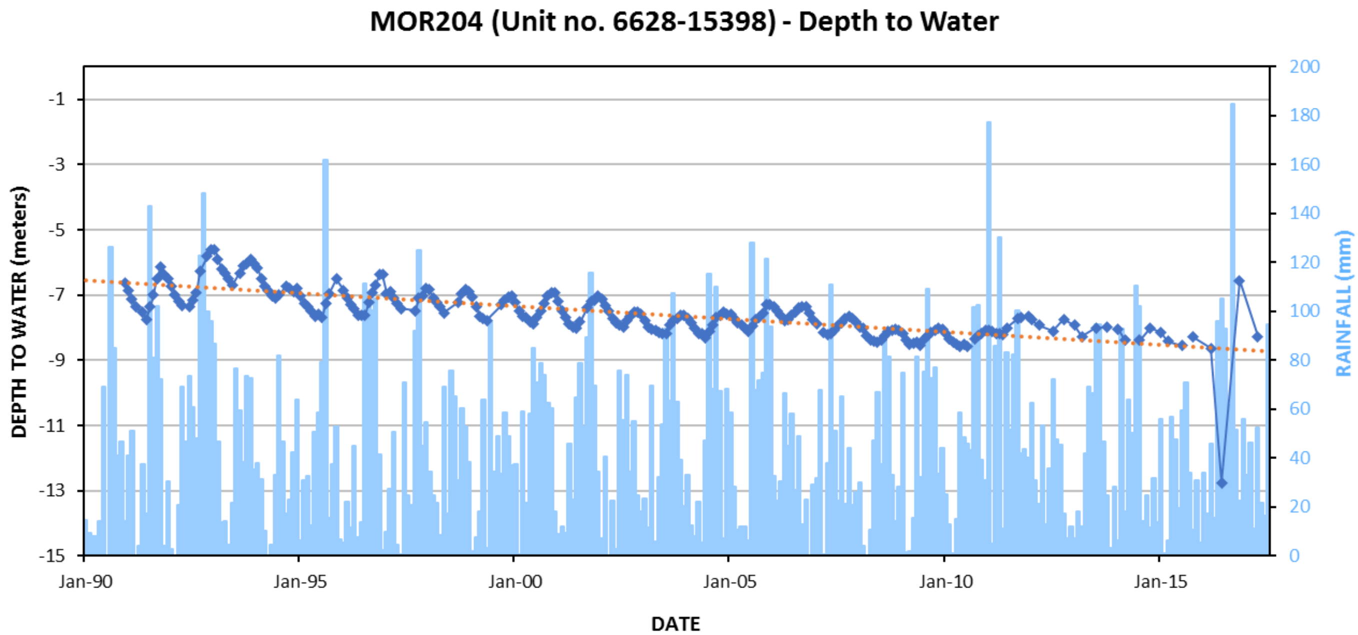
[21] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[22] Data source: http://www.bom.gov.au/climate/data/



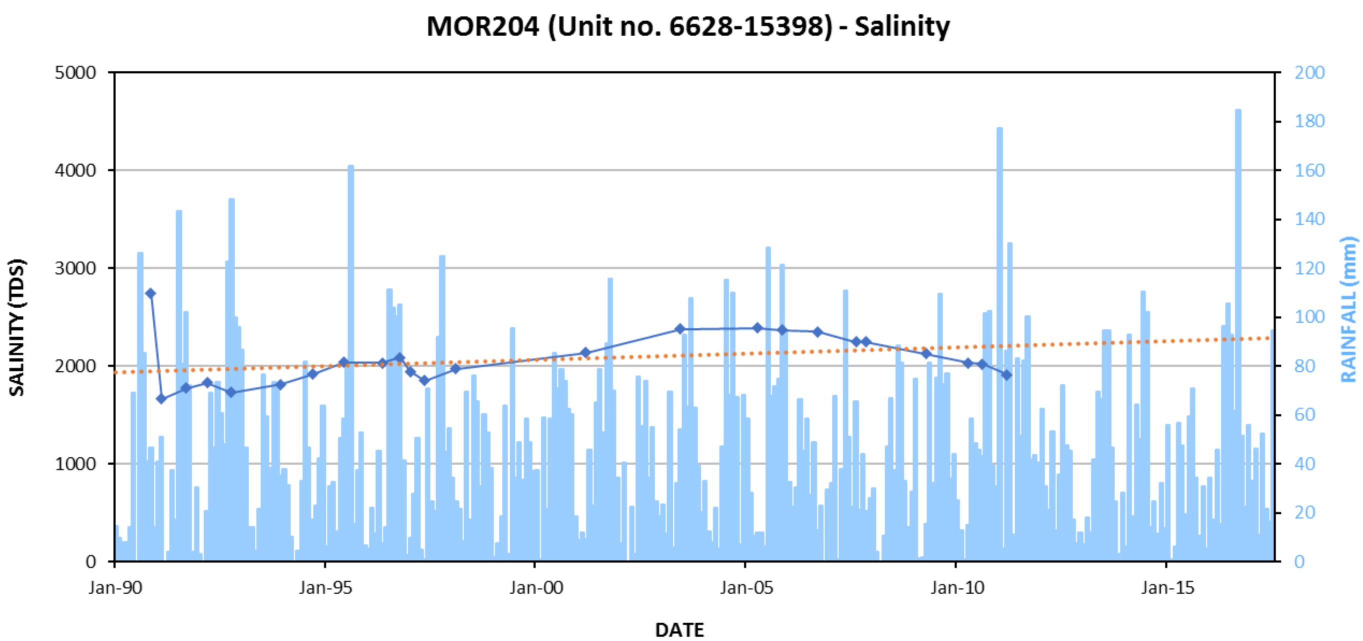
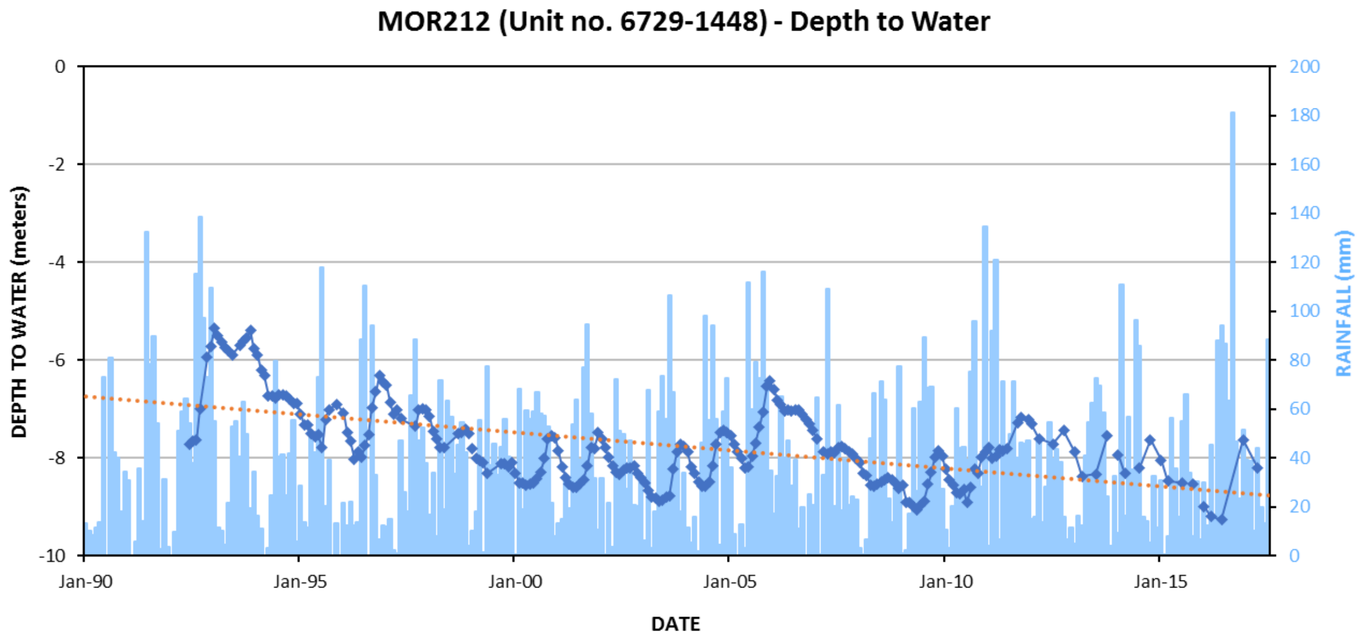


Figure 17. Depth to Water and Salinity for Observation Well MOR204 (Unit no. 6628-15398)[23]. Background rainfall is monthly total precipitation for Tanunda[24]. A trend line for the data points is shown by an orange dotted line.

[23] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[24] Data source: http://www.bom.gov.au/climate/data/



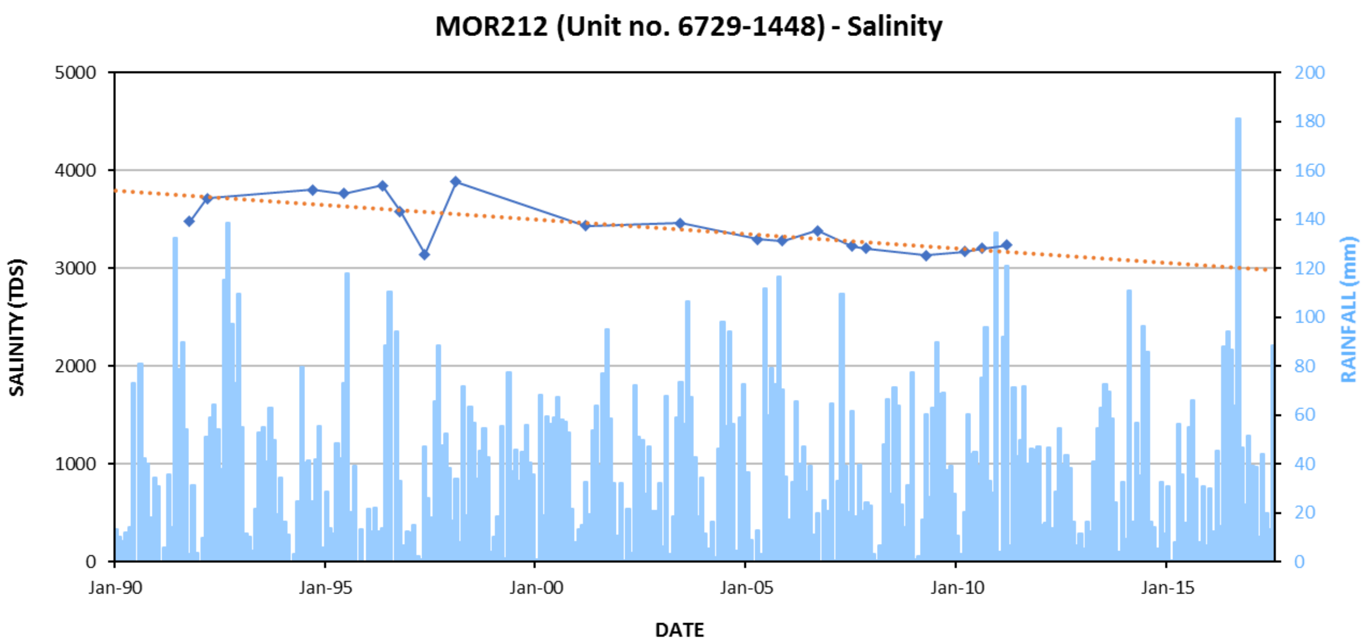


Figure 18. Depth to Water and Salinity for Observation Well MOR212 (Unit no. 6729-1448)[25]. Background rainfall is monthly total precipitation for Nuriootpa[26]. A trend line for the data points is shown by an orange dotted line.

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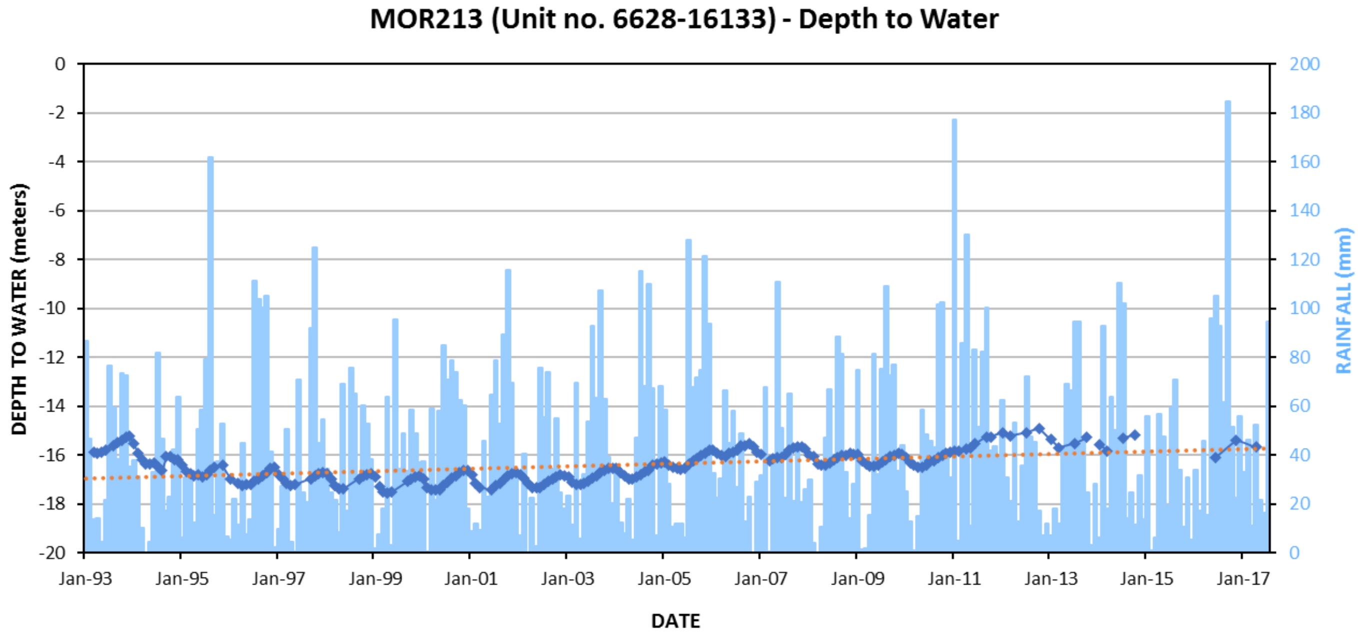
[25] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[26] Data source: http://www.bom.gov.au/climate/data/



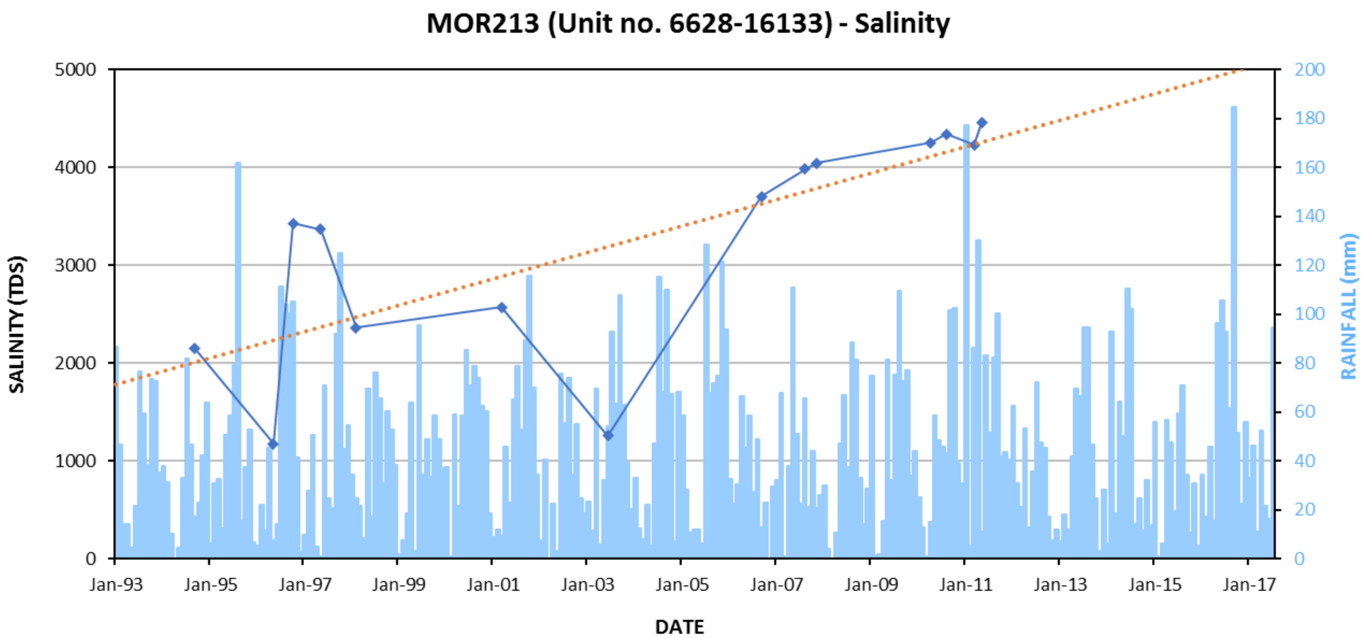


Figure 19. Depth to Water and Salinity for Observation Well MOR213 (Unit no. 6628-16133)[27]. Background rainfall is monthly total precipitation for Tanunda[28]. A trend line for the data points is shown by an orange dotted line.

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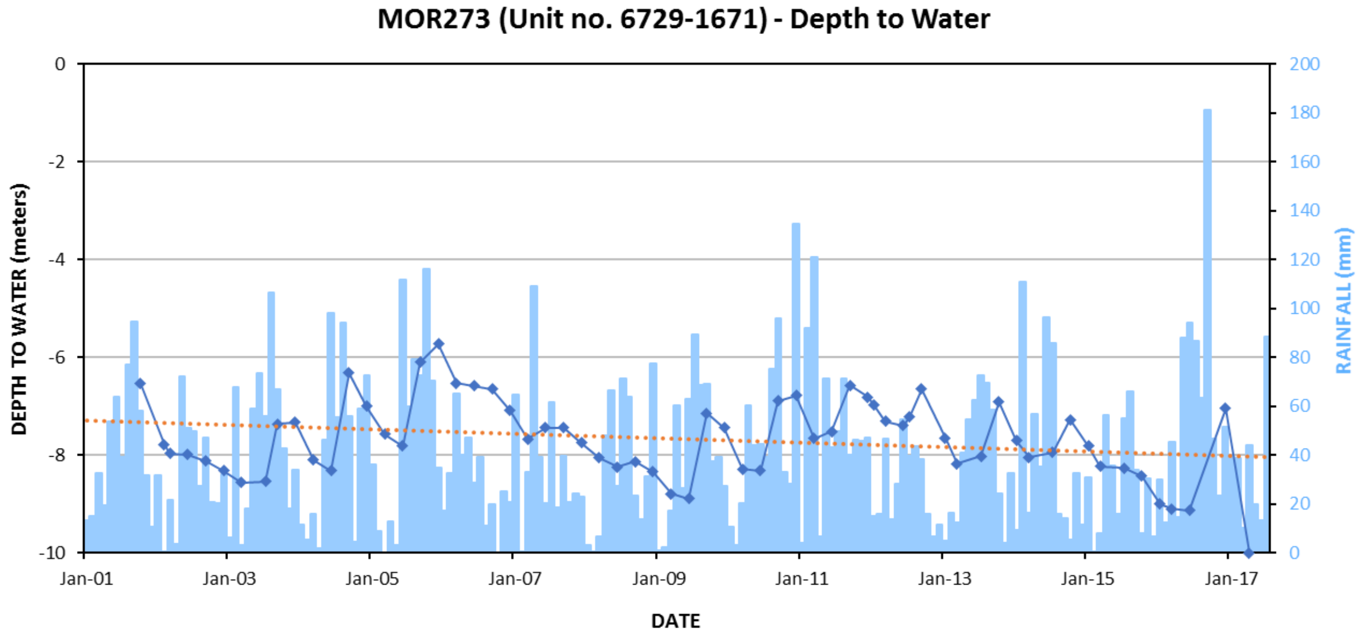
[27] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[28] Data source: http://www.bom.gov.au/climate/data/



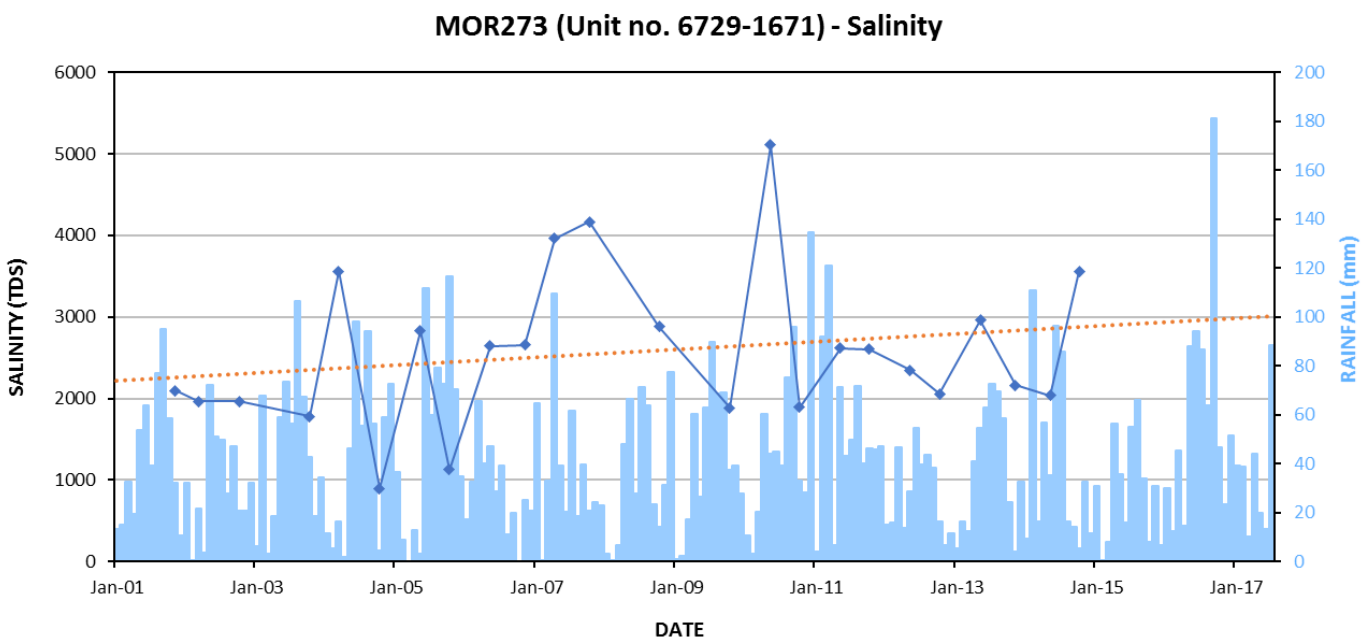
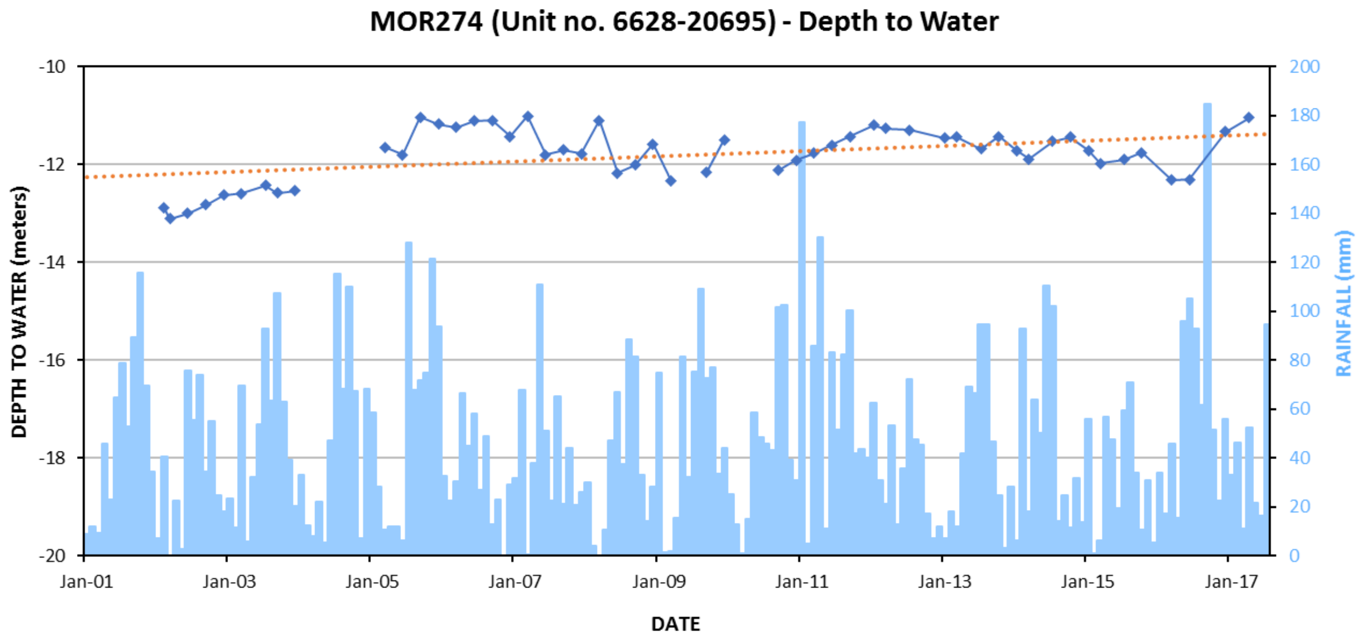


Figure 20. Depth to Water and Salinity for Observation Well MOR273 (Unit no. 6729-1671)[29]. Background rainfall is monthly total precipitation for Nuriootpa[30]. A trend line for the data points is shown by an orange dotted line.

[29] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[30] Data source: http://www.bom.gov.au/climate/data/



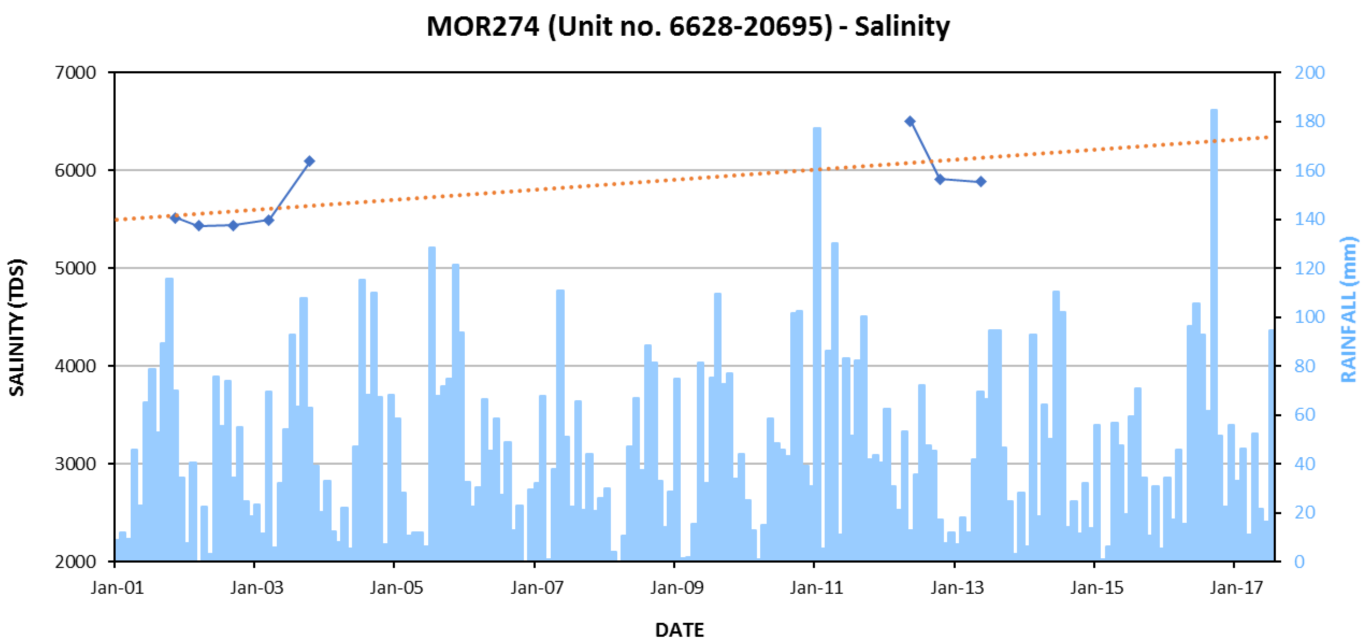


Figure 21. Depth to Water and Salinity for Observation Well MOR274 (Unit no. 6628-20695)[31]. Background rainfall is monthly total precipitation for Tanunda[32]. A trend line for the data points is shown by an orange dotted line.

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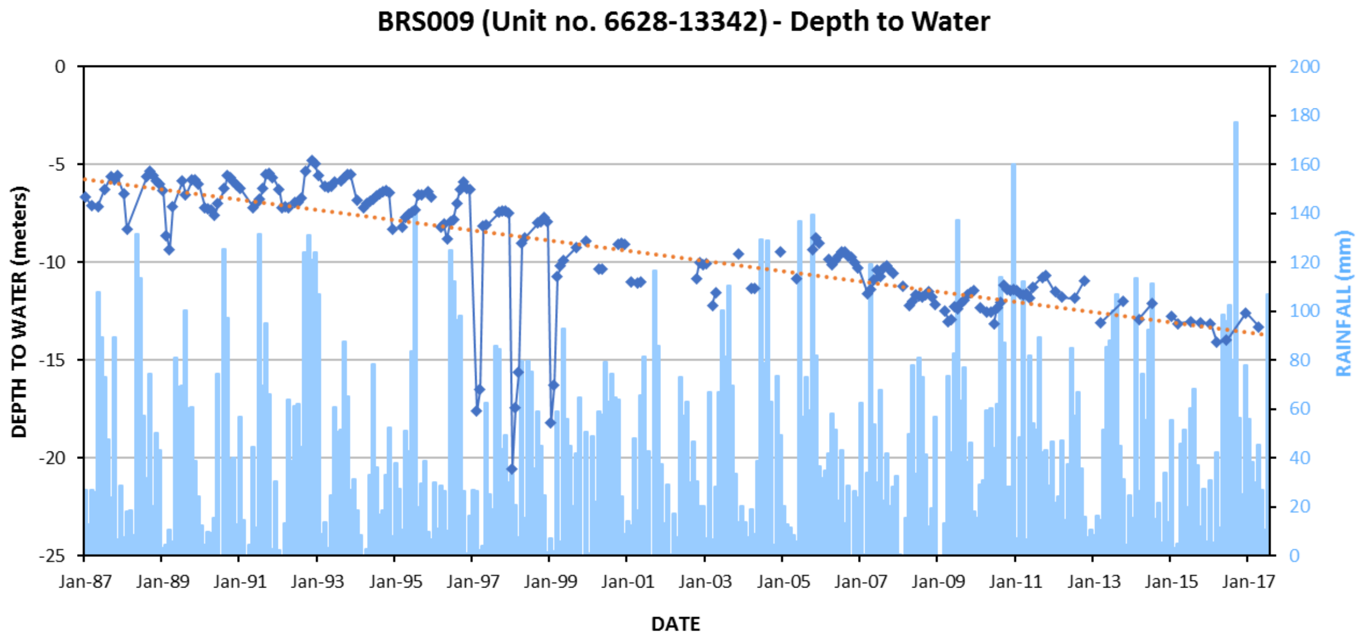
[31] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[32] Data source: http://www.bom.gov.au/climate/data/



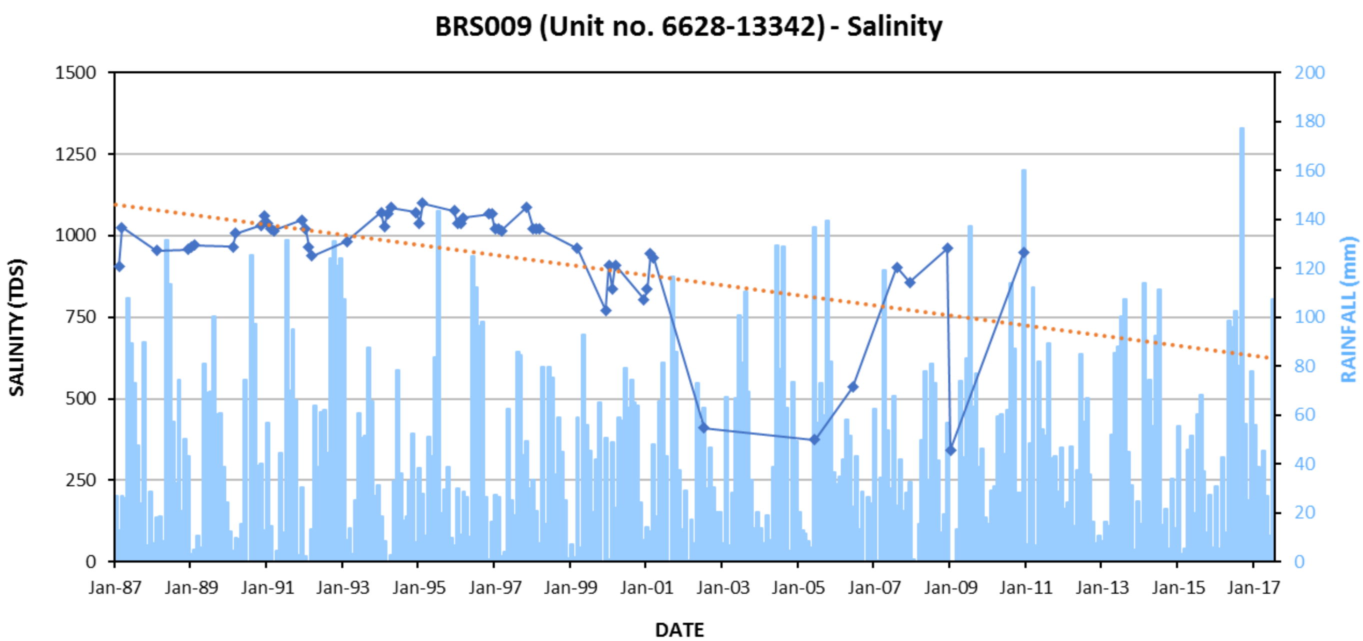


Figure 22. Depth to Water and Salinity for Observation Well BRS009 (Unit no. 6628-13342)[33]. Background rainfall is monthly total precipitation for Lyndoch[34]. A trend line for the data points is shown by an orange dotted line.

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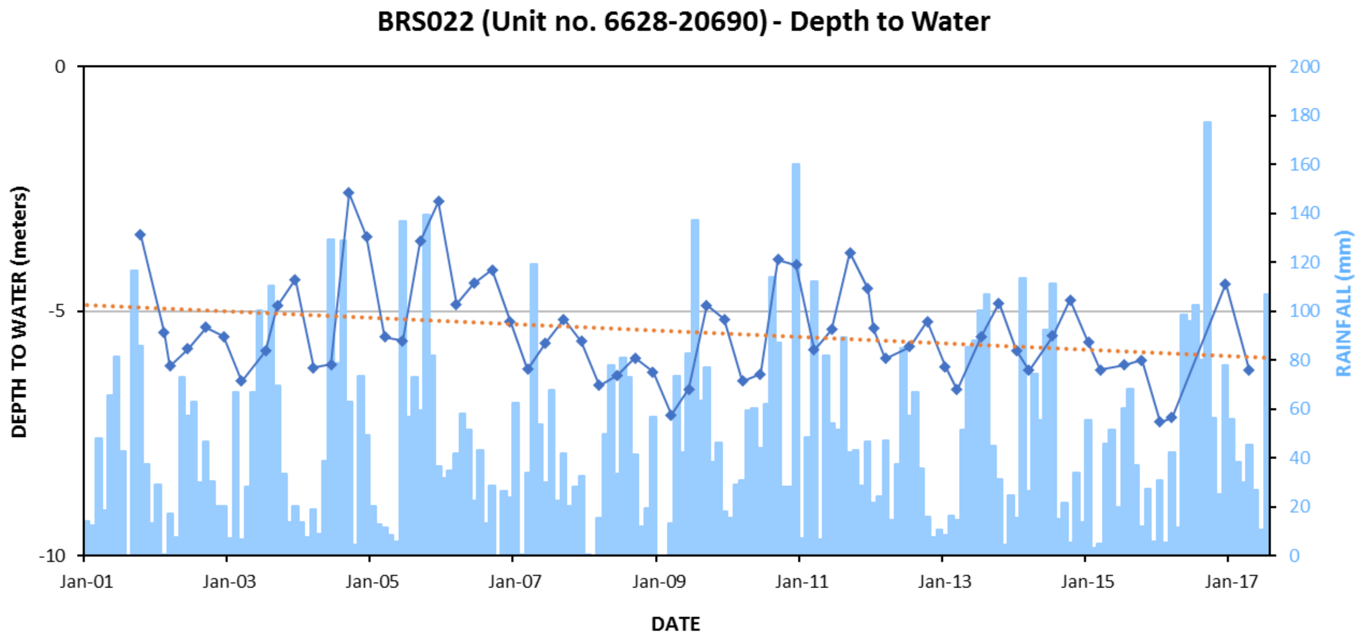
33 Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
34 Data source: http://www.bom.gov.au/climate/data/



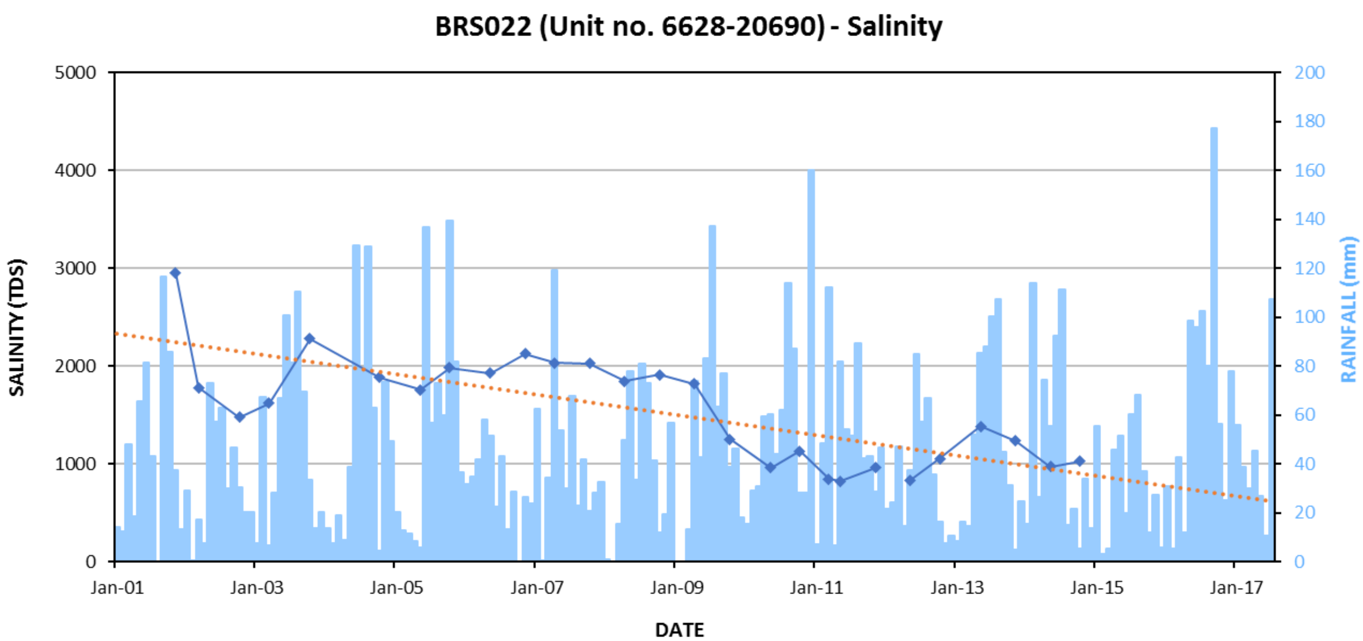
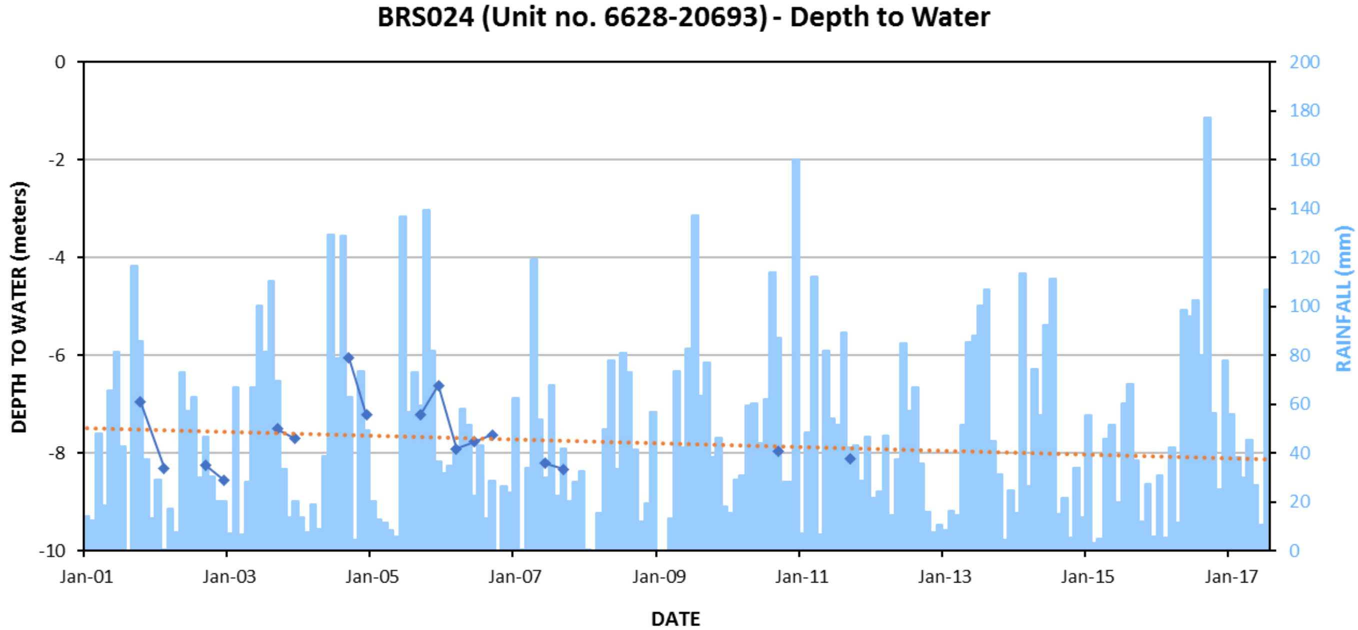


Figure 23. Depth to Water and Salinity for Observation Well BRS022 (Unit no. 6628-20690)[35]. Background rainfall is monthly total precipitation for Lyndoch[36]. A trend line for the data points is shown by an orange dotted line.

[35] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[36] Data source: http://www.bom.gov.au/climate/data/



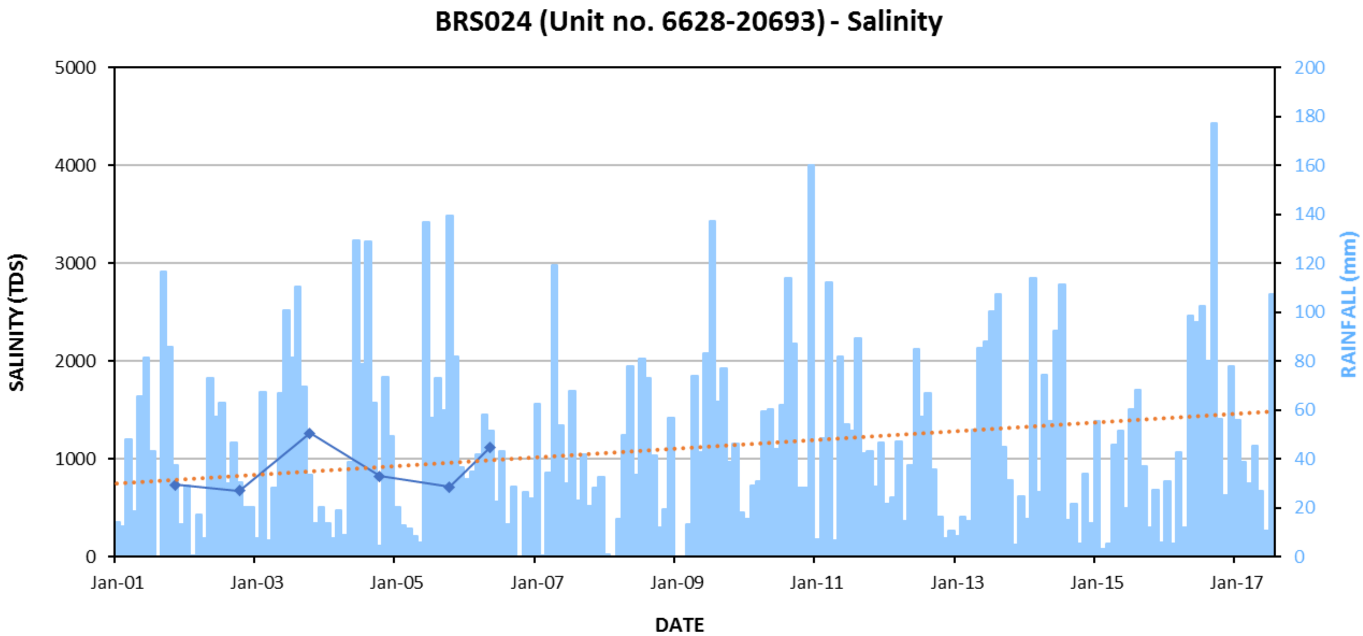
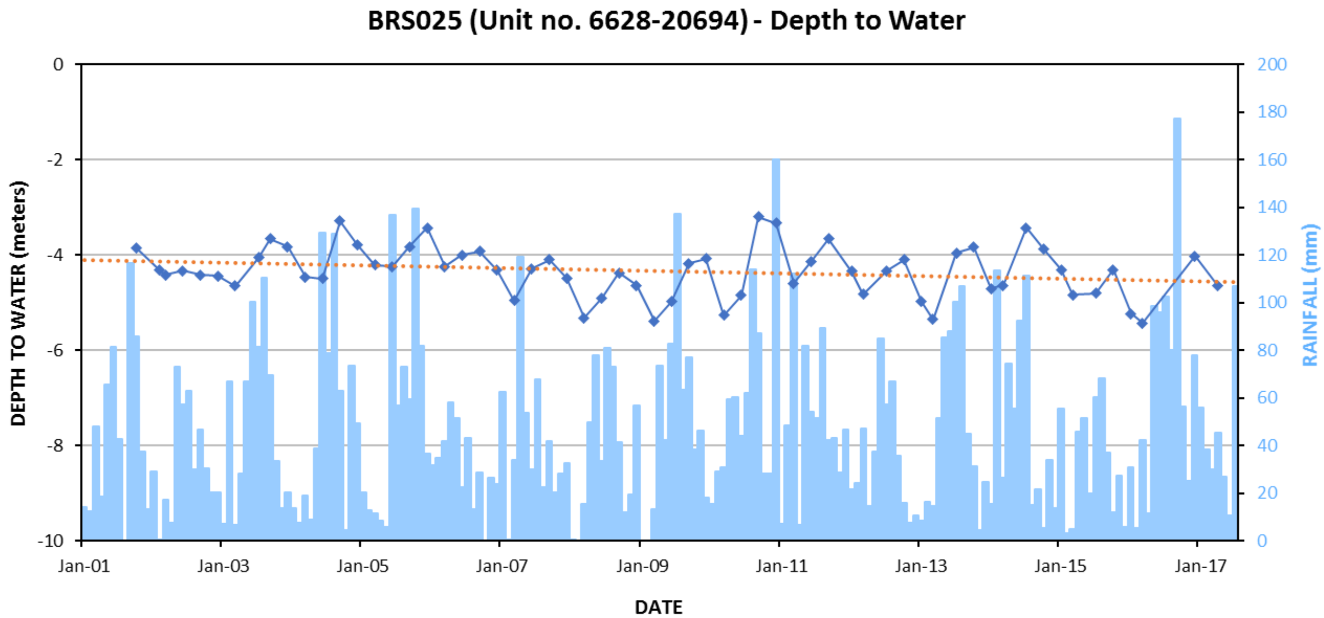


Figure 24. Depth to Water and Salinity for Observation Well BRS024 (Unit no. 6628-20693)[37]. Background rainfall is monthly total precipitation for Lyndoch[38]. A trend line for the data points is shown by an orange dotted line.

[37] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[38] Data source: http://www.bom.gov.au/climate/data/



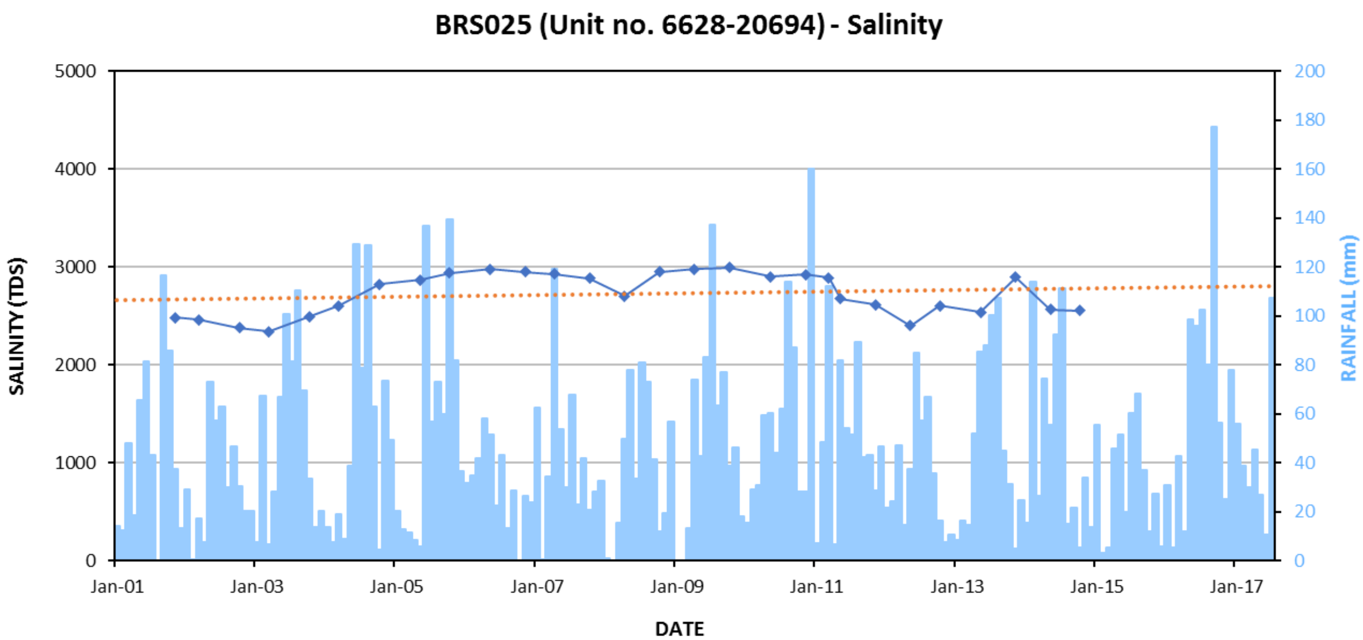


Figure 25. Depth to Water and Salinity for Observation Well BRS025 (Unit no. 6628-20694)[39]. Background rainfall is monthly total precipitation for Lyndoch[40]. A trend line for the data points is shown by an orange dotted line.

[39] Data source: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Default.aspx
[40] Data source: http://www.bom.gov.au/climate/data/