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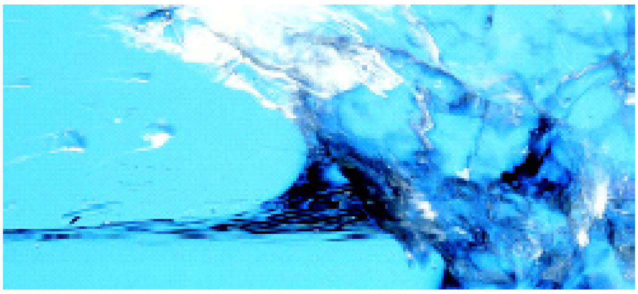

The hydrogeology of the Barossa Basin, South Australia

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Report DWLBC 2002/18

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of South Australia

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Foreword

South Australia's natural resources are fundamental to the economic and social well-being of the State. One of the State's most precious natural resources, water is a basic requirement of all living organisms and is one of the essential elements ensuring biological diversity of life at all levels. In pristine or undeveloped situations, the condition of water resources reflects the equilibrium between, rainfall, vegetation and other physical parameters. Development of these resources changes the natural balance and may cause degradation. If degradation is small, and the resource retains its utility, the community may assess these changes as being acceptable. However, significant stress will impact on the ability of the resource to continue to meet the needs of users and the environment. Understanding the cause and effect relationship between the various stresses imposed on the natural resources is paramount to developing effective management strategies. Reports of investigations into the availability and quality of water supplies throughout the State aim to build upon the existing knowledge base enabling the community to make informed decisions concerning the future management of the natural resources thus ensuring conservation of biological diversity.

Bryan Harris
Director, Knowledge and Information Division
Department of Water, Land and Biodiversity Conservation

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SI UNITS COMMONLY USED WITHIN TEXT

Name of unit	Symbol	Definition in terms of other metric units	
Millimetre	mm	10^{-3} m	length
Metre	m		length
Kilometre	km	10^{3} m	length
Hectare	ha	10^{4} m^{2}	area
Microlitre	µL	10^{-9} m^{3}	volume
Millilitre	mL	10^{-6} m^{3}	volume
Litre	L	10^{-3} m^{3}	volume
Kilolitre	kL	1 m^{3}	volume
Megalitre	ML	10^{3} m^{3}	volume
Gigalitres	GL	10^{6} m^{3}	volume
Microgram	µg	10^{-6} g	mass
Milligram	mg	10^{-3} g	mass
Milligrams per litre	mg/L		
Gram	g		mass
Kilogram	kg	10^{3} g	Mass

Abbreviations Commonly Used Within Text

Abbreviation		Name	Units of measure
AHD	=	Australian height datum	
BIL	=	Barossa Infrastructure Limited	
BS	=	basal sands	
DWLBC	=	Department of Water, Land and Biodiversity Conservation	
FR	=	fractured rock	
Ma	=	million years before present	
MA	=	middle aquifer	
MCA	=	middle carbonaceous aquifer	
SWL	=	standing water level	
sst	=	sandstone	
TDS	=	Total Dissolved Solids *(milligrams per litre)*	mg/L
UG	=	upper gravels	
WT	=	watertable	
EC	=	Electrical Conductivity *(micro Siemens per centimetre)*	µS/cm
PH	=	Acidity	
δD	=	Hydrogen isotope composition	$^{o}/_{oo}$
CFC	=	Chlorofluorocarbon *(parts per trillion volume)*	pptv
$\delta^{18}O$	=	Oxygen isotope composition	$^{o}/_{oo}$
^{14}C	=	Carbon-14 isotope *(percent modern Carbon)*	pmC
Ppm	=	Parts per million	
Ppb	=	Parts per billion	

ABSTRACT

The Barossa Basin is a complex hydrogeological environment containing a sedimentary aquifer system surrounded and underlain by a dual porosity fractured rock aquifer. The hydraulic relationship between the fractured rock aquifer and the sedimentary aquifers is poorly understood.

The difficulties in describing the movement of groundwater through dual porosity media such as a fractured rock aquifer are well documented. While groundwater flow in the sedimentary aquifers can be adequately described using porous media flow techniques in the Barossa Basin, our understanding of interconnectivity between individual sedimentary aquifers is again poor.

The Basin itself is narrow and, immediately adjacent to the Stockwell Fault on the eastern side of the valley, relatively deep (~200 m). Sediments deposited into the trough consisted of mainly discontinuous sequences of overlapping sands and carbonaceous clays. This was followed by the deposition of gravels, sands and clays that form the Barossa Valley as it is today. Various authors have sub-divided the geology into individual hydrostratigraphical units. However, a review of the literature highlighted inconsistencies in the number of aquifers recognised, their exact spatial distribution within the Basin, and that there have been changes in nomenclature that are not satisfactorily described. This has resulted in some confusion that requires clarification.

This study presents the results of an assessment into the hydrogeology of the Barossa Basin. Geological, geophysical and hydrogeological information using more than 130 wells have been used in the reinterpretation. It is recommended, due to the complexity of the hydrogeological environment and our limited understanding of it, that the hydrogeology of the Barossa Basin be simplified to an Upper, Lower and Fractured Rock Aquifer system. By adopting this new classification system it is hoped that the underground water resources can be managed more effectively than at present.

A seasonal change in hydraulic head of up to 50 m observed in the confined Lower Aquifer is believed to be a result of the relatively small size of the aquifer coupled with a discharge boundary effect as the drawdown cone intersects the surrounding Fractured Rock Aquifer. This may also be causing a negative effect on water levels in those wells located in the Fractured Rock Aquifer immediately adjacent to the confined Lower Aquifer system.

1 INTRODUCTION

Located approximately 100 km north of South Australia's state capital Adelaide is the Barossa Valley, one of Australia's best-known wine producing areas (Fig. 1). The Valley is a small north–south trending sedimentary basin ~30 km long, and 6 km wide. In geological terms the valley is referred to as the Barossa Basin. It was formed during the early part of the Cainozoic Era (65 Ma), probably as a result of rifting associated with the break up of Gondwanaland and has subsequently in-filled with non-marine Late Tertiary and Quaternary sediments up to ~200 m in thickness.

To the east of the sedimentary plain is the Barossa Range part of the Mount Lofty Ranges. The Range rises steeply above the valley floor to an elevation of ~500 m above sea level. The Valley floor itself is a relatively low-lying plain that slopes gently from the Range towards the North Para River in the west and down to Gawler in the south. The landscape on the plain is dominated by the numerous vineyards and wineries that make the area famous around the world. A favourable climate, good soils along with the availability of good quality groundwater make the Barossa Valley one of Australia's most famous premium wine-producing areas.

Grapevines were first introduced into the valley in the late 1830s. The first vines were established in the thick sequences of alluvial gravel laid down beside the small number of ephemeral creeks that traverse the plain. The relatively shallow depth to the watertable beneath the gravels allowed the vine roots to tap directly into the underlying aquifer. Since then there have been significant advances in the drilling of water wells and in pump technology, which provide irrigators access to the underground water resources over much of the Valley. The ability to easily extract the groundwater, particularly from deeper aquifers within the basin has led to the expansion of vineyards over most of the plain. Today there are ~6500 ha of grape vines in the Barossa Valley of which nearly 5000 ha are irrigated.

The first major investigation into the water resources of the Barossa Valley was undertaken by Chugg (1955), who at the outset recognised the complexity of the hydrological system and the difficulty in describing it. Subsequent authors have also recognised this complexity, particularly the conceptualisation of inter-aquifer flow beneath the Basin. Cobb (1986) provided probably the most comprehensive hydrogeological study of the area. It is the hydrostratigraphical interpretation from his study that most subsequent authors working in the area have used for their hydrogeological reporting. Later studies including Sibenaler et al. (1987), Sibenaler (1991), Howles (1992), Pugh (1993, 1996), Morton et al. (1998) and Gill (2000) all describe the hydrostratigraphy but none were specifically looking at the hydrogeology. Table 1 shows the aquifer classifications as adopted by the above authors. It is evident from the table that while all use a similar hydrostratigraphical nomenclature, there are some differences. There are also differences in the number of aquifers recognised and it is not clear in some cases the reasons for the subdivision of the hydrostratigraphic units. This lack of consistency, coupled with poor description in some cases, has created confusion as to the correct hydrostratigraphical classification for the area.

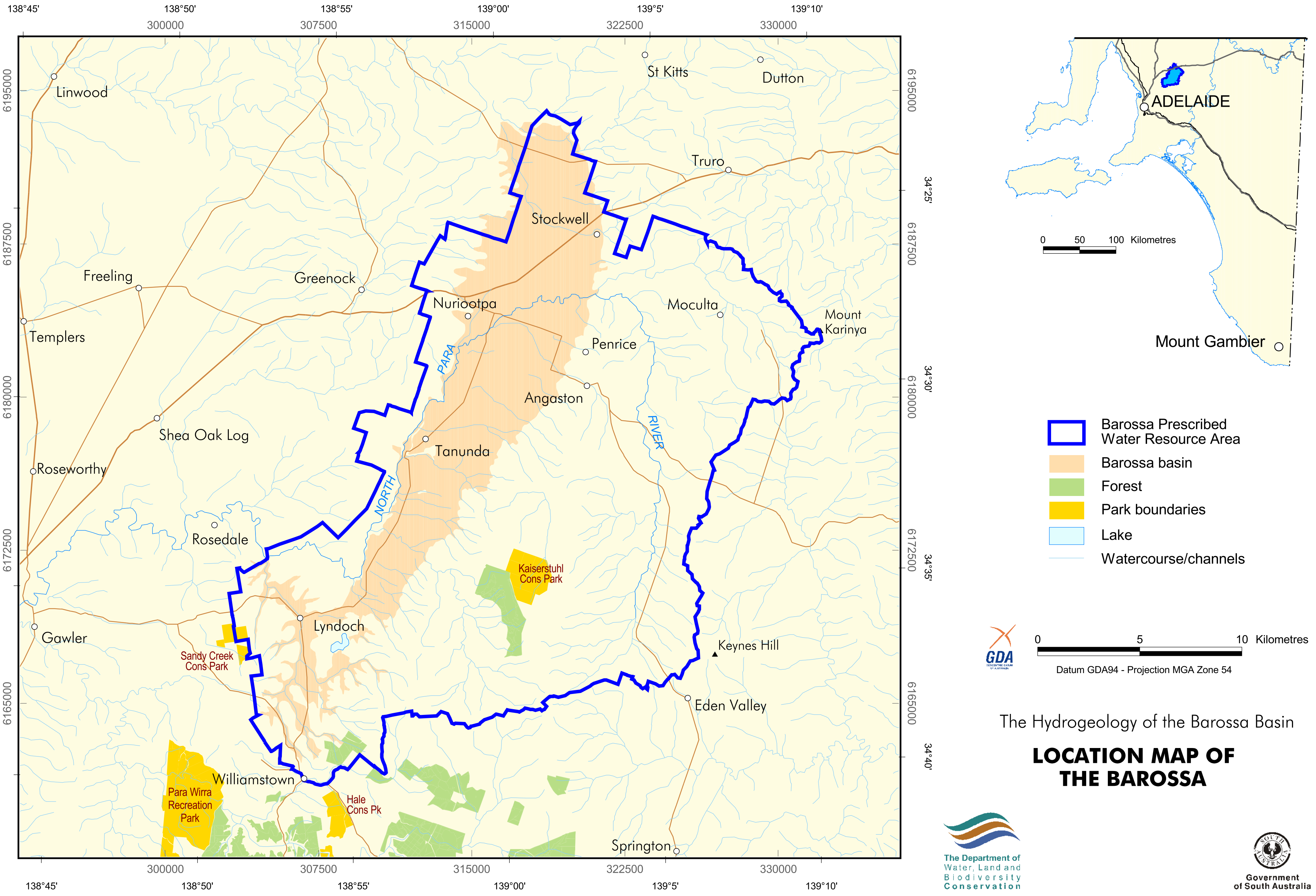

Figure 1

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The introduction of farm dams into the highlands areas coupled with utilisation of off-peak reticulated SA Water and water piped in from the Murray River – Warren Reservoir water under the Barossa Infrastructure Limited (BIL) scheme, all have the potential to impact on the groundwater resources of the region. It is important that there is a clear understanding of the underground water resources so that any changes to the hydrogeological environment, like the introduction of external water sources, can be assessed accurately.

To clarify any confusion, a comprehensive review of the hydrogeology of the Barossa Basin was undertaken incorporating all available information. Geological, geophysical, stratigraphical bore log data and the latest hydraulic information were used to formulate a new hydrogeological framework for the Barossa Basin and this is presented in this report. As part of the assessment, a review of the current groundwater monitoring network was undertaken.

2 GEOLOGY

Chugg (1955) and Cobb (1986), both give good overviews in their respective hydrogeological investigations of the Pre-Cambrian and Paleozoic geology of the area. The latter report in particular discusses the conceptual models describing the evolution of the Barossa Basin. Since the initial Chugg (1955) study there have been a large number of wells drilled in the Basin and the information obtained from the wells has given a much greater insight as to the sub-surface geology of the area. In particular it enables correlation between wells and the ability to define the Basin stratigraphy far more accurately than previously possible. Alley (1995) has further developed our understanding of the geological evolution of the Basin, particularly in determining the age of the Tertiary sedimentary units.

The oldest geological formations in the Barossa Basin are predominantly metasediments, consisting mainly of indurated and metamorphosed siltstone (dolomitic), shales and marble of the Precambrian and Palaeozoic Eras.

The Barossa Basin itself was formed during a period of tectonism during the early Cainozoic Era (65 Ma). Activation of the predominantly north–south -trending Stockwell Fault resulted in uplift on the eastern side of the fault, and subsidence on the western side, forming a north–south -trending trough or fault angle depression (Cobb, 1986) into which the younger sediments were subsequently deposited.

Thick alternating sequences of quartz sands (that generally coarsen with depth) and carbonaceous (lignitic) clays were deposited into the depression. While it is not certain the sediments are believed to be deposited between the Early Oligocene to Early Miocene; deposition probably occurred at the end of the Oligocene (Fig. 2; Alley, 1995).

The sedimentary environment at the time the sediments were deposited into the narrow Basin is considered to be estuarine (Chugg, 1955) or fluviolacustrine (Cobb, 1986). The presence of only terrestrial sediments and the lack of marine sediments suggest that the Basin was isolated from the sea for most of the Cainozoic Era. Typically these environments resulted in the deposition of discontinuous lenticular (convex lens) shaped layers and because of the way they were deposited, the sands and clays continually overlap each other. Even with the large number of wells used in this study (>130 wells) it was not possible to correlate individual sand and clay units, which can be attributed to the way the sediments were deposited into the Basin (App. A).

However, a positive outcome of this study was that the uppermost carbonaceous clay unit appears to be ubiquitous over the eastern margin in the deepest part of the trough and therefore mappable.

Generally overlying the undifferentiated sands and carbonaceous clays are non-carbonaceous quartz sands, probably a continuation of the Tertiary sands that outcrop on the western side of the North Para River. These sediments are considered to be derived and resulted from further uplift along the Stockwell Fault in the Late Miocene (Cobb, 1986). Alley (1995) has tentatively determined the age of the sediments as latter stages of Early to Late Miocene perid. Geologically the carbonaceous and non-carbonaceous sand units are undifferentiated and are collectively referred to as the Rowland Flat Sand (Alley, 1995).

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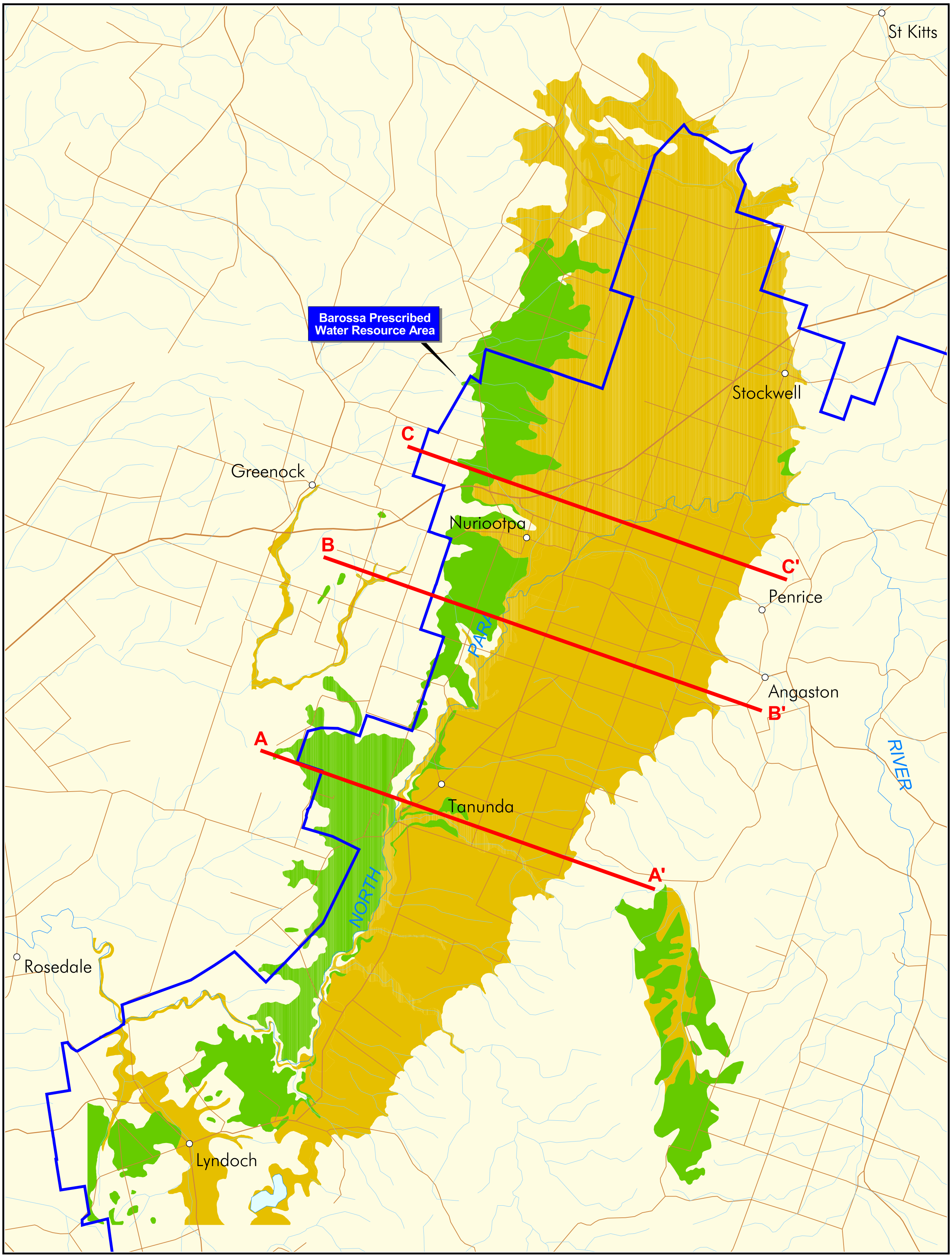
The Hydrogeology of the Barossa Basin

GEOLOGICAL MAP OF THE BAROSSA VALLEY REGION



0 2 4 6 Kilometres

Datum GDA94 - Projection MGA Zone 54

Barossa Prescribed Water Resource Area

Lake

Watercourse/channels

Geology

- Quaternary sediments
- Tertiary sediments
- Basement outcrop

Figure 2

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Overlying the non-carbonaceous sands in areas east of the North Para River are Quaternary outwash sediments consisting of red-brown clays (equivalent to the Pooraka Formation as observed on the Adelaide Plains). Contained within the clay are discontinuous lenses of gravel and sand. During the Holocene (last 10 000 years) ephemeral creeks have formed. The creeks generally traverse the plain in a westerly direction and have cut down into the clays and deposited the alluvial gravel sequences. Table 2 shows the new hydrostratigrahical classification in context with the geology and groundwater hydraulic information of the Basin.

Table 1. Barossa Basin historical hydrostratigraphy classifications

Chugg (1955)	Herramman (1976)	Cobb (1986)	Sibenaler et al. (1987)	Sibenaler (1991)	Howles (1992)	Pugh (1993)	Pugh (1996)	Morton et al. (1998)	Gill (2000)
Basin sediments	Watertable	Watertable	Unconfined–watertable	Watertable	Watertable	–	Watertable	Watertable	Watertable
Shallow alluvium over Adelaide system	–	Upper	Upper gravels	Upper gravels	Upper gravel	–	Upper gravel	Upper gravels	–
Quartz-rich Tertiary	Middle	Middle	Middle	Upper sands (middle)	Middle	Middle	Middle (non-carbonaceous)	–	Middle
–	–	–	–	–	Middle carbonaceous	Middle carbonaceous	Middle carbonaceous	Middle carbonaceous	Middle carbonaceous
	Basal	Lower	Basal	Basal	Basal	Basal	Basal	Basal	Basal
Adelaide system–	Hard rock	Hard rock	Hard rock	Hard rock	Hard rock	Hard rock	Hard rock	Hard rock	Hard rock

Table 2. Barossa Basin stratigraphic and hydrostratigraphic units

Era	Epoch	Geological formation	Geological unit	Depositional environment	Hydrostratigraphic unit
Quaternary	Holocene	Undifferentiated Quaternary	Undifferentiated gravels, sands and silts	Creek beds	Upper Aquifer
	Pleistocene	Undifferentiated Quaternary	Mainly red clay with minor gravel lenses	Outwash sediments (red clay)	
Tertiary	late Early – Late Miocene	Rowland Flat Sand	Non-carbonaceous clays, gravels, sands and silts	Fluviolacustrine and alluvial fan	
	Early Oligocene – Early Miocene	Rowland Flat Sand	Carbonaceous clay	Fluviolacustrine and alluvial fan	Aquitard
	Late Oligocene	Rowland Flat Sand	Carbonaceous clay, gravels, sands and silt	Fluviolacustrine and alluvial fan	Lower Aquifer
Undifferentiated Proterozoic and Paleozoic		Various	Meta-sediments and minor intrusives	–	Fractured Rock Aquifer

3 HYDROGEOLOGY

Chugg (1955) was the first comprehensive study into the hydrology of the Barossa Valley. Following the completion of a comprehensive drilling program in the early 1980s Cobb (1986) further refined the hydrogeology of the area. Most hydrogeological studies undertaken after the Cobb investigation have tended to focus on specific water related issues rather than a further investigation of the hydrostratigraphy. Most adopted his system of classification, although as discussed earlier, there has been some refinement (Table 1). These earlier studies recognised up to six different aquifer systems in the Barossa Basin and is seen by the author as overly complicated, given the inability to correlate stratigraphic units even on a localised scale.

In this report a new hydrostratigraphical system is recommended, based on a three aquifer system consisting of a:

- Fractured Rock Aquifer
- Upper Aquifer
- Lower Aquifer.

The author emphasises that the new system does not negate the work of previous studies. The system is a further refinement based on the latest hydrogeological information. Factors considered in the development of new conceptual model included the influence the geological sedimentation process has had on the groundwater flow system, our limited understanding of the groundwater hydraulics and the degree of interconnectivity between these aquifers.

The three west-east cross-sections presented on Figure 3 represent the three aquifers in their regional context. Note also the steep angle of the fault scarp, and the asymmetric shape and relative narrowness of the trough.

Fractured Rock Aquifer

The Fractured Rock Aquifer (previously referred to as the hard rock aquifer) consists of Pre-Cambrian and Paleozoic mainly indurated metasediments that surround and underlie the younger Cainozoic sediments of the Barossa Valley. Groundwater flow in this type of aquifer occurs mainly through the fractures and fissures that exist within the rock. The movement of water through the rock matrix itself is considered to be secondary relative to the flow through the fractures. Typically, fractured rock aquifers have very low storage capabilities. It is no surprise therefore that groundwater extraction from a fractured rock aquifer, results in significant changes in hydraulic head. In the Barossa Valley there are a number of observation wells completed in the Fractured Rock Aquifer that display large seasonal changes in head which is most probably a phenomenon resulting from the low storage potential of the rock and a high extraction rate (App. B). Natural recharge (rainfall or lateral inflow) also cause seasonal fluctuations in head, but recharge-induced head change is generally a lot less than the observed >20 m head change in some wells.

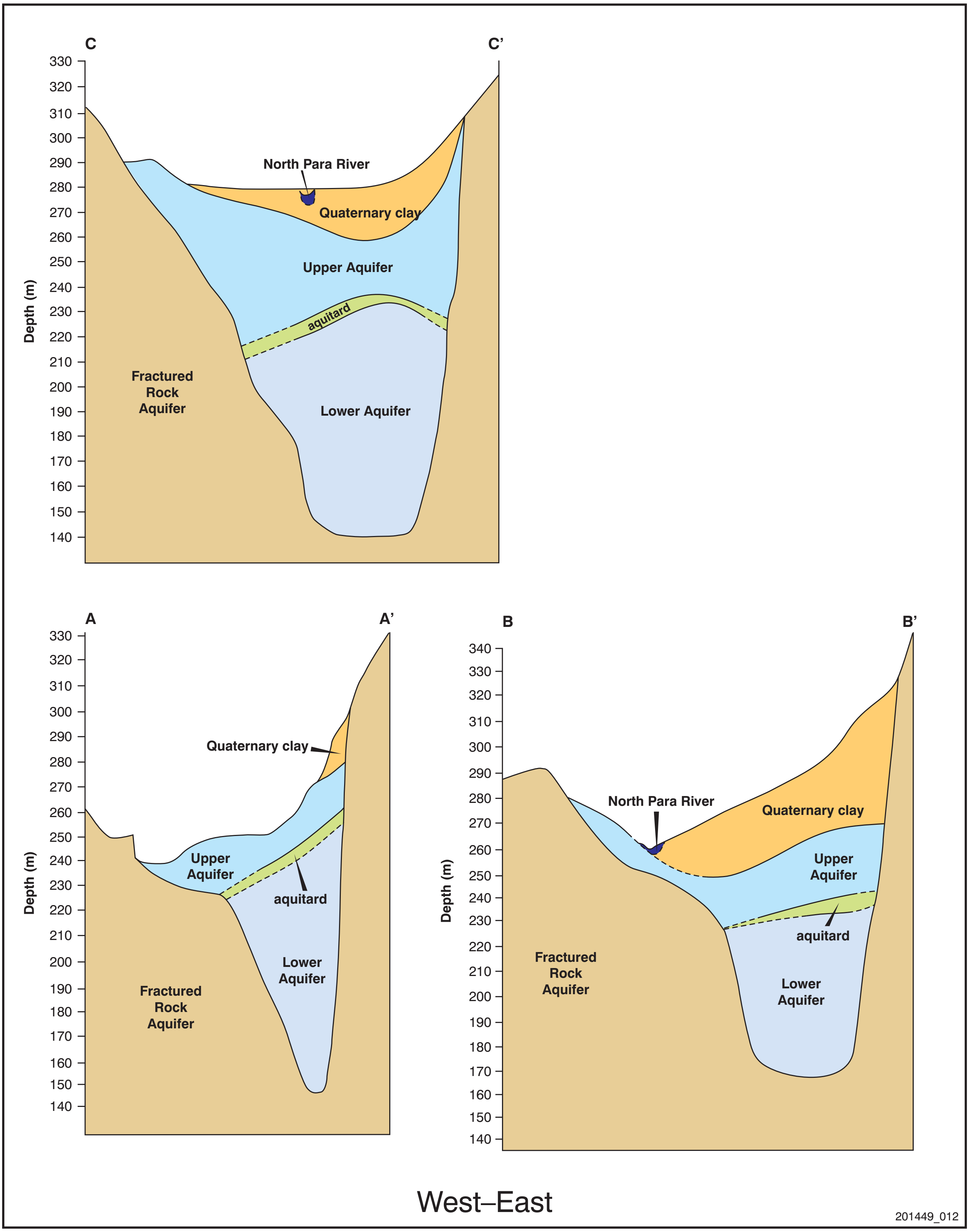

Figure 3 Cross-sections (see Figure 2 for locations).

The upper part of the Fractured Rock Aquifer can be highly weathered and can form thick clay sequences beneath the basin (Alley, 1995). These clays can act as a hydraulic barrier inhibiting groundwater flow between the Fractured Rock Aquifer and the two sedimentary aquifers.

Generally the potentiometric surface of the Fractured Rock Aquifer mimics topographic contours. Groundwater flow is inferred to be perpendicular to the contours of the potentiometric surface. The Barossa Ranges to the east of the Valley are considered to be the major source of recharge, via lateral throughflow, for both the Upper and Lower sedimentary aquifers. The amount of recharge from the Fractured Rock Aquifer to the sedimentary aquifers has yet to be estimated and is one of the biggest hydrogeological unknowns in the Barossa Basin flow system. The Research and Development Group of the Department of Water, Land and Biodiversity Conservation is currently undertaking a major research project into better understanding and quantifying groundwater flow between the Fractured Rock Aquifer and the Lower Aquifer.

The groundwater salinity distribution in the Fractured Rock Aquifer ranges from 440 to 2810 mg/L total dissolved solids (TDS; Fig. 4). This variation can be partially explained by different degrees of evaporative concentration of salts deposited in rainfall prior to recharging the aquifer. Another possible explanation for the observed salinity distribution is geochemical interactions with different rock types and/or back diffusion of accumulated salts from the matrix into the fractures.

Lower Aquifer

The Lower Aquifer collectively consists of the carbonaceous clays and sands deposited into the deepest part of the sedimentary basin. The quartz sands generally coarsen with depth (Cobb, 1986) and infer an improvement in the hydraulic properties of the aquifer with depth. The high number of wells completed in the deeper basal sand units support this hypothesis.

The top of the aquifer is considered to be the top of the uppermost carbonaceous clay unit. From the results of this study it is likely that the clay unit is present over much of the eastern part of the Basin. The clay has a very low vertical hydraulic conductivity ($\sim 1*10^{-10}$ m/s; Cobb, 1986), and where present, the clay would act as very low permeability aquitard effectively separating the Upper and Lower Aquifers. Given that it is very easy to identify from drillhole cuttings, the clay provides an excellent marker for delineating the two aquifers. A contoured elevation map showing the top of the uppermost clay unit and its western limit is presented in Figure 5.

The sand units within the Lower Aquifer are the main conduits for groundwater flow. The depositional environment of the sediments has resulted in the formation of discontinuous overlapping lenses of sand and clay. The sand lenses therefore continually cut out or intersect others forming a series of unmappable sub-aquifers. The Lower Aquifer, for the purpose of simplicity, is undifferentiated and is a composite of the sub-aquifers.

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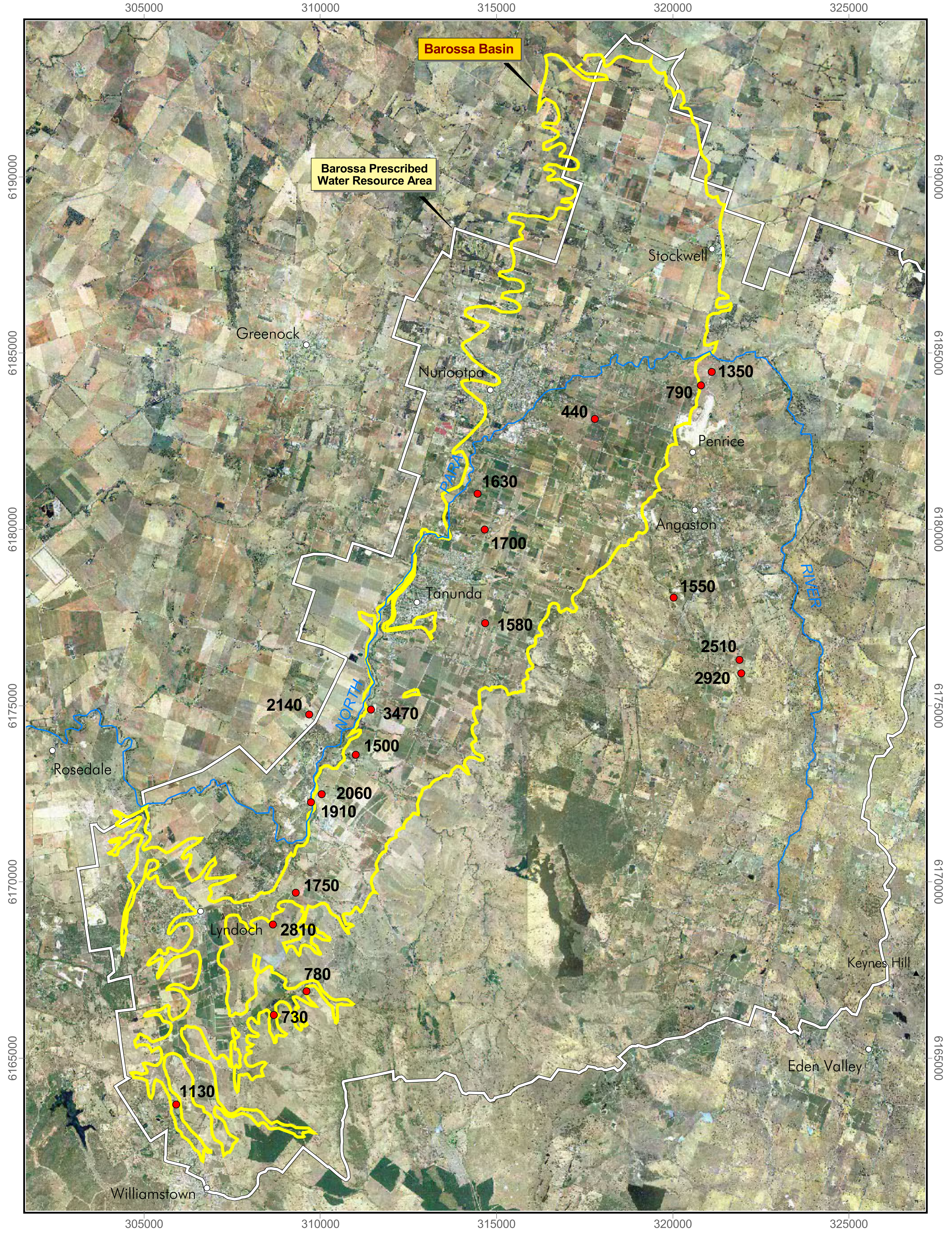
The Hydrogeology of the Barossa Basin

SPATIAL DISTRIBUTION OF FRACTURED ROCK AQUIFER SALINITY VALUES – FEBRUARY 1998



GDA

0 2 4 6 Kilometres

Datum GDA94 - Projection MGA Zone 54

1580 ● Fractured rock salinity (mg/L)

Figure 4

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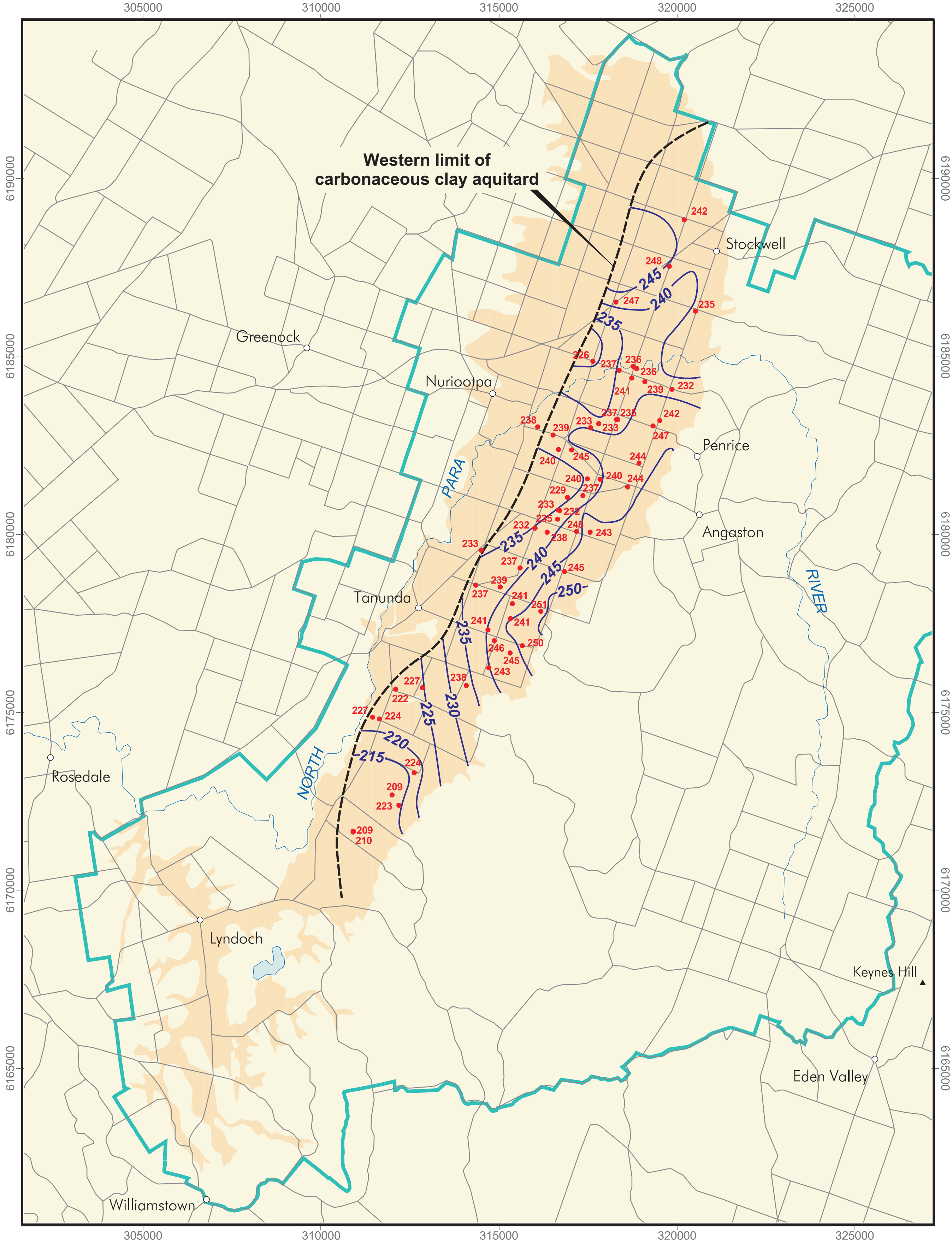
The Hydrogeology of the Barossa Basin

ELEVATION MAP OF THE TOP OF THE CARBONACEOUS CLAY AQUITARD



0 1 2 3 4 5 Kilometres

Datum GDA94 - Projection MGA Zone 54

Elevation of the top of the carbonaceous clay aquitard

Figure 5

PIRSA Publishing Services AV:201449_004

The Lower Aquifer is generally a confined aquifer system and as such has confined aquifer storage characteristics. Hydrographs show a seasonal fluctuation of more than 50 m in deeper parts of the Basin (App. B), which is almost certainly due to the effects of extraction and the relative narrowness of the basin.

The potentiometric surface of the Lower Aquifer for October 2001 is shown on Figure 6. Groundwater flow is generally westward in the Barossa Ranges but rotates such that flow is generally in a southwesterly direction beneath the plain. A lack of data points in the Barossa Ranges east of Tanunda gives a slightly misleading picture. It is more probable that the water elevation contours follow the topography more closely. This highlights a need for more observation wells in this area. By including heads from the Fractured Rock Aquifer, hydraulic continuity with the Lower Aquifer is inferred. Groundwater salinity is generally lower than that of the overlying Upper Aquifer, ranging between ~600 and 2500 mg/L TDS. Salinity values in mg/L for the Lower Aquifer are shown in Figure 7.

Upper Aquifer

The Upper Aquifer is considered to be all of those sediments within the Basin lying above the top of the uppermost carbonaceous clay unit. It includes the aquifers previously referred to by Cobb (1986) as the 'middle', 'upper gravels' and 'watertable' aquifers.

In the Cobb (1986) report it is not clear which stratigraphical units were used to construct his 'watertable' aquifer water elevation map. This has subsequently created some confusion. It is also not evident as to the spatial and stratigraphic position of his 'upper gravels' aquifer as no potentiometric map for the aquifer was presented.

In this report the Upper Aquifer includes the Tertiary non-carbonaceous quartz sands, the discontinuous sands and gravels in the Quaternary clay, and the Holocene gravels associated with the ephemeral creek beds.

On the eastern side of the valley the Quaternary red clay overlies most of the aquifer. There is therefore no free surface for the aquifer (i.e. it is possibly confined) except where the Holocene creek alluvium cuts through the clay and down into the underlying sands. A good example of this is shown on cross-section B–B in Figure 3.

Generally however, the creek alluvium does not fully penetrate the clay. In this situation the alluvium is considered to be isolated from the underlying basin sands. While they can offer an important water source albeit on a localised scale, sub-dividing the gravels from the rest of the Upper Aquifer is in the author's opinion unnecessary as only minimal extraction occurs from them.

A water level contour map of the Upper Aquifer is presented on Figure 8. Generally groundwater flow directions are the same as those for the Lower Aquifer. Hydraulic continuity between the Fractured Rock and Upper Aquifer is also assumed. Hydrographs generally show little seasonal change in head in those parts of the aquifer that underlie the Quaternary clay. It is therefore inferred that very little direct (rainfall) recharge is occurring beneath the clay. A seasonal head response is observed in those hydrographs located near the creek beds and the North Para River, suggesting recharge (and possibly discharge) could be occurring in these areas.

The Hydrogeology of the Barossa Basin

LOWER and FRACTURED ROCK AQUIFERS POTENTIOMETRIC SURFACE CONTOUR MAP – OCTOBER 2001

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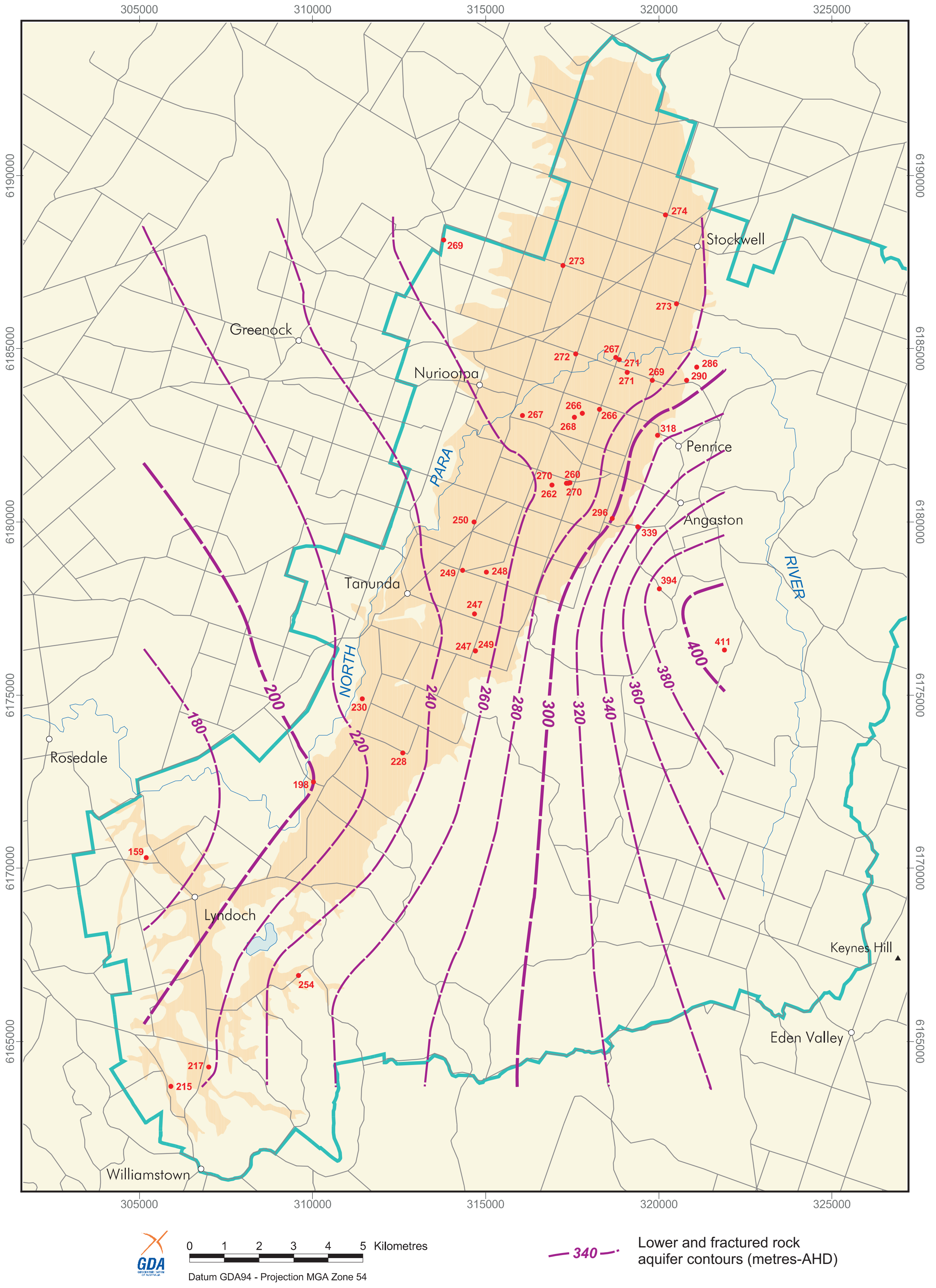

Figure 6

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SPATIAL DISTRIBUTION OF LOWER AQUIFER SALINITY VALUES – FEBRUARY 1998

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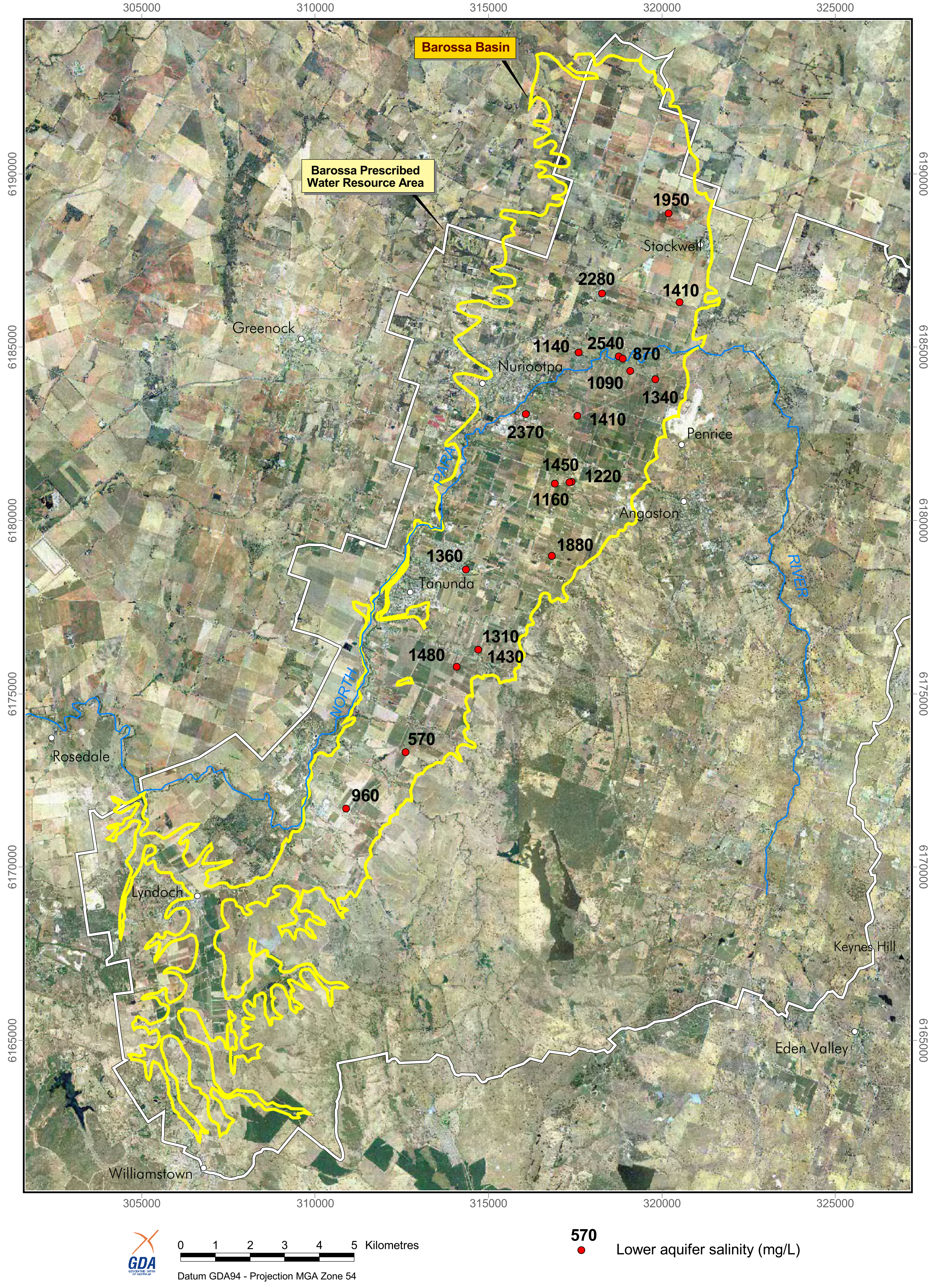

Figure 7

The Hydrogeology of the Barossa Basin

UPPER and FRACTURED ROCK AQUIFERS POTENTIOMETRIC SURFACE CONTOUR MAP – OCTOBER 2001

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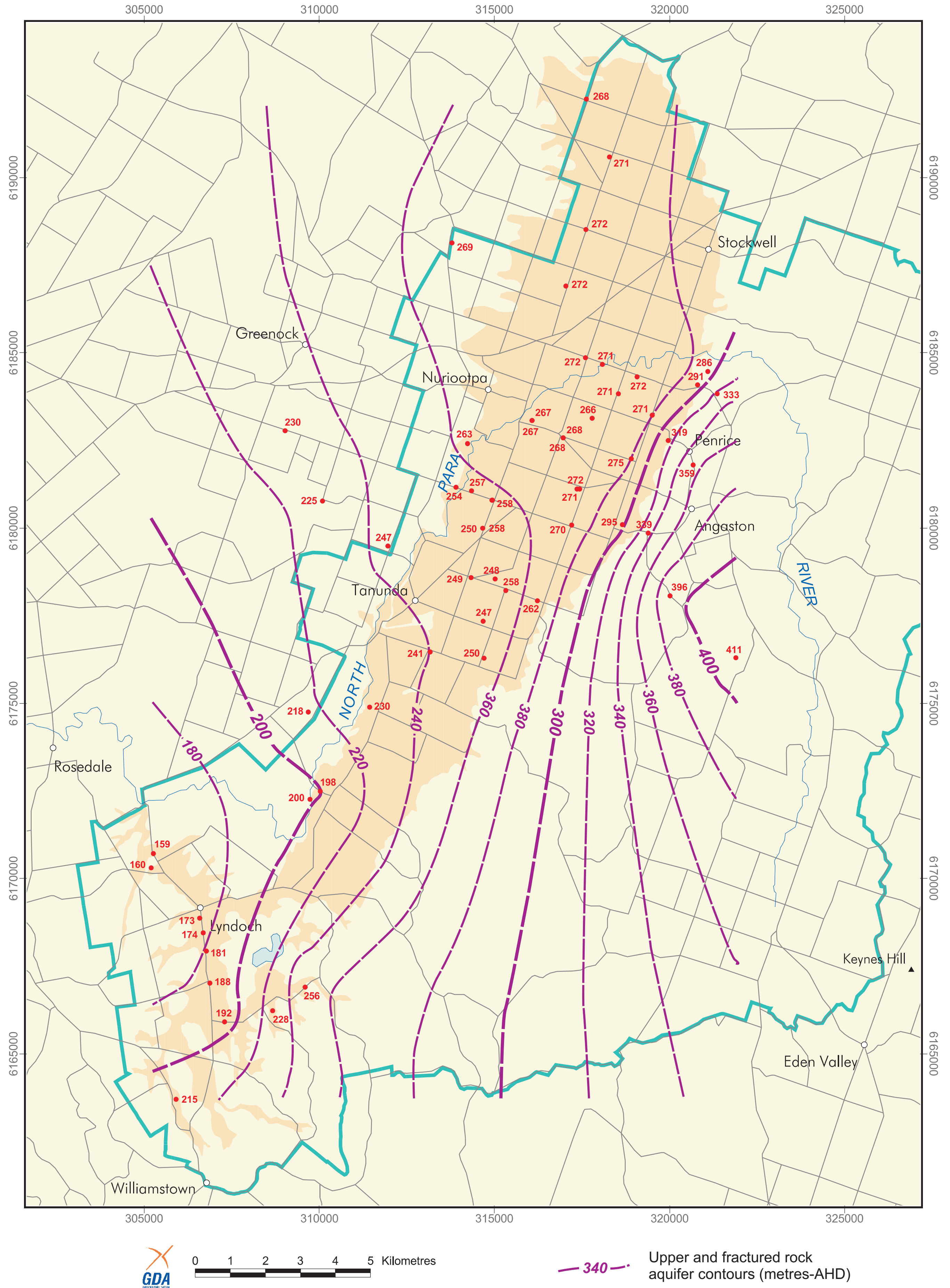

Figure 8

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Hydrographs from observation wells MOR 95 (unit number 6729-783) and MOR 97 (6729-780) show the difference in storage characteristics between the Upper and Lower aquifers. The wells are located less than 75 m from one another. MOR 97, located in the Lower Aquifer, has a seasonal head change of 50 m but there is little or no response in MOR 95 located in the Upper Aquifer.

The rapid rise in water level as shown on the MOR 95 hydrograph at the end of 1992 is also observed in most of the Upper Aquifer and Fractured Rock Aquifer hydrographs at the same time. It is almost certainly a response to unseasonably high rainfall that occurred at that time.

Groundwater salinity in the Upper Aquifer ranges between ~740 and 11 440 mg/L TDS, and is generally of a higher salinity than the Lower Aquifer. Salinity values obtained for the Upper Aquifer are presented in Figure 9. Generally groundwater salinity is higher in the Upper Aquifer west of the North Para River than in the central and lower parts of the valley.

During the winter period there is a negligible difference in hydraulic head between the Upper and Lower Aquifers. There is therefore little potential for downward leakage of the higher salinity groundwater from the overlying aquifer system during the winter period. In the summer irrigation period the head difference can be more than 50 m, but while this seasonal head difference is of a long enough duration to induce downward movement of water, it is however unlikely.

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The Hydrogeology of the Barossa Basin

SPATIAL DISTRIBUTION OF UPPER AQUIFER SALINITY VALUES – FEBRUARY 1998

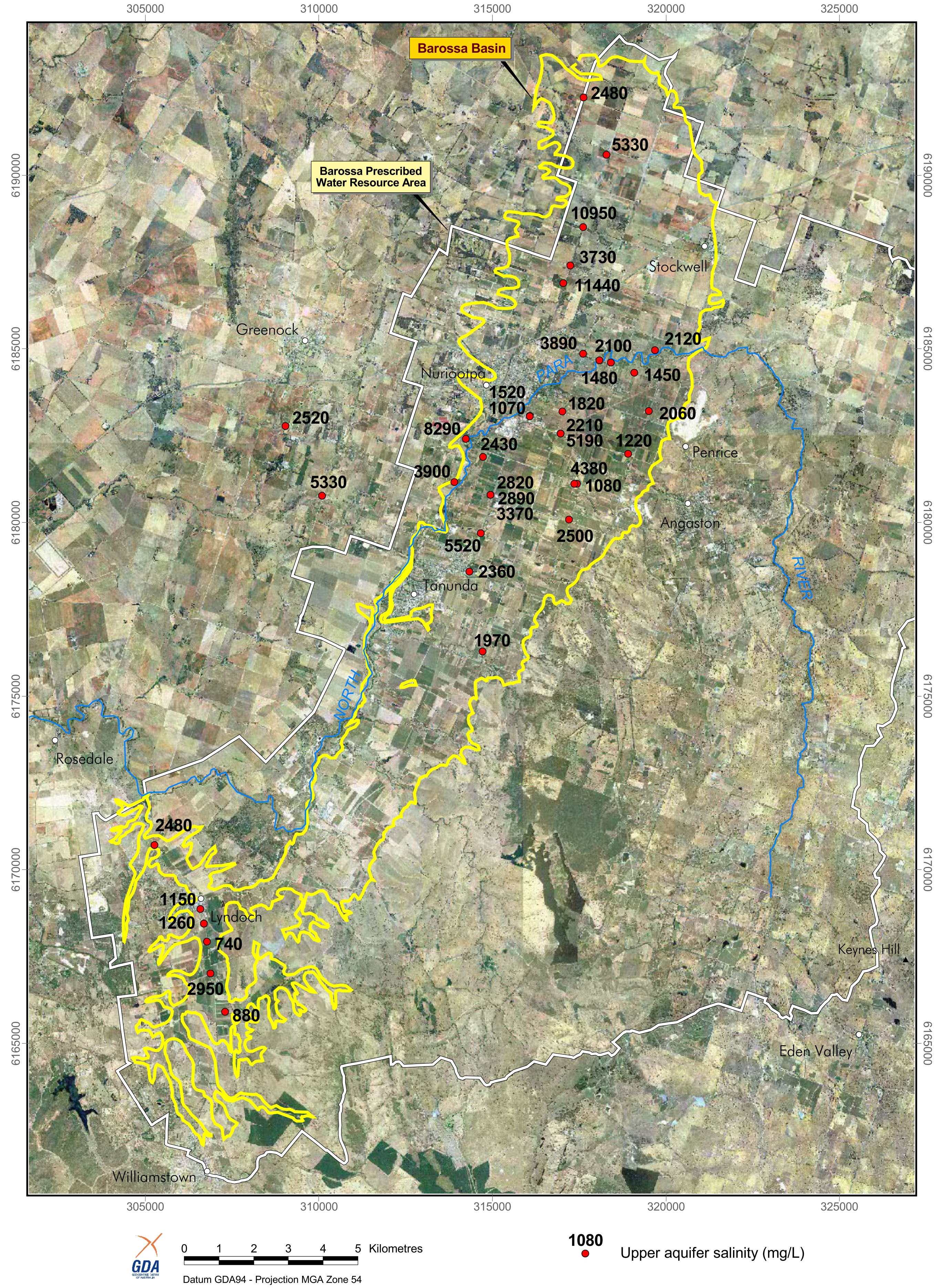

Figure 9

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4 GROUNDWATER MONITORING NETWORK

The State government, currently under the Department of Water, Land and Biodiversity Conservation (DWLBC), has operated a groundwater monitoring network in the Barossa Valley since the mid 1960s. Initially only water levels were measured. Groundwater salinity monitoring was introduced in the late 1970s. As Departmental standard practice, the groundwater salinity is presented in TDS (mg/L) and is derived from a electrical conductivity measurement. There are a total of 102 wells in the current monitoring network. The location of the current observation wells are presented in the succeeding sections on a per aquifer basis. A full list of the current observation wells showing aquifer monitored and parameter measured (water level, salinity, or both) is given in Appendix C. It includes the 14 new wells drilled as part of the BIL (Barossa Infrastructure Limited) Murray River – Warren Reservoir imported water scheme. Table 3 presents the numbers of wells sub-divided into each of the aquifers.

Table 3. Number of observation wells by aquifer type

Aquifer	Water level	Salinity
Fractured Rock	36[1]	28
Lower	19	20
Upper	39[1]	38

1. One well is completed in both the Upper and Fractured Rock Aquifers.

As part of the review of the hydrostratigraphy, the monitoring network was also investigated to assess the integrity of the observation wells and therefore the data produced from them (App. D). During the review it was noted that a number of the current observation wells are now used as recharge wells; they have therefore been withdrawn from the network. Observation wells that have been excluded from the network are listed in Appendix E.

Many of the early salinity samples were obtained by bailing. These data should not be used in any assessment of the resource. The salinity graphs presented in Appendix C have, to the author's knowledge, not included bailed samples. Wells that do not fit into the expected salinity range should also be treated with some caution.

Water level monitoring is currently undertaken by a field officer on contract to the DWLBC. The officer also collects groundwater salinity samples from 18 private wells. These samples tend to be supplied on an *ad hoc* basis (App. C). During the summer irrigation season samples are much easier to obtain than in the winter non-irrigation period. The number of irrigators supplying samples has also declined since the inception of a scheme sampling private wells. Groundwater salinity sampling of Departmental wells was last undertaken in March 2001, the last major sampling undertaken prior to that was in February 1998.

The following are general water level and salinity trends for observation wells located in each of the aquifer systems in the Barossa Valley.

Fractured Rock Aquifer

Fractured rock aquifers, because of their low storage capabilities, often display significant fluctuations in water level, which can affect the groundwater salinity. Interpreting water level and salinity trends in fractured rock aquifers therefore requires constant monitoring and a long-term data set before trends can be interpreted with confidence.

The location of each of the Fractured Rock Aquifer observation wells is shown in Figure 10. The long-term water level and salinity trends generally show negligible changes for either parameter. Most of the observation wells show a post-1993 to present short-term decline in water level. Good examples of this are BRS 10 (6628-12503), BRS 13 (6628-12578), BRS 17 (6628-12105) and MOR 264 (6729-985). This decline is observed in other parts of the State and is consistent with below average rainfall. However, there is some concern that there was no recovery observed in 2001, a high rainfall year. These wells should be monitored closely over the next two to three years. There appears to have been no impact on salinity as a result of the water level decline.

There are some notable exceptions to the observed negligible change in the long-term water levels. BLV 7 (6629-328) has had a water level decline of ~10 m over the past 20 years, while water levels in NTP 5 (6628-5897) and MOR 107 (6628-17545) appear to be rising slightly.

MOR 135 (6729-1532) is completed in the Fractured Rock Aquifer and was part of an aquifer storage and recovery project. It is located in the central eastern plain beneath the Upper and Lower Aquifers. The salinity value of 440 mg/L is very low. Previous sampling showed the salinity of the groundwater to be ~2170 mg/L. The reason for this disparity is probably aquifer storage recovery related and the salinity values are therefore not representative of the aquifer.

Lower Aquifer

The location of each of the Lower Aquifer observation wells is shown in Figure 11. Long-term water level and salinity trends in the Lower Aquifer generally show no significant increasing or decreasing trend. The exception is MOR 62 (6628-6002) , which shows a decline of ~3 m in the last 25 years. However it appears to have stabilised in recent times.

Hydrographs from observation wells MOR 200 (6729-1400), MOR 209 (6729-1431) and MOR 211 (6729-1449) appear to have a hydraulic response similar to that of the Upper Aquifer. There is no immediate explanation for this observation.

Upper Aquifer

The location of each of the Upper Aquifer observation wells for both water level and salinity are shown in Figure 12. Most show the post-1993 head decline with the exception that it does not have as dramatic seasonal head changes as observed in the Fractured Rock Aquifer system. There is no observable long-term change in groundwater salinity in the Upper Aquifer.

The Hydrogeology of the Barossa Basin

LOCATION OF FRACTURED ROCK AQUIFER OBSERVATION WELLS IN CURRENT NETWORK

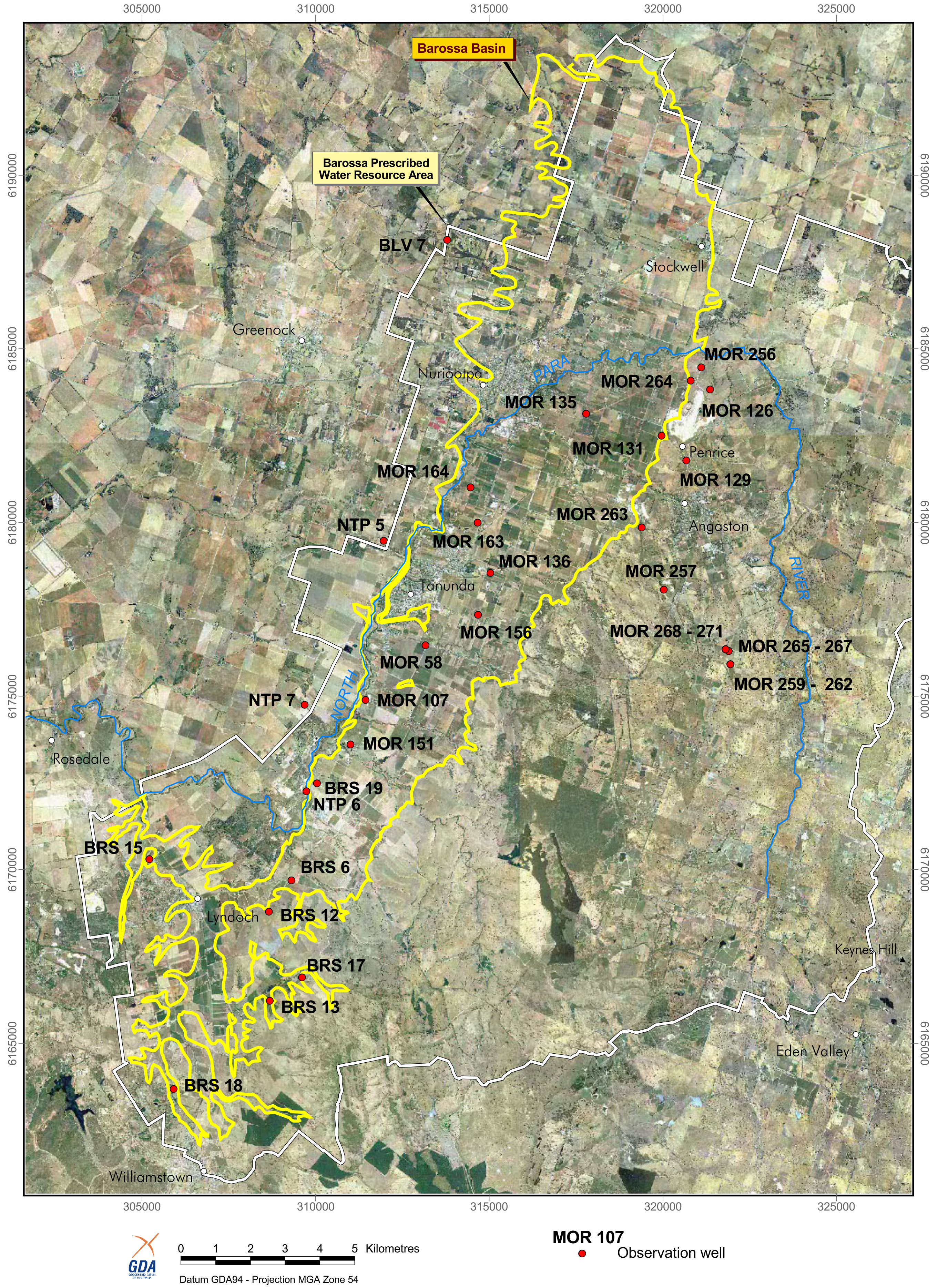

Figure 10

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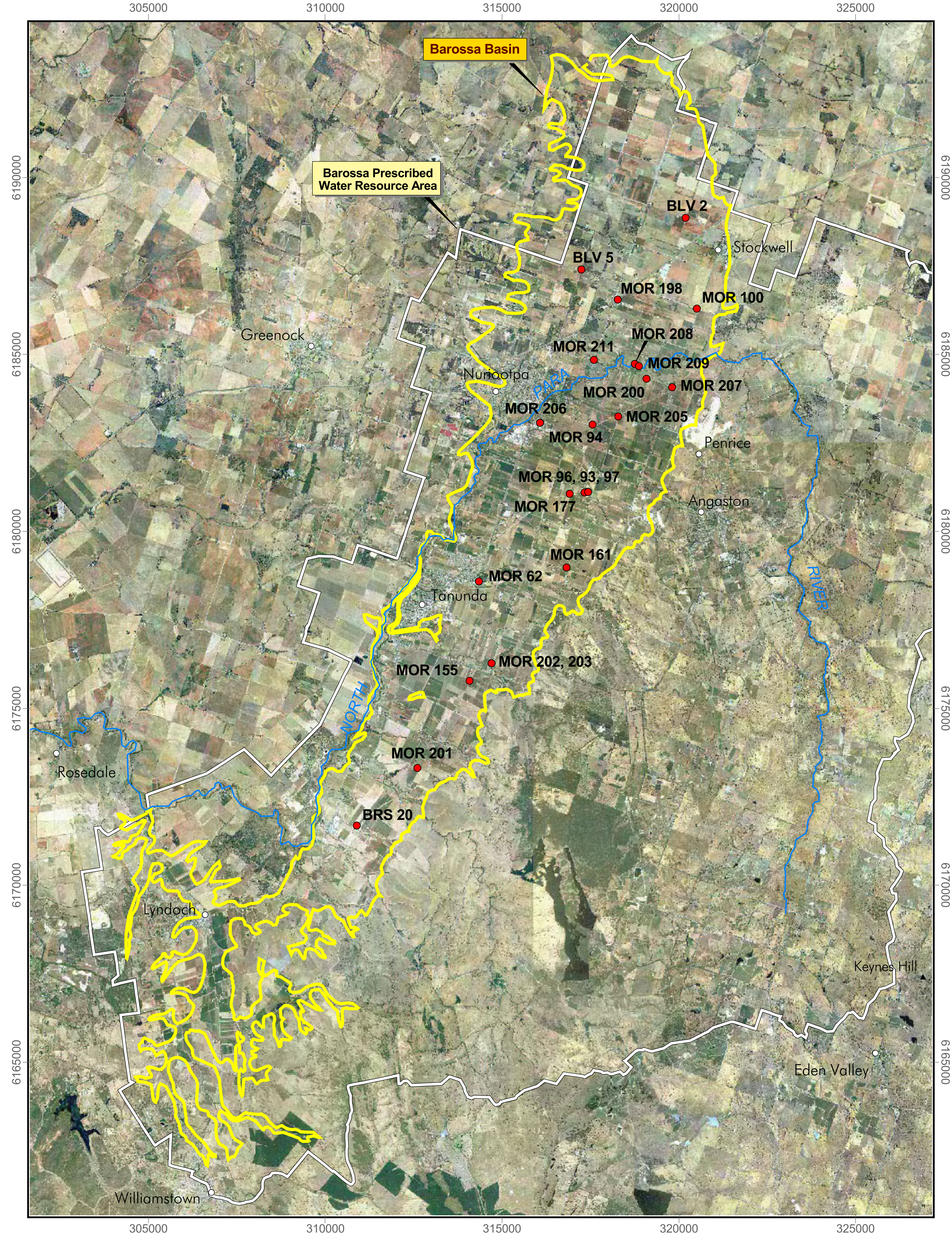
The Department of Water, Land and Biodiversity Conservation

Government of South Australia

The Hydrogeology of the Barossa Basin

LOCATION OF LOWER AQUIFER OBSERVATION WELLS IN CURRENT NETWORK



GDA

0 1 2 3 4 5 Kilometres

Datum GDA94 - Projection MGA Zone 54

MOR 201 ● Observation well

Figure 11

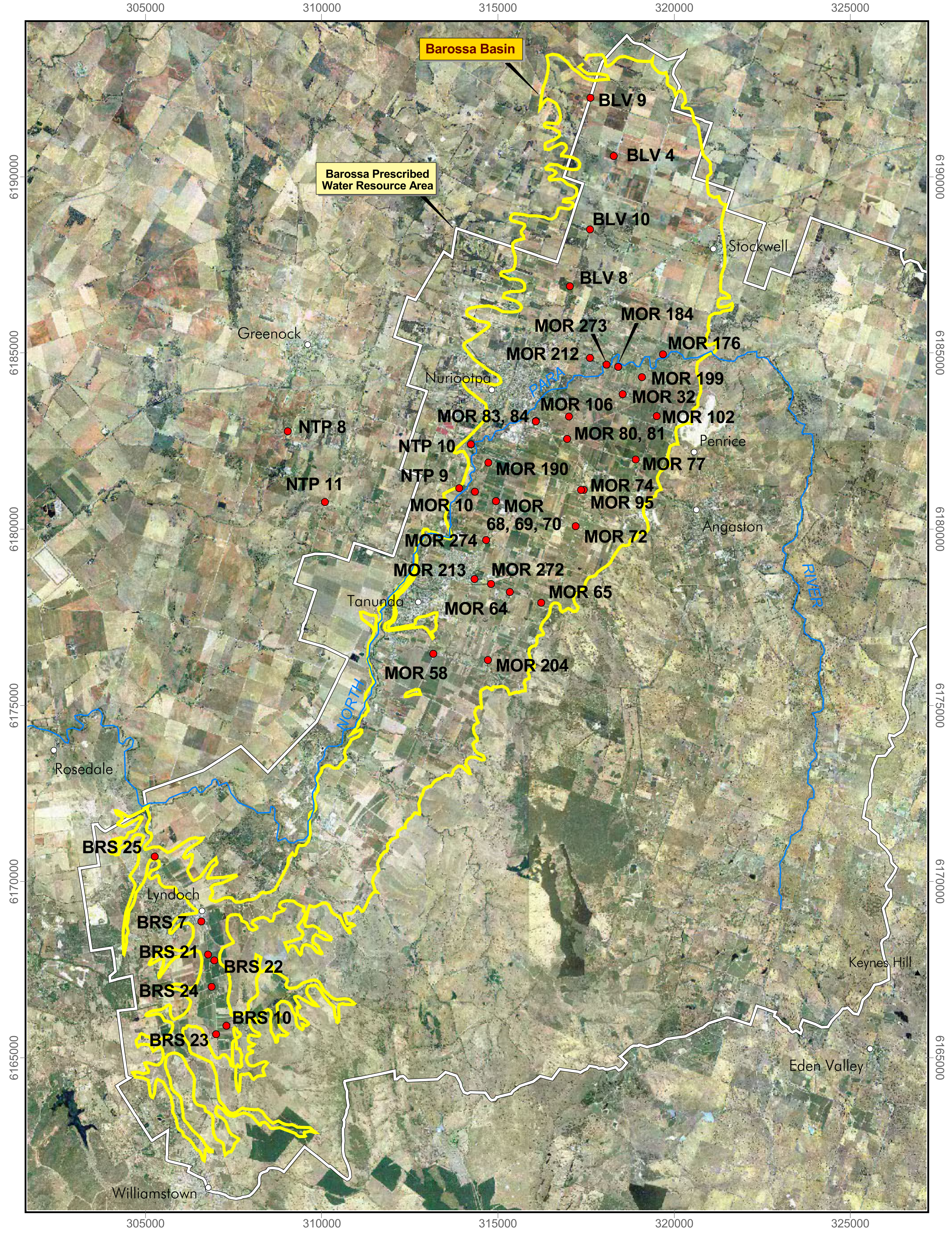
PIRSA Publishing Services AV:201449_010

The Department of Water, Land and Biodiversity Conservation

The Hydrogeology of the Barossa Basin

LOCATION OF UPPER AQUIFER OBSERVATION WELLS IN CURRENT NETWORK

Government of South Australia



GDA

0 1 2 3 4 5 Kilometres

Datum GDA94 - Projection MGA Zone 54

MOR 65 ● Observation well

Figure 12

PIRSA Publishing Services AV:201449_011

Exceptions to the general trends are: a small long-term decline in water level is observed in MOR 58 (6628-5941); and a dramatic and unexplainable rise in salinity in BLV 4 (more than 2500 mg/L over the last 10 years; unit number 6729-344).

5 DISCUSSION AND CONCLUSIONS

This report presents the results of a study into the underground water resources of the Barossa Basin and incorporates the latest hydrogeological information.

Groundwater flow beneath the Barossa Basin is complex and it is therefore difficult to describe the hydrogeological system except in broad terms. Generally the Basin can be conceptualised as a three-aquifer system, comprising a Fractured Rock, a Lower and an Upper Aquifer. A more definitive description of the aquifer system within the Barossa Basin was limited for the following reasons:

- Understanding of groundwater flow through a dual porosity medium such as the Fractured Rock Aquifer is limited. There have been significant scientific advances towards understanding of flow in fractured rock aquifers in the last 20 years, which has increased our knowledge in this type of system. However, the problem still exists of how to upscale results from intensive site studies so that they can be useful in a regional context.
- The geological environment that existed at the time the oldest sediments were deposited into the trough resulted in a series of discontinuous overlapping lenses of sand and carbonaceous clay. Together the sand lenses have formed a series of sub-aquifers, the interconnection of which is currently beyond our present level of understanding. In the Lower Aquifer, for example, there is a significant head difference (and sometimes salinity difference) in observation wells located in the aquifer. Lateral and vertical changes in stratigraphy even over small distances are the most likely cause for these observed head differences. Simply relying on hydraulic head, or salinity, difference to define an aquifer in such a sedimentary environment is therefore not valid.
- The three regional aquifers described in this report are, depending on location, hydraulically connected. The degree of interconnection between the aquifers remains unknown and is an area of research currently being investigated by the DWLBC.
- This assessment has shown that water level and water chemistry data obtained from some wells in the observation network are unreliable. Removing these wells from the network has highlighted shortfalls in data in some areas.

These observations highlight the inherent difficulties related to describing a complex hydrogeological system such as the Barossa Basin. A positive outcome of the new system of hydrogeological classification is that it will be easier to manage the resource, especially in terms of determining flow budgets for the system as a whole and on an individual aquifer basis.

The seasonal head fluctuation in the Lower Aquifer is more than 50 m in some wells and is almost certainly a result of seasonally high extraction and the narrow geometry of the aquifer. The cone of depression that develops as a result of seasonal extraction is unable to expand as it would in a larger aquifer. Once the cone comes into contact with the low yielding Fractured Rock Aquifer, it must take water from a much smaller area to maintain the rate of extraction from the aquifer (in hydrogeological terms the contact between the Lower Aquifer and the Fractured Rock Aquifer is a discharge boundary). This results in much greater drawdown than would usually be expected and is consistent with observations of the aquifer. The high level of seasonal extraction in the Lower Aquifer may also be causing the abnormally large seasonal fluctuations in water level (and possibly the recent short-term decline) observed in wells located in the Fractured Rock Aquifer immediately adjacent to the sedimentary plain.

In this study geological logs from more than 130 wells were examined. Geologists prepared most of the logs, however, some driller's logs were also used. The reliability of some of the descriptions is questionable. It was surprising therefore that the upper carbonaceous clay unit could be observed and shown to be mappable in just about all cases on the eastern margin of the plain. The clay is therefore a good marker and has been used in this study to delineate aquifer systems beneath the plain.

As more hydrogeological information becomes available it may be possible to further sub-divide the hydrostratigraphy, particularly the basal sands in the deepest part of the Lower Aquifer. At this stage, however, there are significant advantages to adopting the recommended simplified approach, particularly in the management of the resource.

6 RECOMMENDATIONS FOR FURTHER WORK

As a result of this assessment the following recommendations are made:

- The relationship between the three aquifer systems be investigated as a matter of priority, particularly recharge via lateral throughflow from the Barossa Ranges into the deeper confined aquifer system. Recharge to the Fractured Rock Aquifer in the Barossa Ranges should also be quantified as part of this investigation.
- A comprehensive flow and solute (salt) balance be undertaken once the flow system of the Barossa has been determined, possibly with the aim of undertaking a groundwater modelling exercise.
- To increase our understanding of the basin it is further recommended that the monitoring network be expanded to include areas of poor coverage and that investigation wells are drilled in areas where there is little hydrostratigraphical control.
- An investigation be undertaken into the causes and potential impacts the 50m-seasonal change in head is having on the Lower Aquifer.

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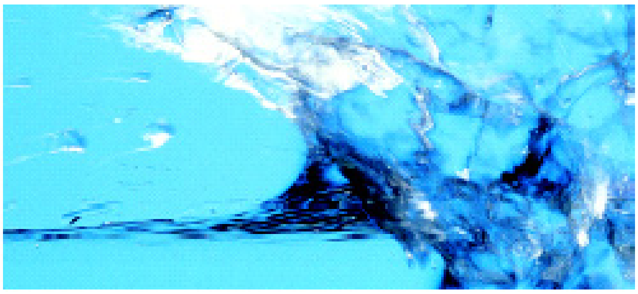
8 APPENDIX A





ELEVATIONS OF HYDROSTRATIGRAPHIC UNITS

Observation well	Unit number	Easting	Northing	Ground surface (m)	Bot_Upper_Clay (m)	T_Clay (m)	T_Lower Snd (m)	Frac_Rock (m)
–	6729-1647	319769	6187546	294	–	248	238	200
–	6628-4725	311977	6172690	237	–	209	206	184
–	6628-15342	312172	6172408	246	–	223	221	–
–	6729-1176	318598	6181350	304	284	244	–	–
BLV 2	6729-369	320180	6188854	293.29	274	242	240	–
BLV 4	6729-344	318280	6190583	281.4	254	–	245	237
BLV 5	6729-371	317232	6187393	278.5	–	–	–	–
BLV 6	6629-1233	315158	6189924	295.5	–	–	–	294
BLV 7	6629-328	313786	6188131	321	–	–	321	273
BLV 8	6729-1672	317035	6186891	–	–	–	–	–
BLV 9	6729-1673	317617	6192235	–	–	–	–	–
BLV 10	6729-1674	317608	6188504	–	–	–	–	–
BRS 5	6628-8965	310886	6171646	238.5	215	209	205	185
BRS 6	6628-13078	309299	6169689	233	–	–	–	213
BRS 7	6628-13111	306582	6168855	176	–	–	–	–
BRS 8	6628-13514	306949	6167750	185	–	–	–	145
BRS 9	6628-13342	307049	6166807	197	–	–		–
BRS 10	6628-12503	307290	6165902	212	–	–	–	177
BRS 11	6628-13681	306682	6168438	176	160	–	–	136
BRS 12	6628-2835	308643	6168783	240.5	–	–	–	237

Observation well	Unit number	Easting	Northing	Ground surface (m)	Bot_Upper_Clay (m)	T_Clay (m)	T_Lower Snd (m)	Frac_Rock (m)
BRS 13	6628-12578	308669	6166220	239	230	–	–	230
BRS 15	6628-6092	305202	6170293	168.4	–	–	–	168
BRS 16	6628-11945	307000	6164244	238	235	–	–	235
BRS 17	6628-12105	309595	6166895	267	–	–	–	267
BRS 18	6628-15183	305906	6163683	228	218	–	–	218
BRS 19	6628-15211	310027	6172478	202	196	–	–	196
BRS 20	6628-20432	310882	6171680	238	–	210	208	183
BRS 22	6628-20690	306769	6167916	–	–	–	–	–
BRS 23	6628-20691	306997	6165654	–	–	–	–	–
BRS 24	6628-20693	306868	6167003	–	–	–	–	–
BRS 25	6628-20694	305255	6170699	–	–	–	–	–
MOR 8	6628-6049	313993	6180371	260	248	–	–	242
MOR 16	6729-757	317468	6181567	289	–	240	236	–
MOR 19	6729-744	317026	6182390	280	–	245	242	–
MOR 24	6729-701	316505	6182801	274.5	–	239	237	–
MOR 32	6729-669	318537	6183819	281	265	–	–	–
MOR 37	6729-607	318710	6184406	278.92	–	241	235	–
MOR 57	6628-5946	312080	6175671	251.04	–	222	–	–
MOR 58	6628-5941	313161	6176460	255	–	–	–	238
MOR 62	6628-6031	314335	6178582	266	252	237	236	217
MOR 65	6628-6002	316220	6177909	290.7	282	–	–	–
MOR 68	6629-10	314935	6180785	266.4	256	–	–	232

Observation well	Unit number	Easting	Northing	Ground surface (m)	Bot_Upper_Clay (m)	T_Clay (m)	T_Lower Snd (m)	Frac_Rock (m)
MOR 71	6728-1717	317167	6180100	291.51	–	246	241	186
MOR 76	6729-724	318825	6182018	302.73	260	–	–	–
MOR 77	6729-725	318903	6181965	302.74	279	–	–	–
MOR 82	6629-71	316072	6183037	271.49	–	238	237	235
MOR 85	6729-689	318319	6183231	284.81	264	235	222	162
MOR 92	6729-781	317346	6181097	288	–	237	233	174
MOR 94	6729-696	317559	6183009	281	–	233	228	200
MOR 99	6729-592	319839	6184083	292	265	232	229	156
MOR 100	6729-521	320505	6186288	285	276	235	230	–
MOR 102	6729-678	319500	6183207	298.5	262	242	–	–
MOR 105	6729-572	317623	6184879	277.53	–	226	220	–
MOR 107	6628-17545	311428	6174882	230	–	227	205	190
MOR 111	6729-575	318355	6184624	279	–	237	231	–
MOR 126	6729-885	321348	6183818	346.743	–	–	–	347
MOR 129	6729-805	320670	6181784	360.93	–	–	–	361
MOR 131	6729-808	319957	6182491	327.03	–	–	–	327
MOR 132	6729-830	320737	6182320	357.53	–	–	–	358
MOR 133	6729-1370	320629	6188346	298	–	–	–	–
MOR 134	6628-6008	315362	6178065	280.7	250	241	212	195
MOR 135	6729-1532	317781	6183119	279.742	–	233	230	183
MOR 136	6628-17220	315020	6178538	272	–	239	233	209
MOR 151	6628-4788	310997	6173604	228	–	–	–	202

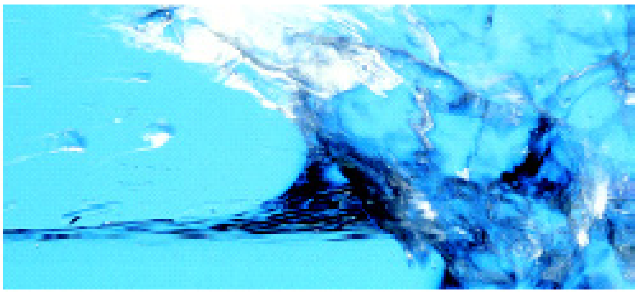
Observation well	Unit number	Easting	Northing	Ground surface (m)	Bot_Upper_Clay (m)	T_Clay (m)	T_Lower Snd (m)	Frac_Rock (m)
MOR 152	6628-11094	311622	6174826	234	–	224	208	–
MOR 153	6628-11405	312834	6175708	266	–	227	224	204
MOR 154	6628-11198	314404	6184624	324	–	–	–	322
MOR 155	6628-5938	314067	6175772	270	–	238	234	–
MOR 156	6628-8984	314672	6177327	270.5	255	241	240	209
MOR 158	6628-5976	315636	6176889	286	–	250	210	185
MOR 159	6628-11085	315298	6176682	278	–	245	224	195
MOR 160	6628-9453	316158	6177855	290	280	251	218	174
MOR 161	6728-2038	316822	6178969	295	273	245	215	179
MOR 162	6628-6044	314480	6179566	264	–	233	–	232
MOR 163	6628-6095	314654	6179982	264.395	–	–	–	232
MOR 165	6629-8	314034	6180717	262	–	–	–	226
MOR 166	6628-6059	316336	6180075	278	–	238	232	184
MOR 167	6629-43	314724	6181921	266	–	–	–	238
MOR 168	6629-28	315441.2	6181797	271	243	–	–	240
MOR 170	6629-53	315062	6182406	268	253	–	–	246
MOR 171	6729-988	316654	6182395	278	–	240	238	222
MOR 172	6729-766	317826	6181561	294	262	240	233	180
MOR 173	6728-1714	316629	6180440	281	–	235	–	177
MOR 174	6729-1618	316697	6180681	281	–	232	–	
MOR 176	6729-1111	319675	6184957	282	270	–	–	
MOR 177	6729-775	316909	6181057	283	–	229	228	176

Observation well	Unit number	Easting	Northing	Ground surface (m)	Bot_Upper_Clay (m)	T_Clay (m)	T_Lower Snd (m)	Frac_Rock (m)
MOR 179	6628-11156	314846	6177020	270	256	246	–	208
MOR 181	6628-11091	312053	6177073	237.5	–	–	–	222
MOR 182	6629-29	315289	6181587	268	249	–	–	245
MOR 183	6729-674	319311	6183054	299	–	247	245	
MOR 186	6728-2080	317548	6180072	296.86	269	243	217	177
MOR 188	6628-6060	315996	6180187	275	–	232	224	199
MOR 189	6628-12026	315304	6177646	277	–	241	227	195
MOR 190	6629-1261	314725	6181881	267	247	–	–	–
MOR 191	6628-12228	315576	6179065	275	–	237	225	199
MOR 192	6728-2462	318652	6180082	321	–	–	–	268
MOR 193	6729-1611	316654	6180692	281	239	233	–	195
MOR 195	6729-726	318921	6182012	302.48	–	244	224	–
MOR 198	6729-966	318269	6186543	281	–	247	233	221
MOR 200	6729-1400	319083	6184307	280.7	–	239	237	–
MOR 201	6628-14328	312604	6173312	269	–	224	–	166
MOR 203	6628-15394	314700	6176268	257.5	253	243	237	–
MOR 205	6729-1430	318281	6183237	285	–	237	231	–
MOR 208	6729-1429	318753	6184731	279	259	236	233	158
MOR 209	6729-1431	318857	6184668	279	–	236	234	–
MOR 210	6628-15396	312966	6177007	244	232	–	–	232
MOR 213	6628-16133	314327	6178582	265	–	–	–	–
MOR 256	6729-1552	321092	6184460	320	317	–	–	317

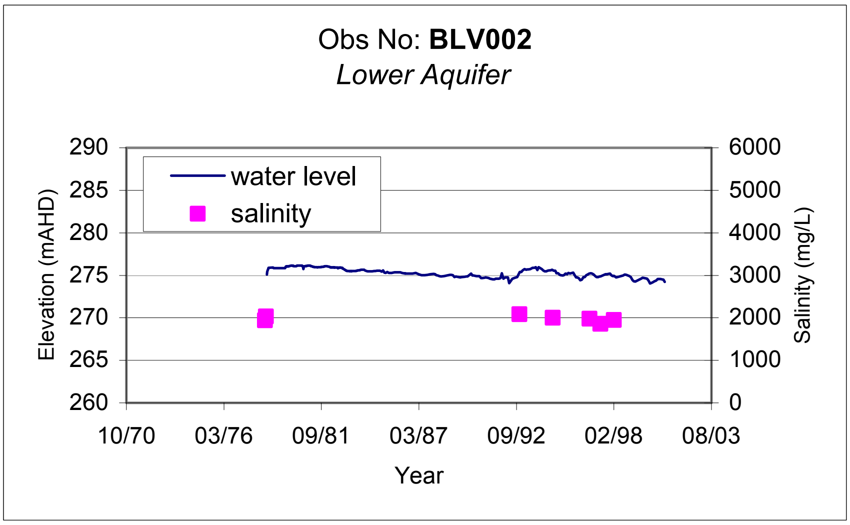
Observation well	Unit number	Easting	Northing	Ground surface (m)	Bot_Upper_Clay (m)	T_Clay (m)	T_Lower Snd (m)	Frac_Rock (m)
MOR 257	6728-3069	320012	6178053	413.5	–	–	–	414
MOR 259	6728-3238	321936	6175904	412	–	–	–	412
MOR 263	6728-3071	319388	6179847	348	–	–	–	348
MOR 264	6729-985	320791	6184082	324	–	–	–	324
MOR 272	6628-20692	314798	6178433	–	–	–	–	–
MOR 273	6729-1671	318075	6184661	–	–	–	–	–
MOR 274	6628-20695	314652	6179689	–	–	–	–	–
NTP 5	6628-5897	311952	6179471	271.5	–	–	–	272
NTP 6	6628-15539	309732	6172253	206.5	–	–	–	197
NTP 7	6628-17398	309681	6174745	245	227	–	–	227
NTP 8	6629-1811	309024	6182768	–	–	–	–	–
NTP 9	6629-1812	313897	6181156	–	–	–	–	–
NTP 10	6629-1813	314223	6182400	–	–	–	–	–
NTP 11	6629-1814	310086	6180765	–	–	–	–	–

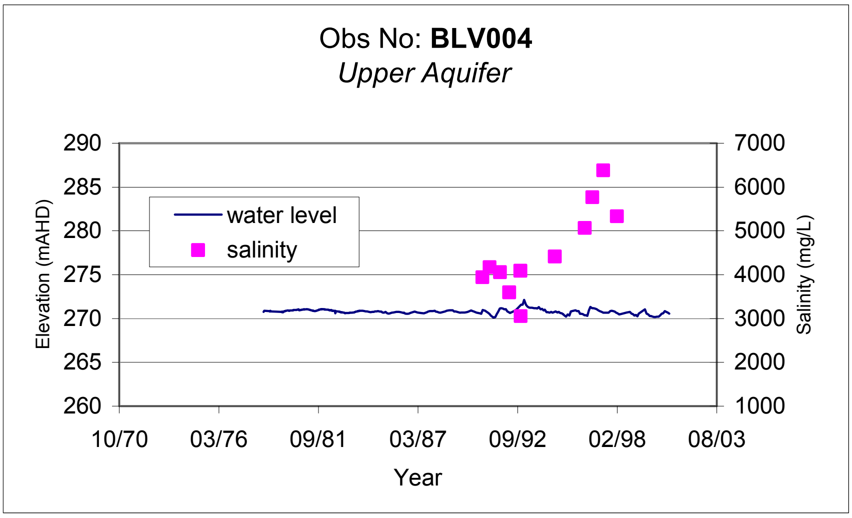
9 APPENDIX B

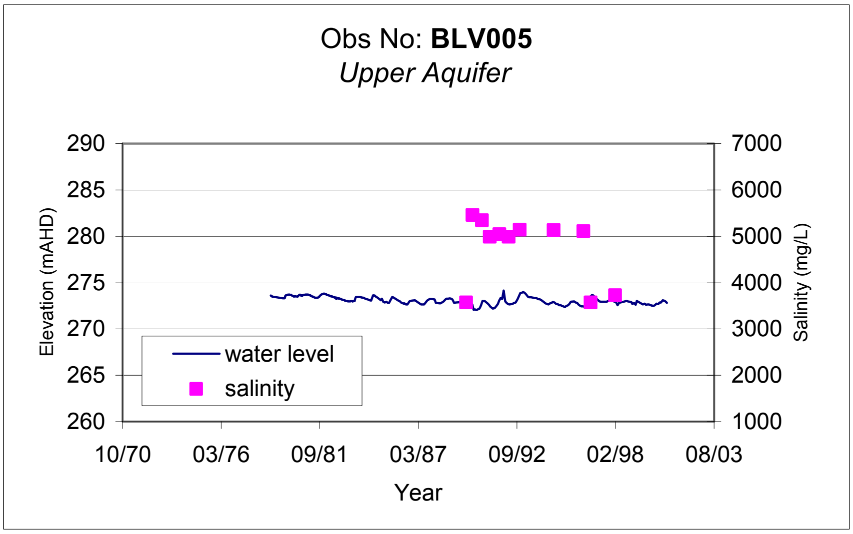


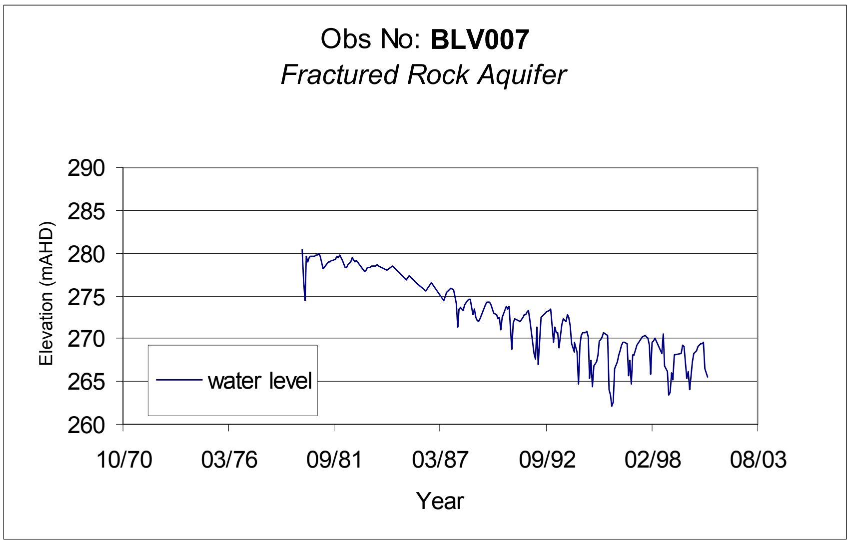


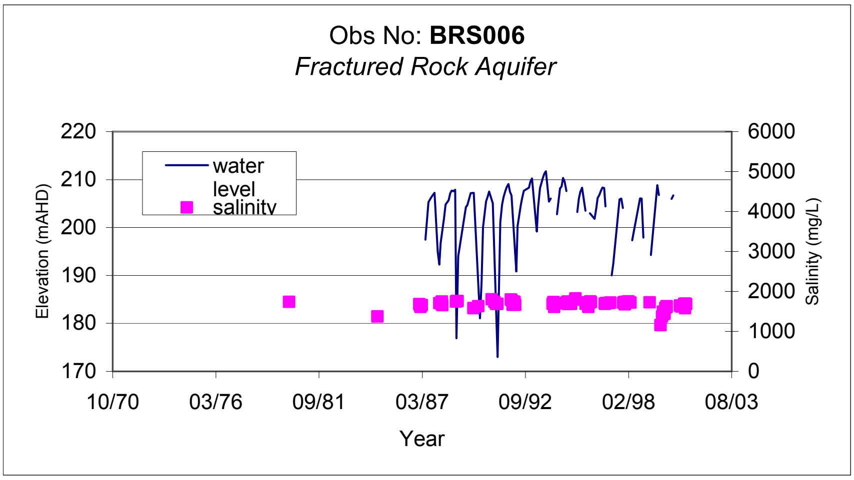
HYDROGRAPHS AND TIME SERIES SALINITY GRAPHS FROM OBSERVATION WELLS

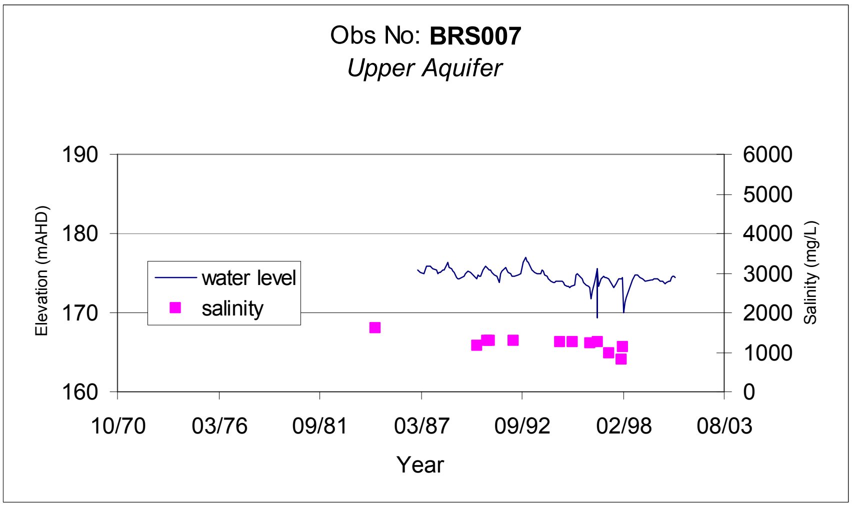

Obs No: **BLV002**
Lower Aquifer
water level
salinity
Elevation (mAHD)
Salinity (mg/L)
290
285
280
275
270
265
260
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

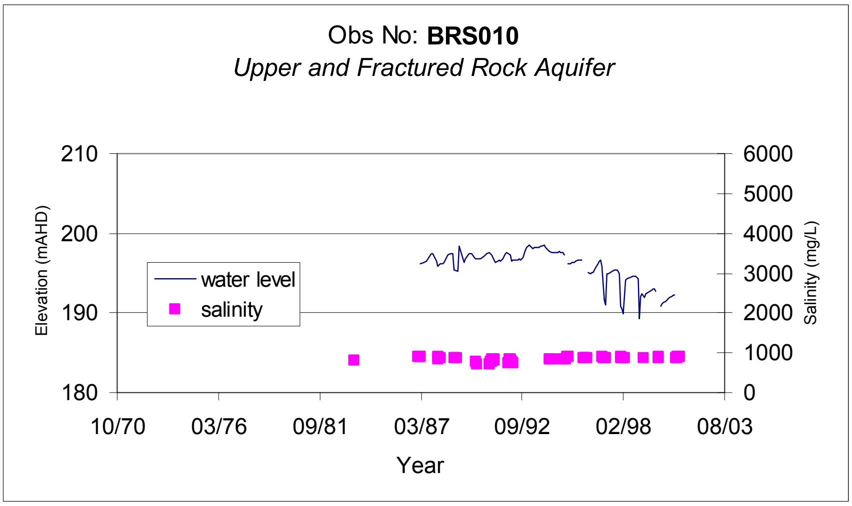

Obs No: **BLV004**
Upper Aquifer
water level
salinity
Elevation (mAHD)
Salinity (mg/L)
290
285
280
275
270
265
260
7000
6000
5000
4000
3000
2000
1000
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year


Obs No: **BLV005**
Upper Aquifer
water level
salinity
Elevation (mAHD)
Salinity (mg/L)
290
285
280
275
270
265
260
7000
6000
5000
4000
3000
2000
1000
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

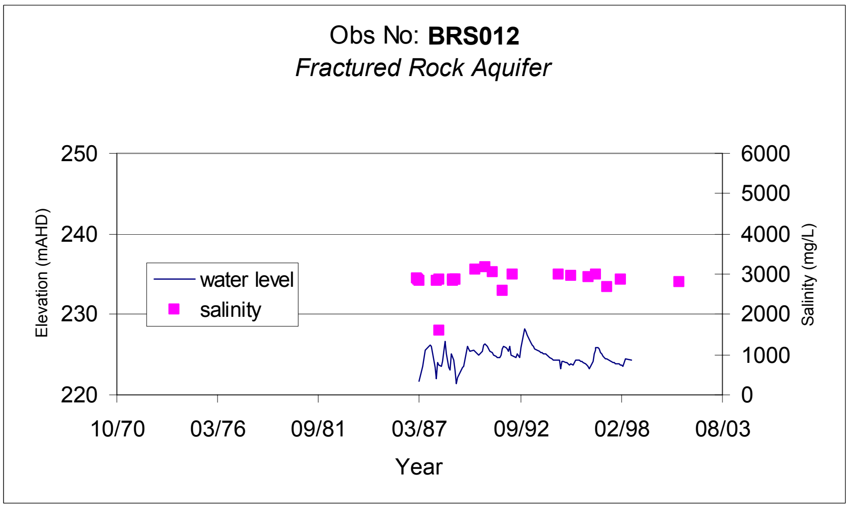

Obs No: BLV007
Fractured Rock Aquifer
290
285
280
275
270
265
260
Elevation (mAHD)
water level
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year


Obs No: BRS006
Fractured Rock Aquifer
220
210
200
190
180
170
Elevation (mAHD)
water level
salinity
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

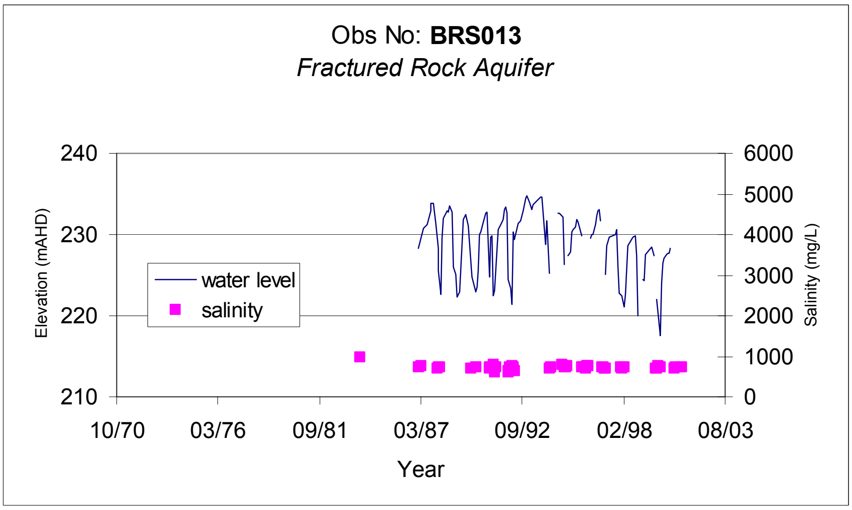

Obs No: BRS007
Upper Aquifer
190
180
170
160
Elevation (mAHD)
water level
salinity
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year



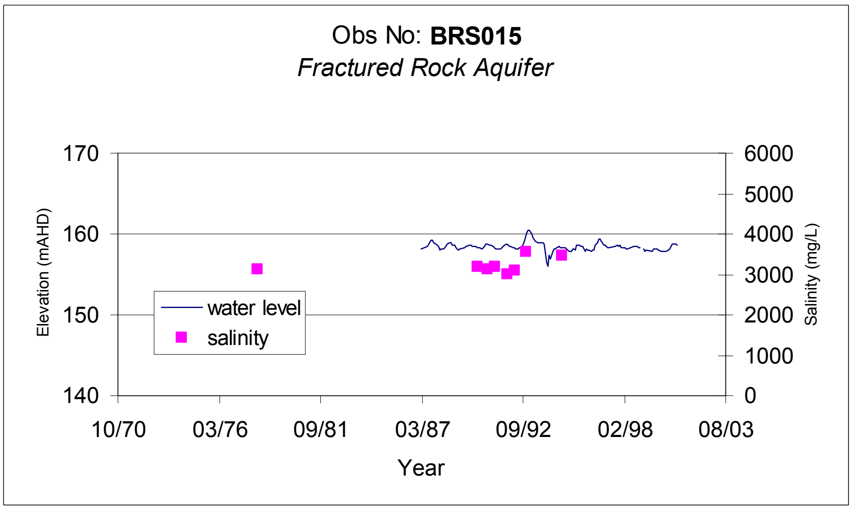
Obs No: **BRS010**
Upper and Fractured Rock Aquifer
Elevation (mAHD)
210
200
190
180
water level
salinity
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

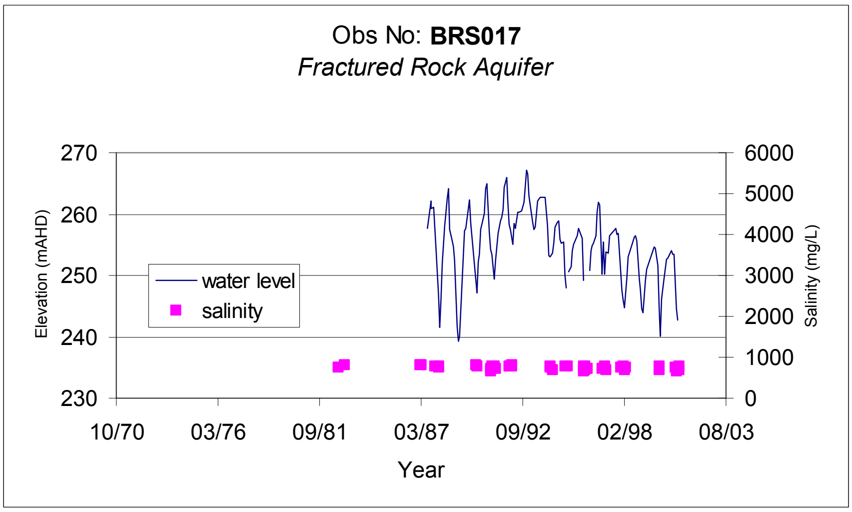


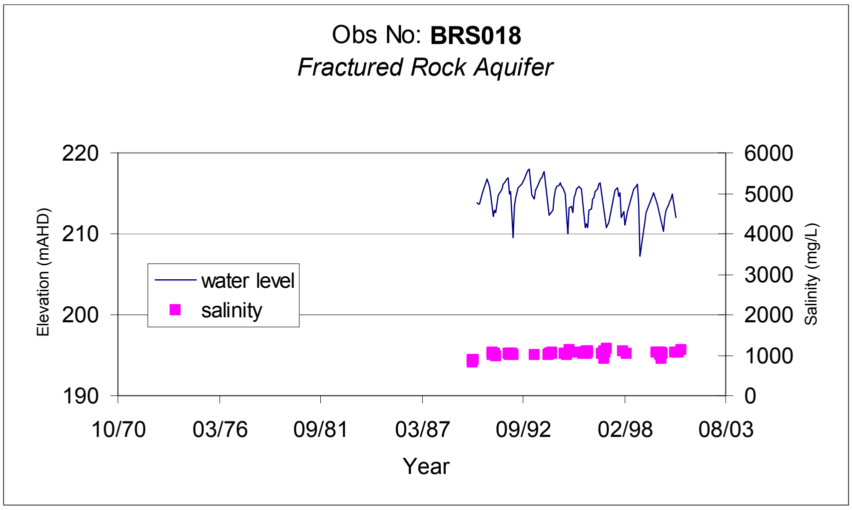
Obs No: **BRS012**
Fractured Rock Aquifer
Elevation (mAHD)
250
240
230
220
water level
salinity
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

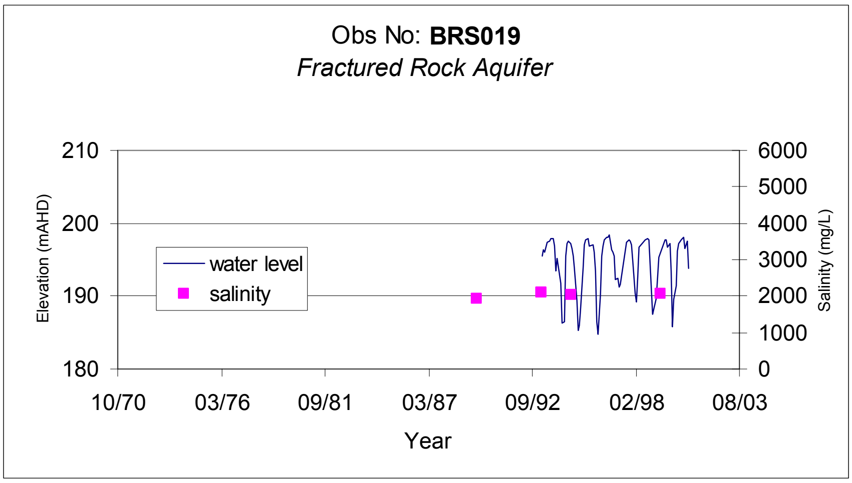


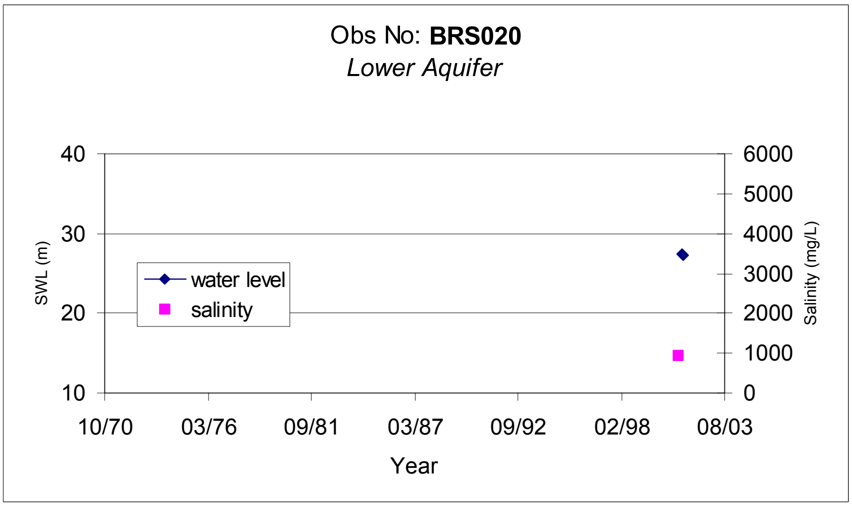
Obs No: **BRS013**
Fractured Rock Aquifer
Elevation (mAHD)
240
230
220
210
water level
salinity
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

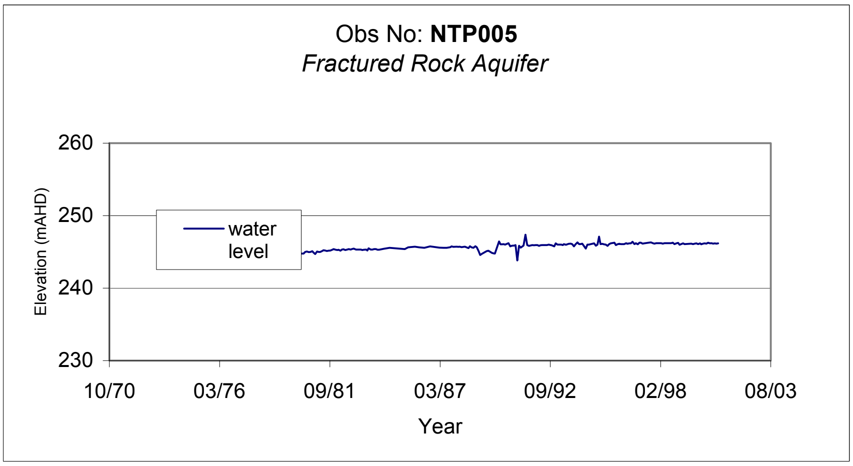

Obs No: BRS015
Fractured Rock Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
170
160
150
140
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

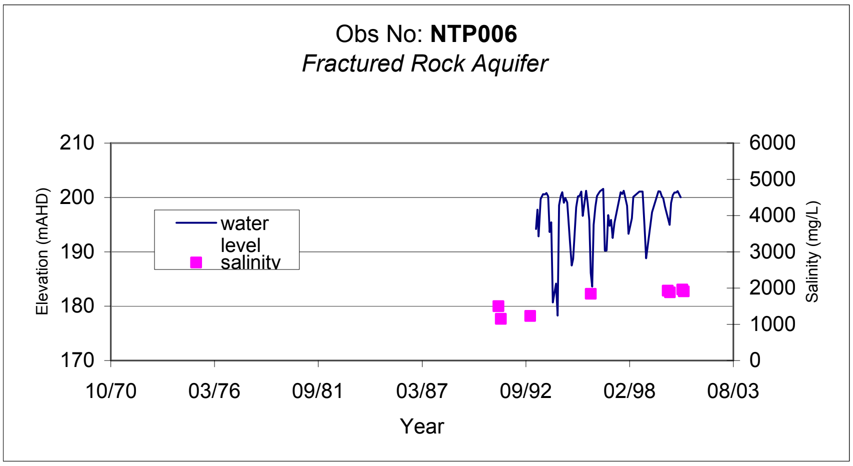

Obs No: BRS017
Fractured Rock Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
270
260
250
240
230
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year


Obs No: BRS018
Fractured Rock Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
220
210
200
190
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

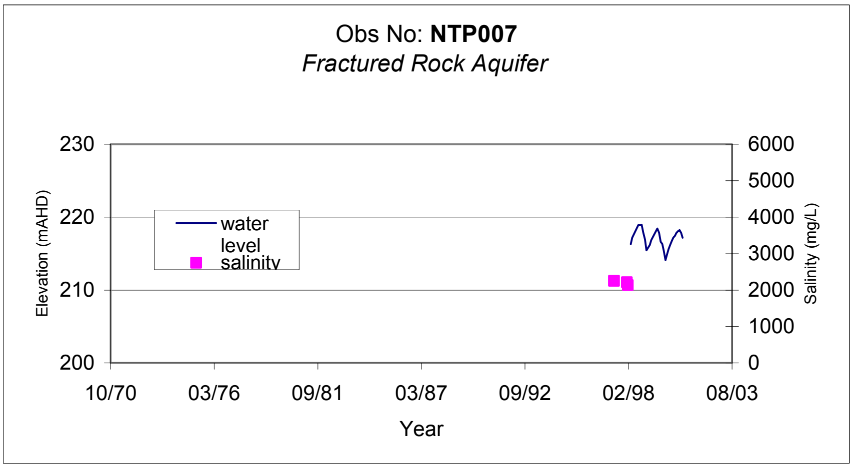

Obs No: BRS019
Fractured Rock Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
210
200
190
180
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year


Obs No: BRS020
Lower Aquifer
SWL (m)
Salinity (mg/L)
water level
salinity
40
30
20
10
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

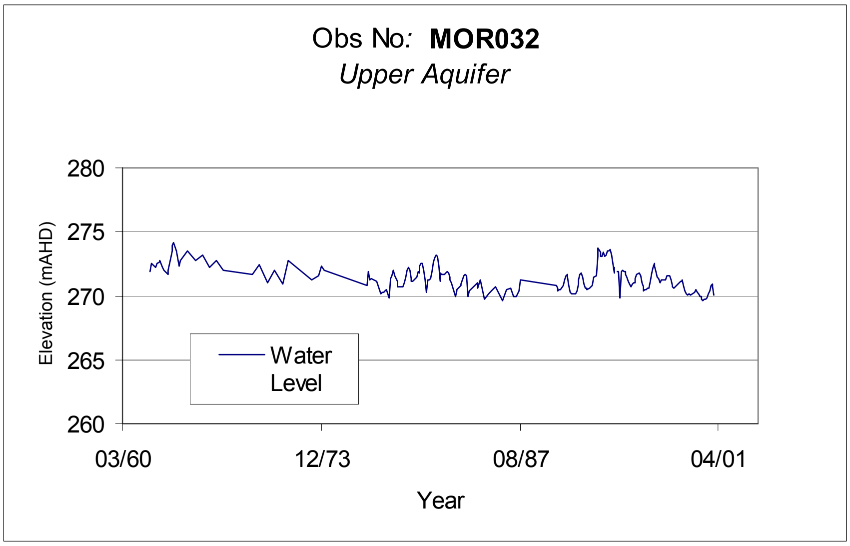

Obs No: NTP005
Fractured Rock Aquifer
Elevation (mAHD)
water level
260
250
240
230
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year



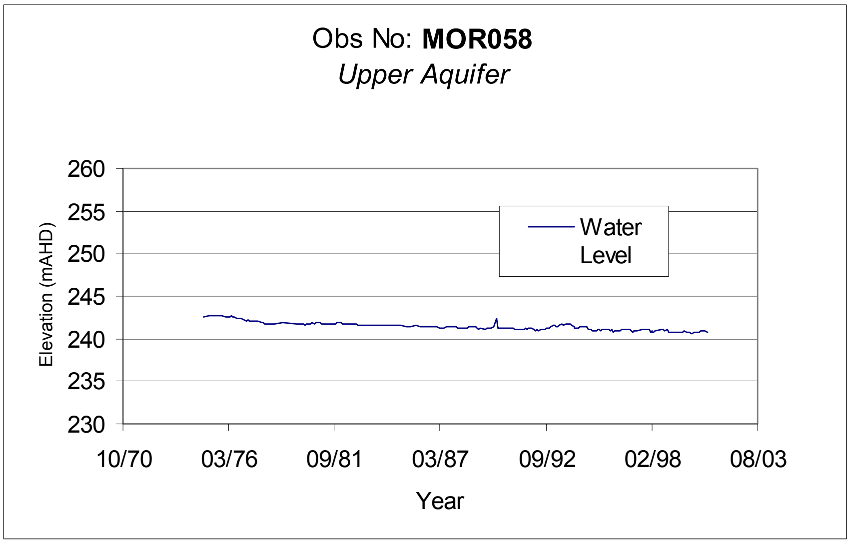
Obs No: NTP006
Fractured Rock Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
210
200
190
180
170
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

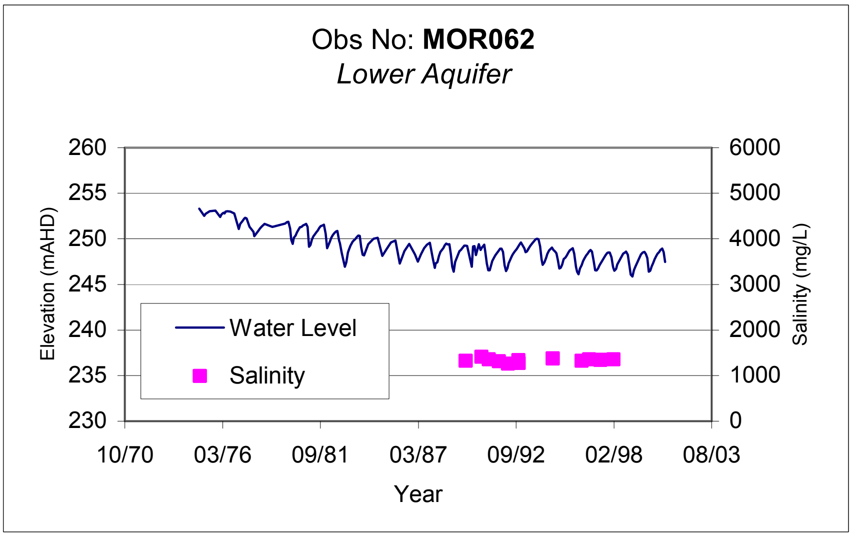


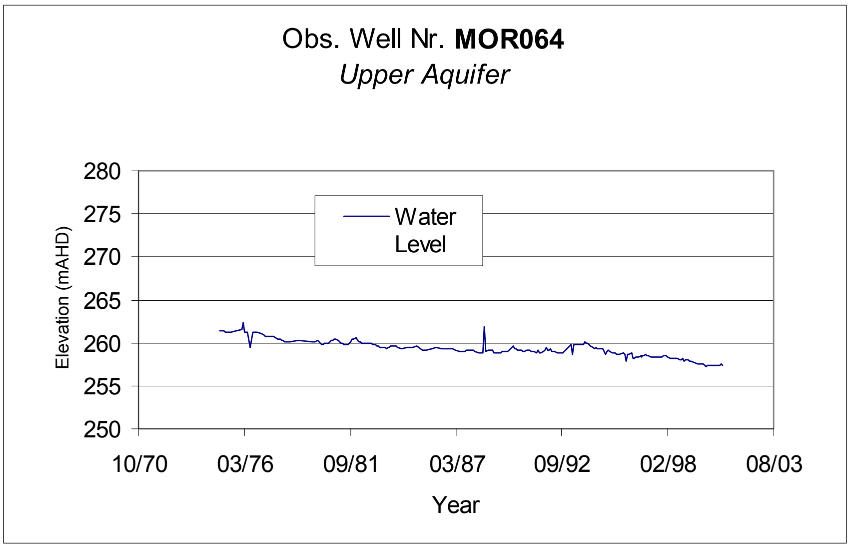
Obs No: NTP007
Fractured Rock Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
230
220
210
200
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

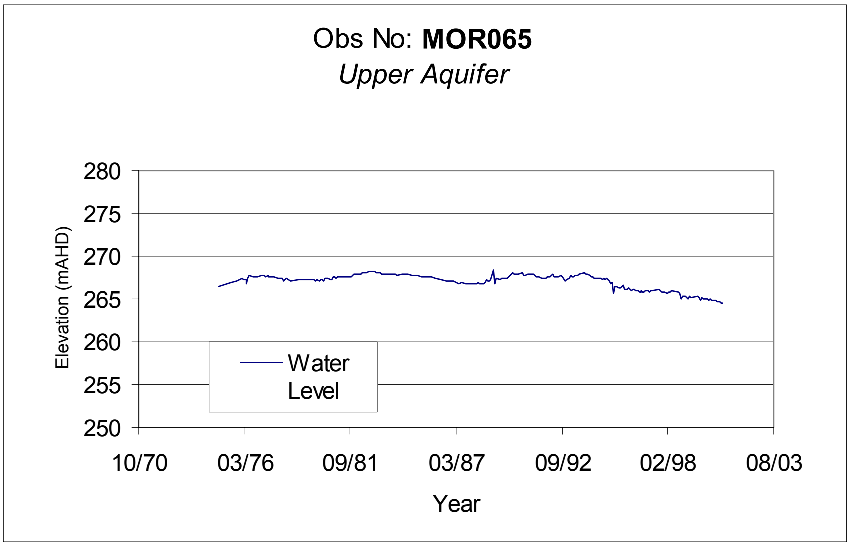


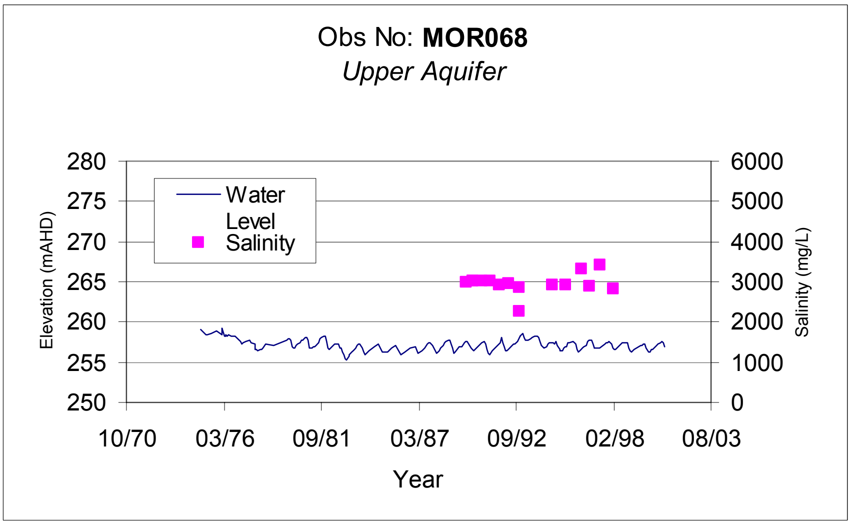
Obs No: MOR032
Upper Aquifer
Elevation (mAHD)
Water Level
280
275
270
265
260
03/60
12/73
08/87
04/01
Year

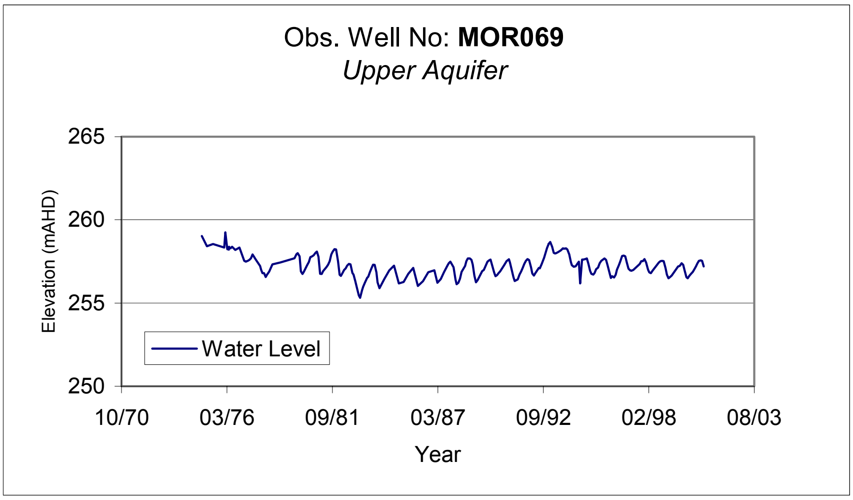

Obs No: **MOR058**
Upper Aquifer
Water Level
Elevation (mAHD)
260
255
250
245
240
235
230
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

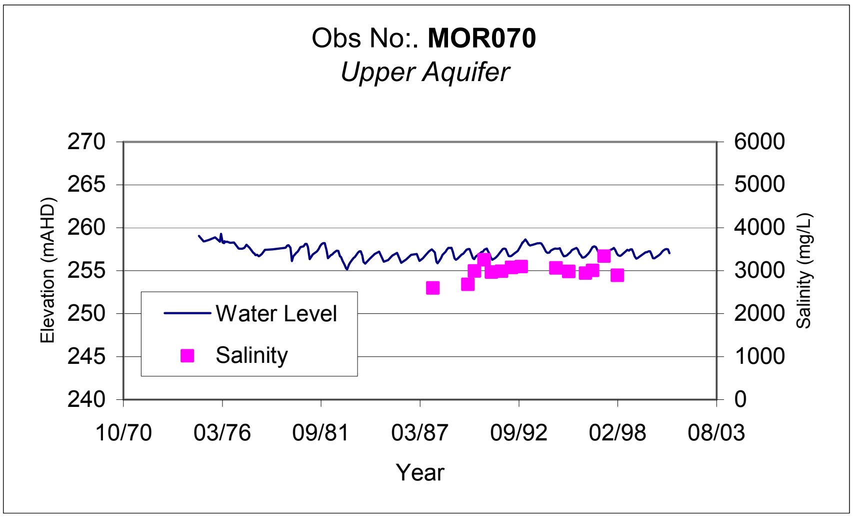

Obs No: **MOR062**
Lower Aquifer
Water Level
Salinity
Elevation (mAHD)
Salinity (mg/L)
260
255
250
245
240
235
230
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

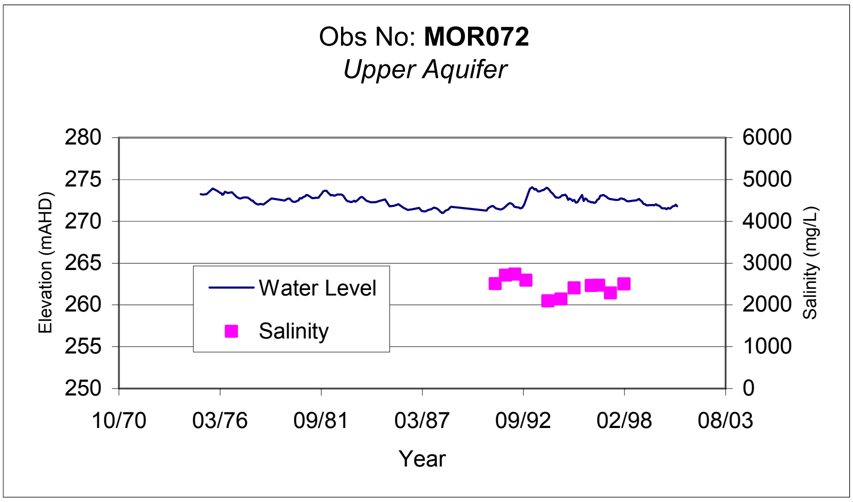

Obs. Well Nr. **MOR064**
Upper Aquifer
Water Level
Elevation (mAHD)
280
275
270
265
260
255
250
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

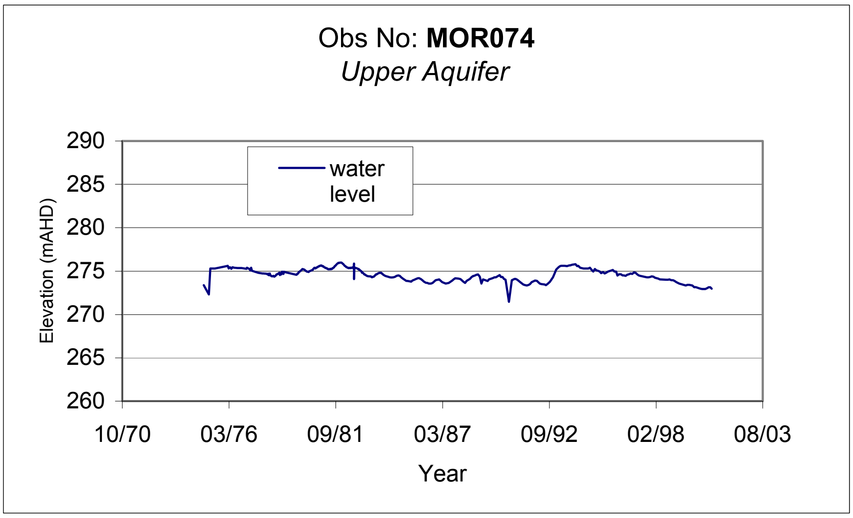

Obs No: MOR065
Upper Aquifer
Elevation (mAHD)
280
275
270
265
260
255
250
Water Level
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

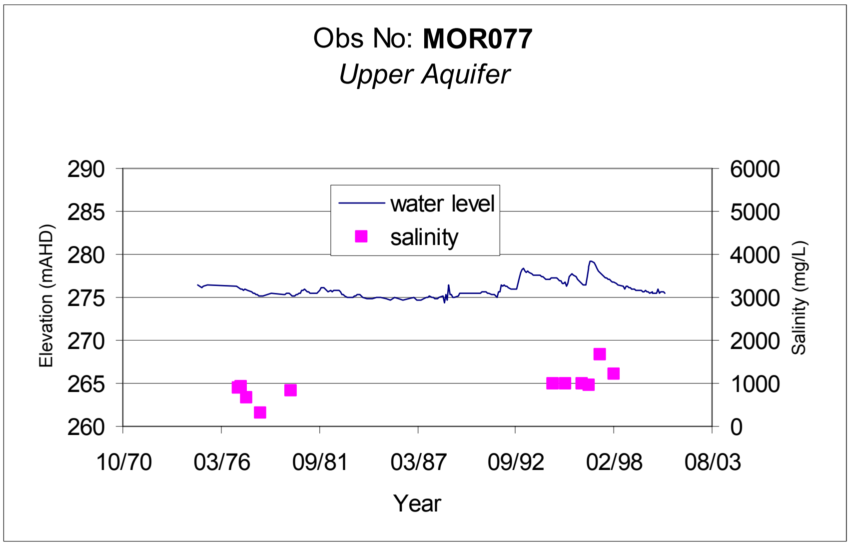

Obs No: MOR068
Upper Aquifer
Elevation (mAHD)
280
275
270
265
260
255
250
Water Level
Salinity
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

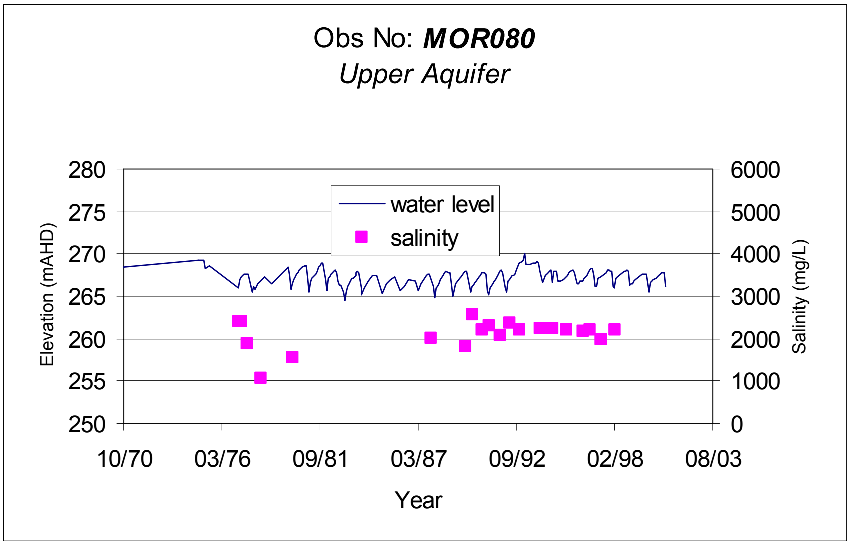

Obs. Well No: MOR069
Upper Aquifer
Elevation (mAHD)
265
260
255
250
Water Level
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

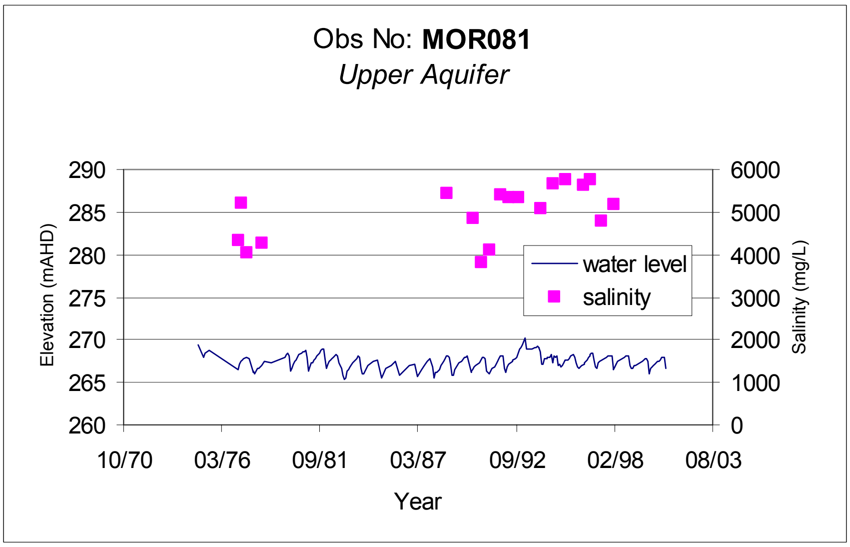

Obs No:. MOR070
Upper Aquifer
270
265
260
255
250
245
240
6000
5000
4000
3000
2000
1000
0
Elevation (mAHD)
Salinity (mg/L)
Water Level
Salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

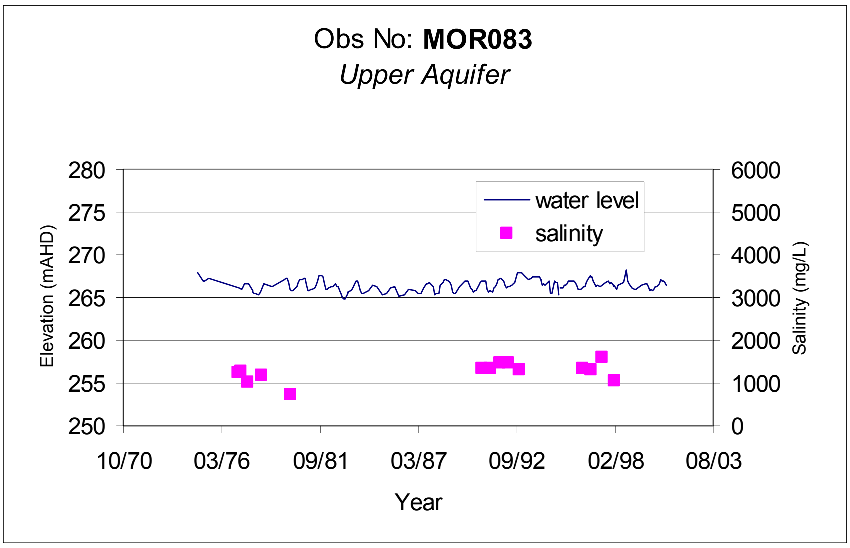

Obs No: MOR072
Upper Aquifer
280
275
270
265
260
255
250
6000
5000
4000
3000
2000
1000
0
Elevation (mAHD)
Salinity (mg/L)
Water Level
Salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year


Obs No: MOR074
Upper Aquifer
290
285
280
275
270
265
260
Elevation (mAHD)
water level
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

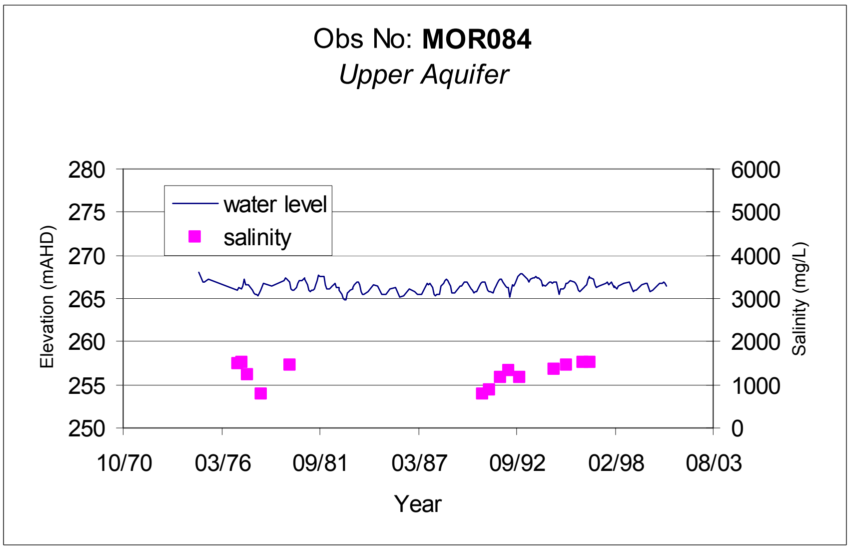

Obs No: MOR077
Upper Aquifer
water level
salinity
Elevation (mAHD)
Salinity (mg/L)
290
285
280
275
270
265
260
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year


Obs No: MOR080
Upper Aquifer
water level
salinity
Elevation (mAHD)
Salinity (mg/L)
280
275
270
265
260
255
250
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

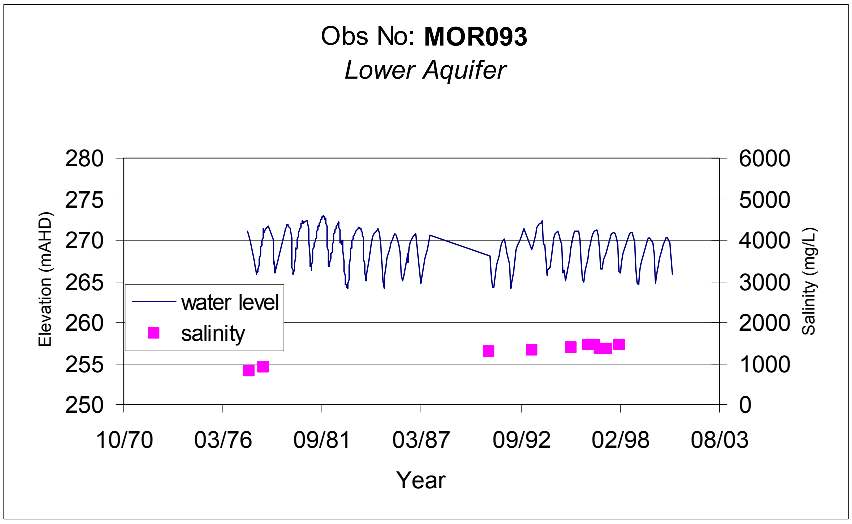

Obs No: MOR081
Upper Aquifer
water level
salinity
Elevation (mAHD)
Salinity (mg/L)
290
285
280
275
270
265
260
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year



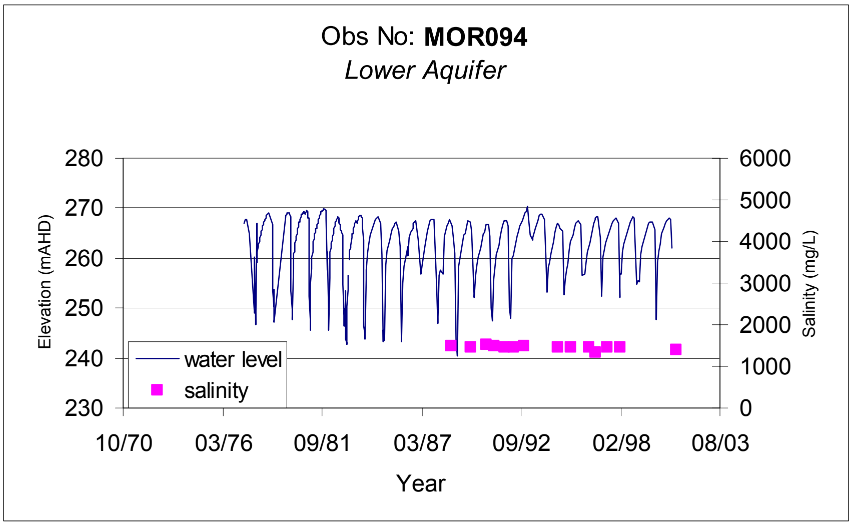
Obs No: MOR083
Upper Aquifer
280
275
270
265
260
255
250
6000
5000
4000
3000
2000
1000
0
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

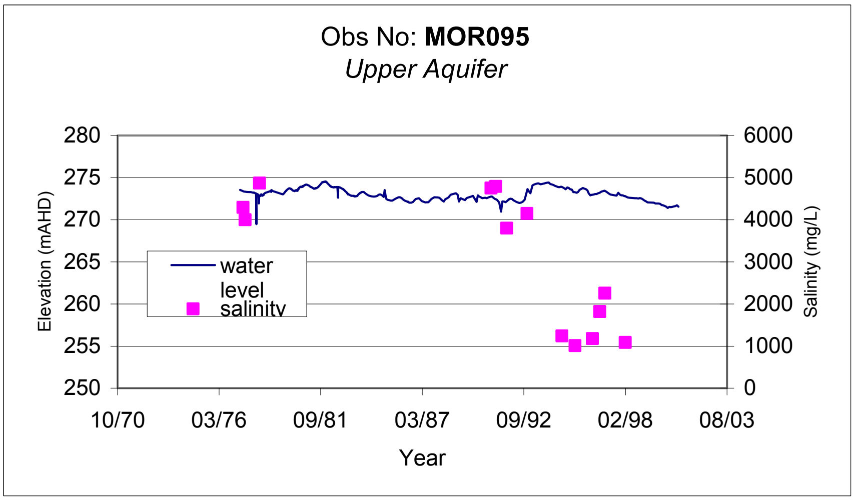


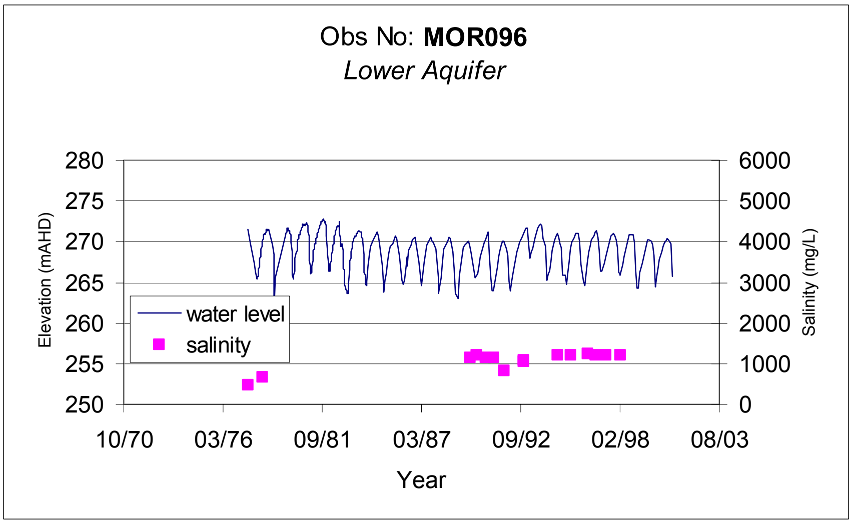
Obs No: MOR084
Upper Aquifer
280
275
270
265
260
255
250
6000
5000
4000
3000
2000
1000
0
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

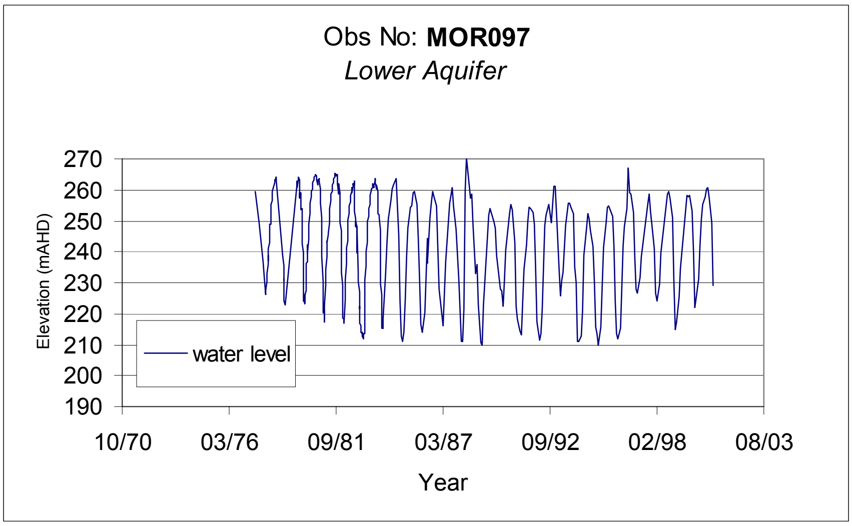


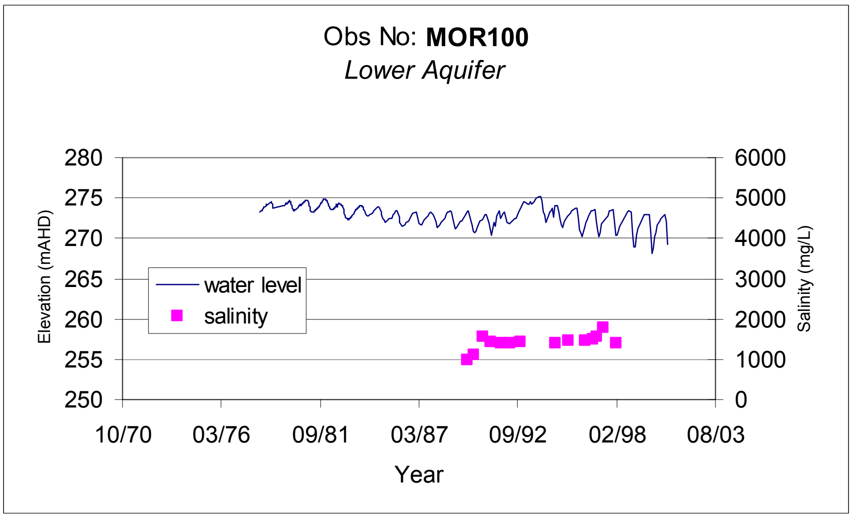
Obs No: MOR093
Lower Aquifer
280
275
270
265
260
255
250
6000
5000
4000
3000
2000
1000
0
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

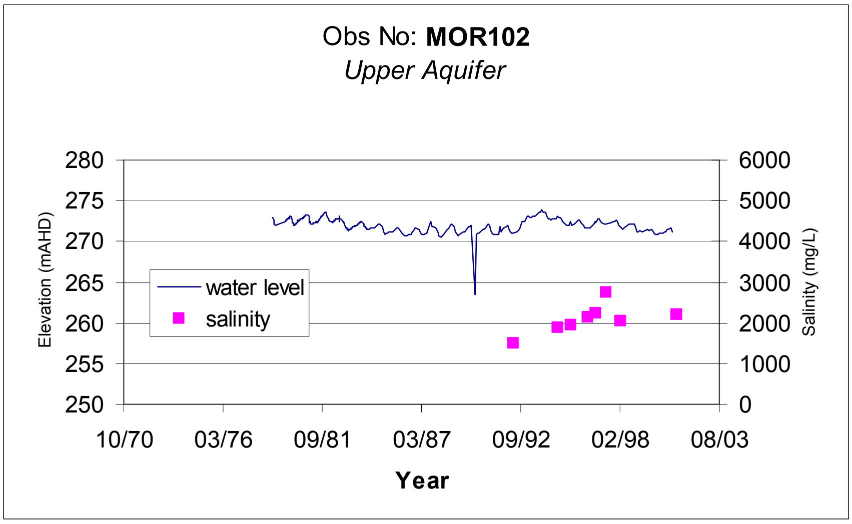

Obs No: MOR094
Lower Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
Year
280
270
260
250
240
230
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03

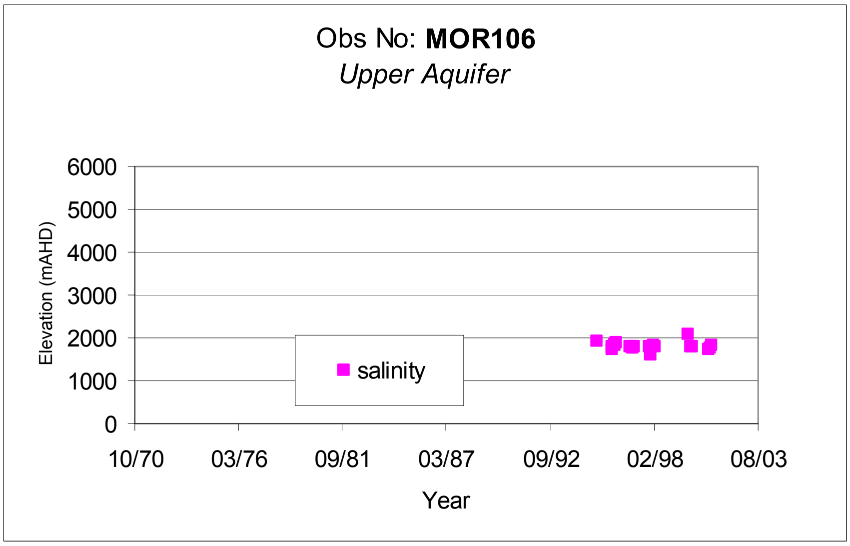

Obs No: MOR095
Upper Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
Year
280
275
270
265
260
255
250
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03

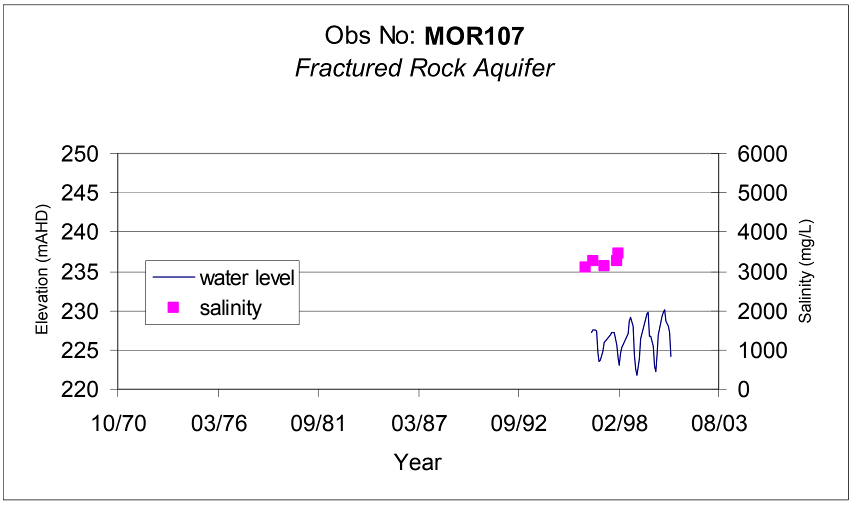

Obs No: MOR096
Lower Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
Year
280
275
270
265
260
255
250
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03

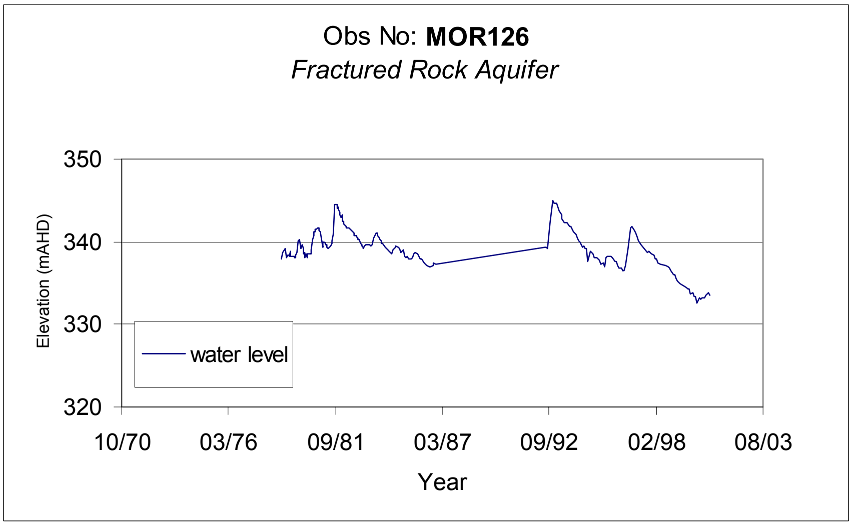

Obs No: MOR097
Lower Aquifer
270
260
250
240
230
220
210
200
190
Elevation (mAHD)
water level
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

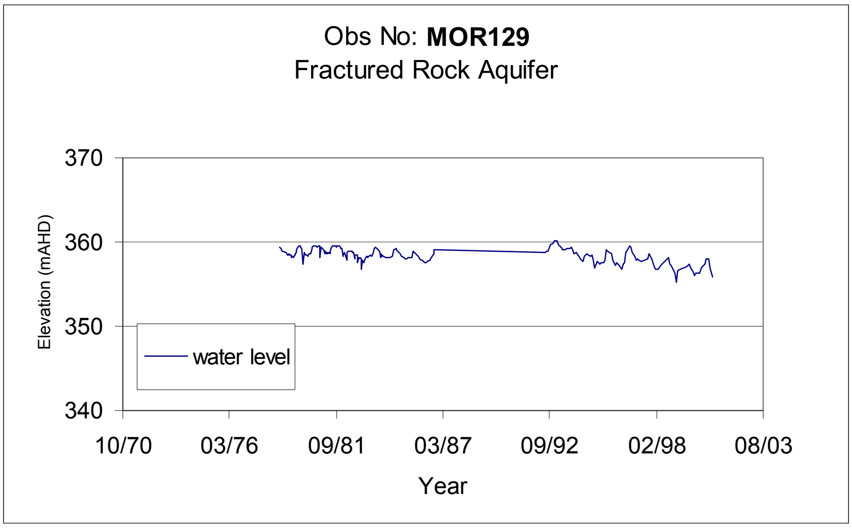

Obs No: MOR100
Lower Aquifer
280
275
270
265
260
255
250
Elevation (mAHD)
water level
salinity
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

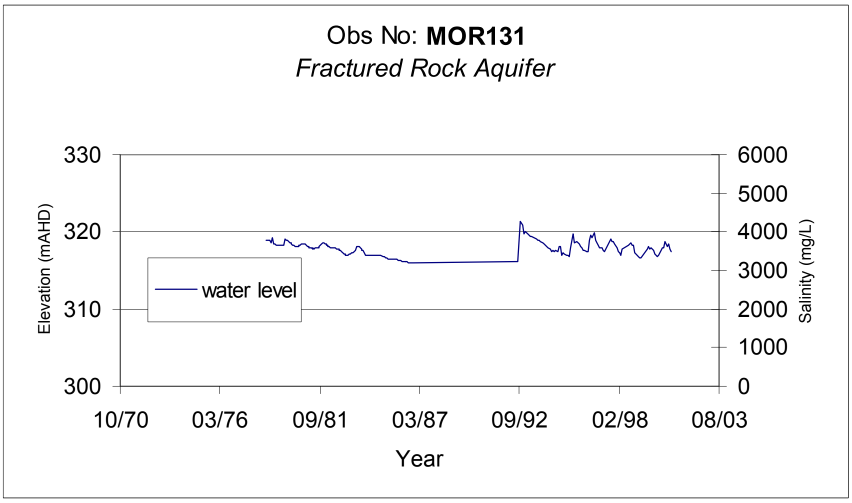

Obs No: MOR102
Upper Aquifer
280
275
270
265
260
255
250
Elevation (mAHD)
water level
salinity
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

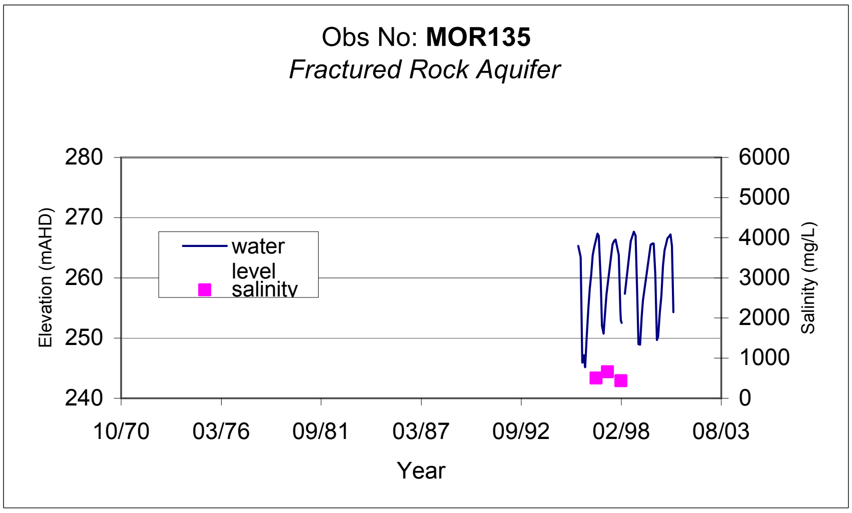

Obs No: MOR106
Upper Aquifer
Elevation (mAHD)
6000
5000
4000
3000
2000
1000
0
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

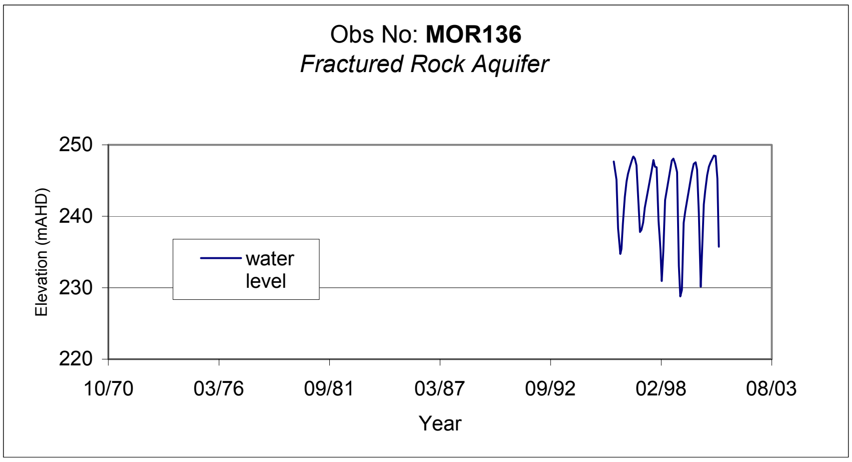

Obs No: MOR107
Fractured Rock Aquifer
Elevation (mAHD)
250
245
240
235
230
225
220
water level
salinity
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

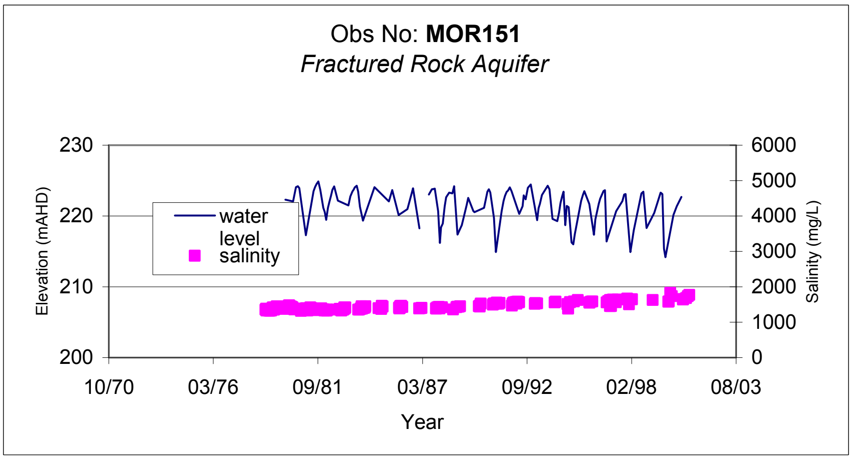

Obs No: MOR126
Fractured Rock Aquifer
Elevation (mAHD)
350
340
330
320
water level
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

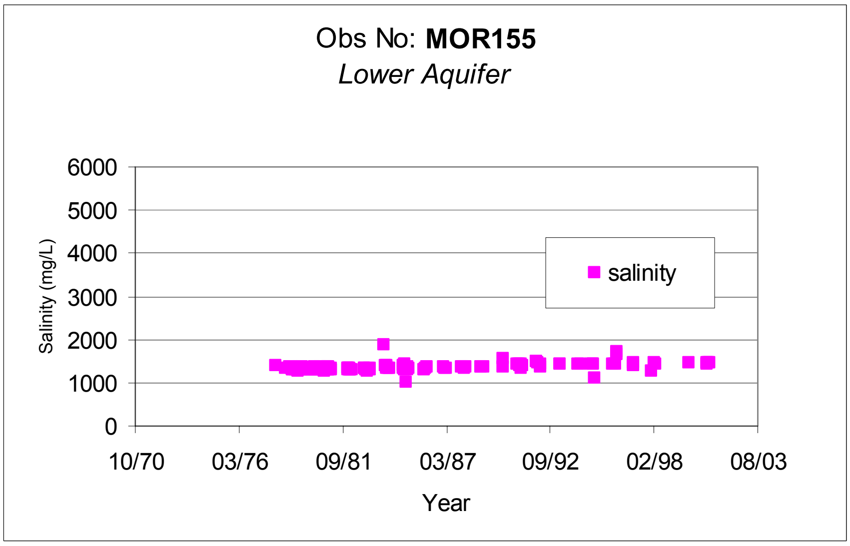

Obs No: **MOR129**
Fractured Rock Aquifer
370
360
350
340
Elevation (mAHD)
water level
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

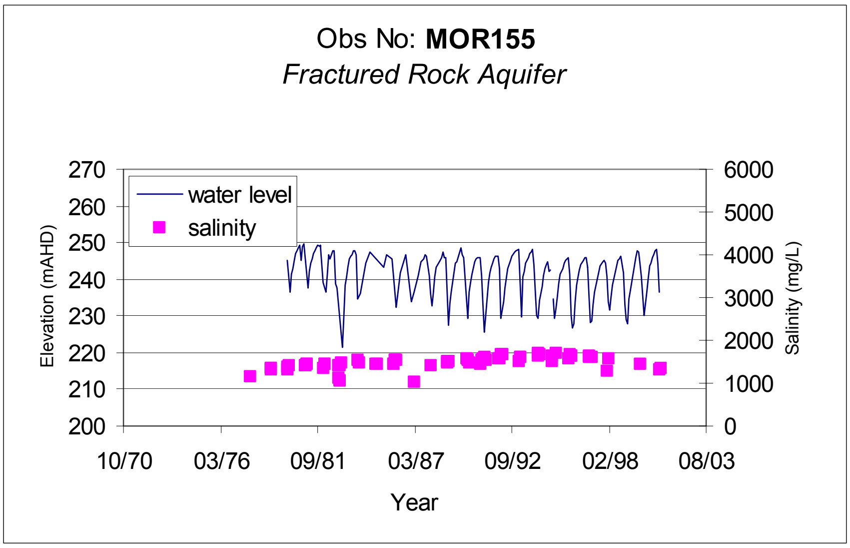

Obs No: **MOR131**
Fractured Rock Aquifer
330
320
310
300
Elevation (mAHD)
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
water level
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

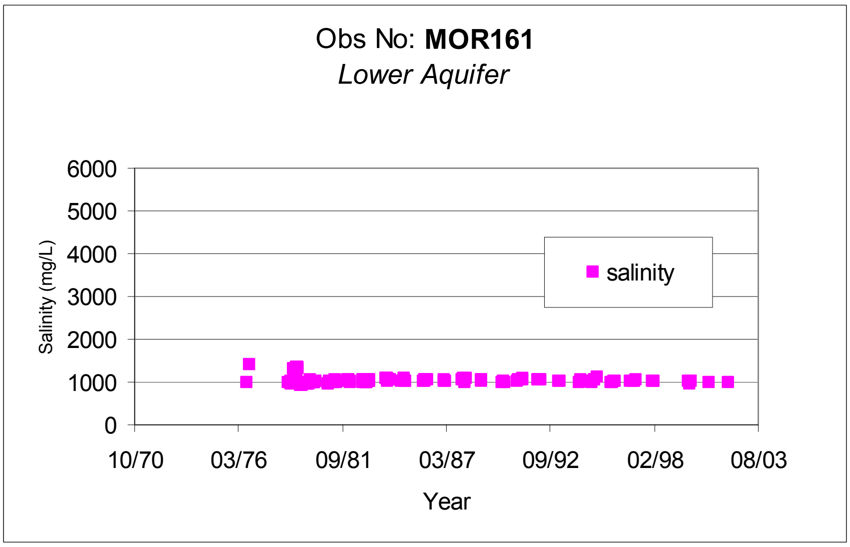

Obs No: **MOR135**
Fractured Rock Aquifer
280
270
260
250
240
Elevation (mAHD)
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
water level
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

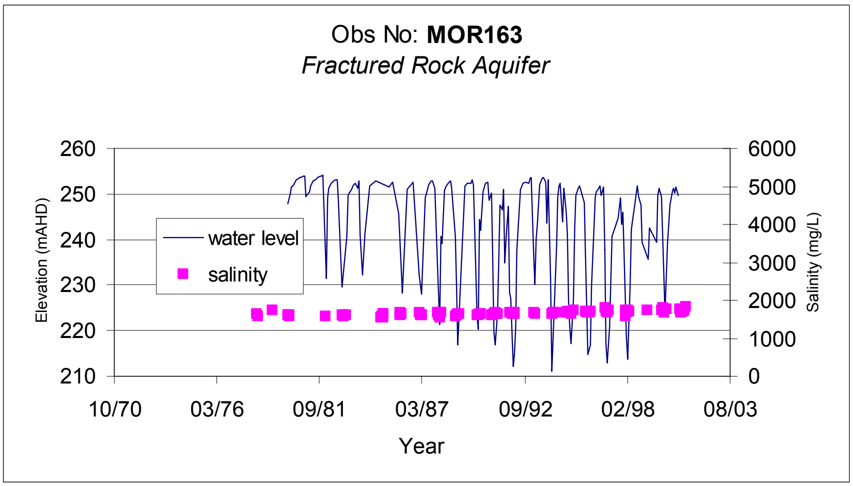

Obs No: MOR136
Fractured Rock Aquifer
Elevation (mAHD)
250
240
230
220
water level
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

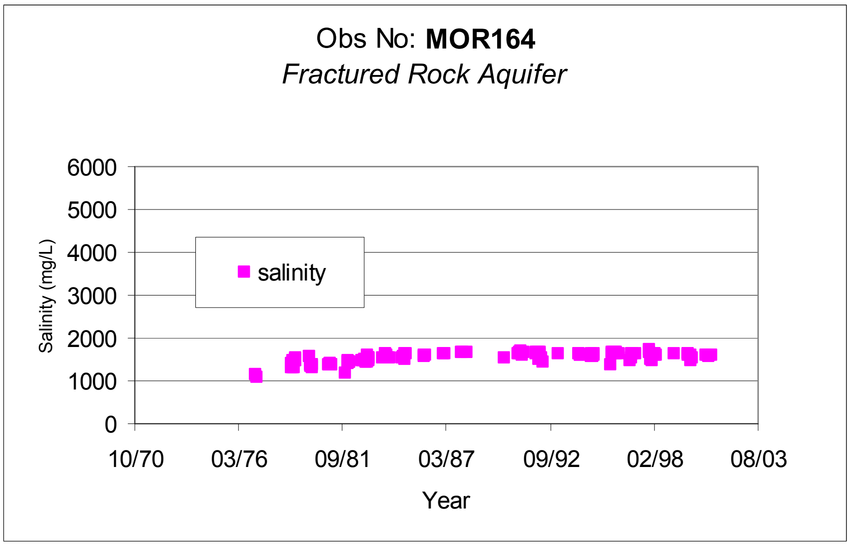

Obs No: MOR151
Fractured Rock Aquifer
Elevation (mAHD)
230
220
210
200
water level
salinity
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

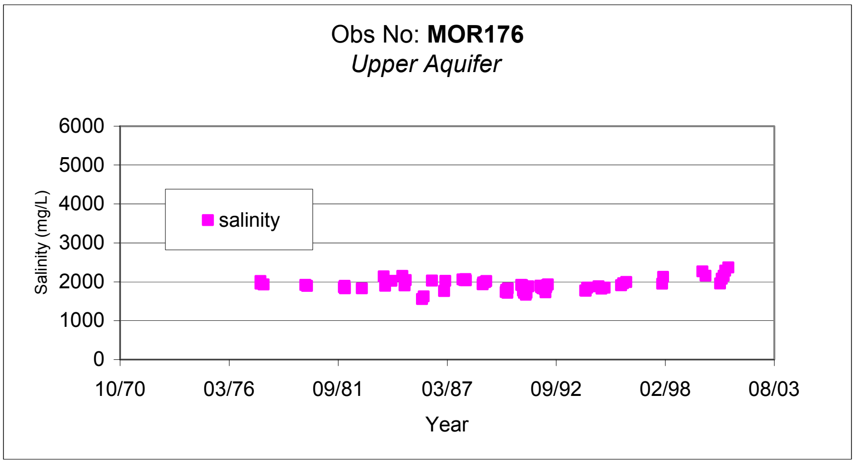

Obs No: MOR155
Lower Aquifer
Salinity (mg/L)
6000
5000
4000
3000
2000
1000
0
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

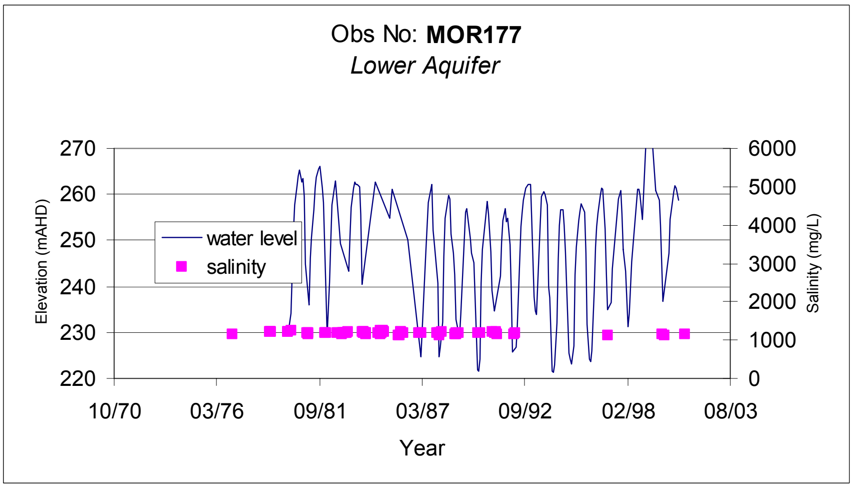

Obs No: **MOR155**
Fractured Rock Aquifer
water level
salinity
Elevation (mAHD)
Salinity (mg/L)
270
260
250
240
230
220
210
200
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

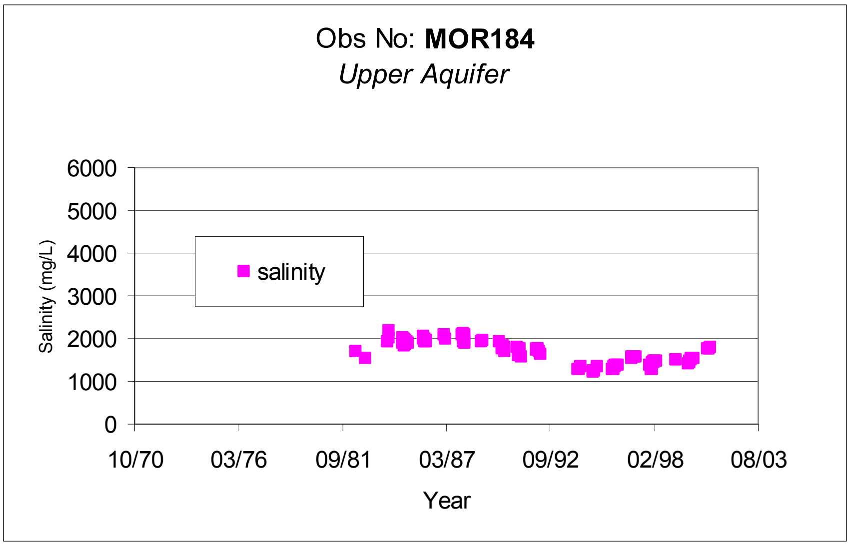

Obs No: **MOR161**
Lower Aquifer
salinity
Salinity (mg/L)
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

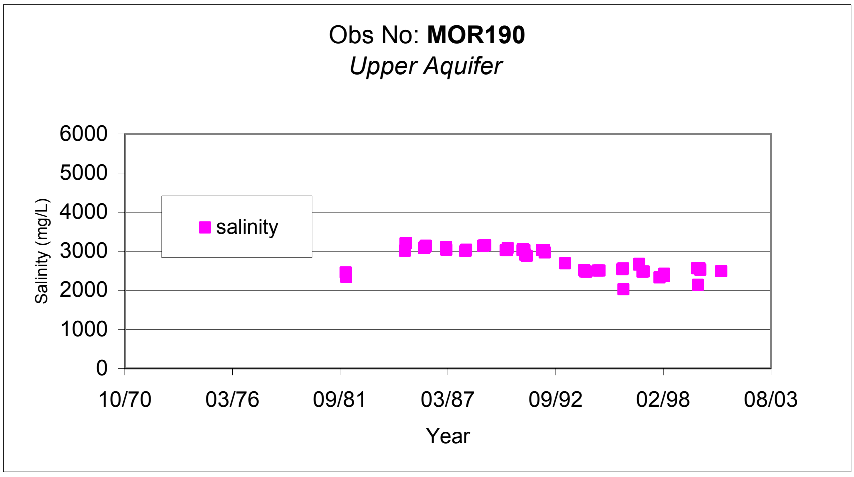

Obs No: **MOR163**
Fractured Rock Aquifer
water level
salinity
Elevation (mAHD)
Salinity (mg/L)
260
250
240
230
220
210
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

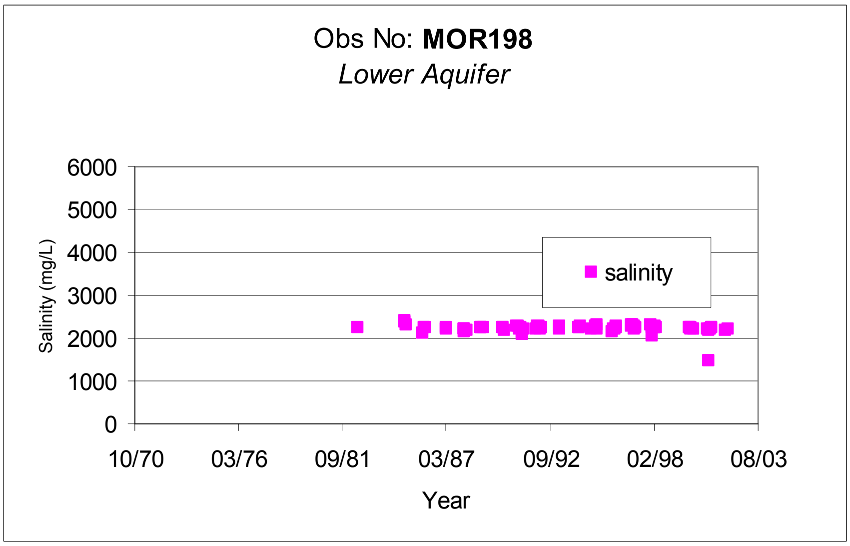

Obs No: MOR164
Fractured Rock Aquifer
salinity
Salinity (mg/L)
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

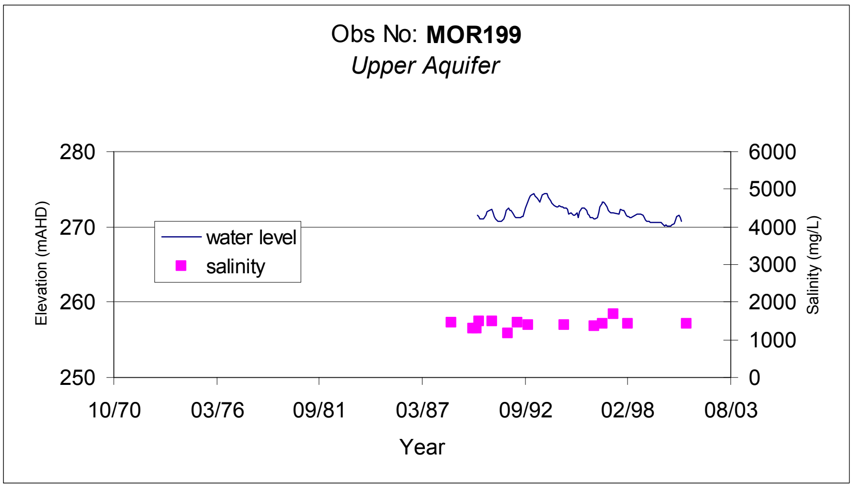

Obs No: MOR176
Upper Aquifer
salinity
Salinity (mg/L)
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

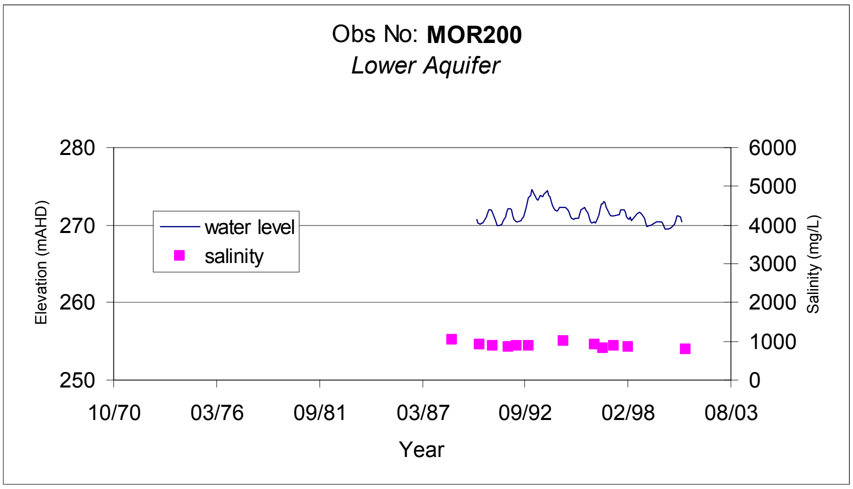

Obs No: MOR177
Lower Aquifer
water level
salinity
Elevation (mAHD)
270
260
250
240
230
220
Salinity (mg/L)
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

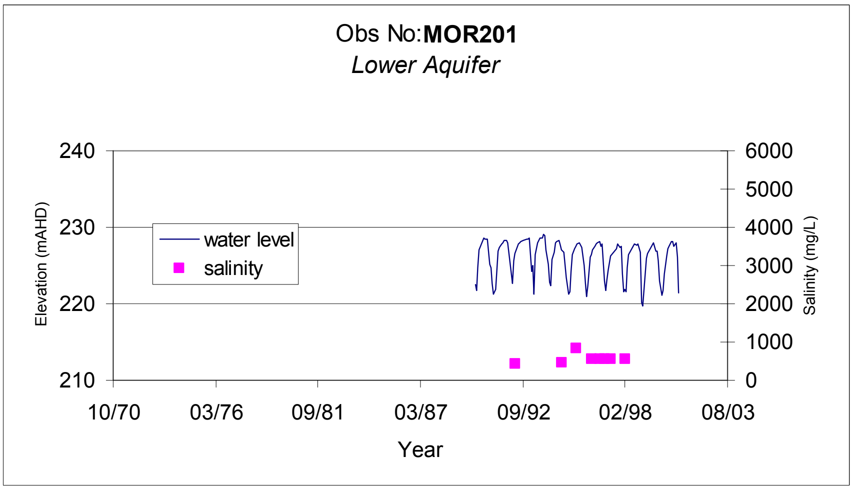

Obs No: MOR184
Upper Aquifer
Salinity (mg/L)
6000
5000
4000
3000
2000
1000
0
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

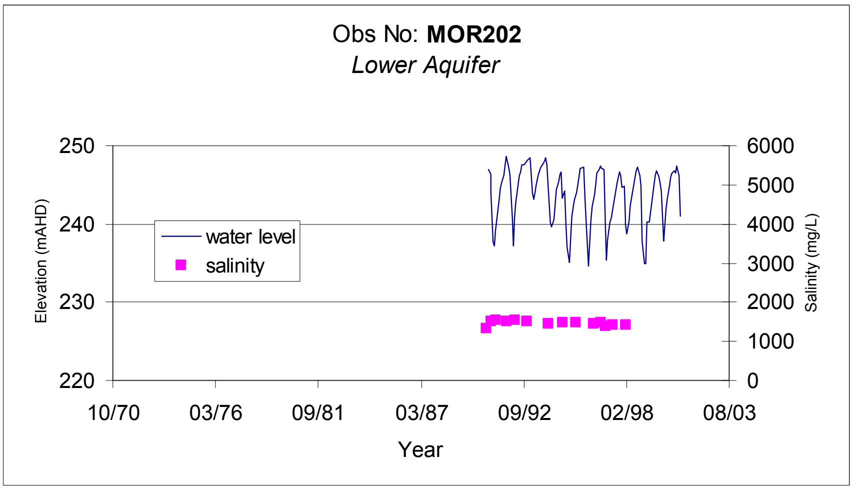

Obs No: MOR190
Upper Aquifer
Salinity (mg/L)
6000
5000
4000
3000
2000
1000
0
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

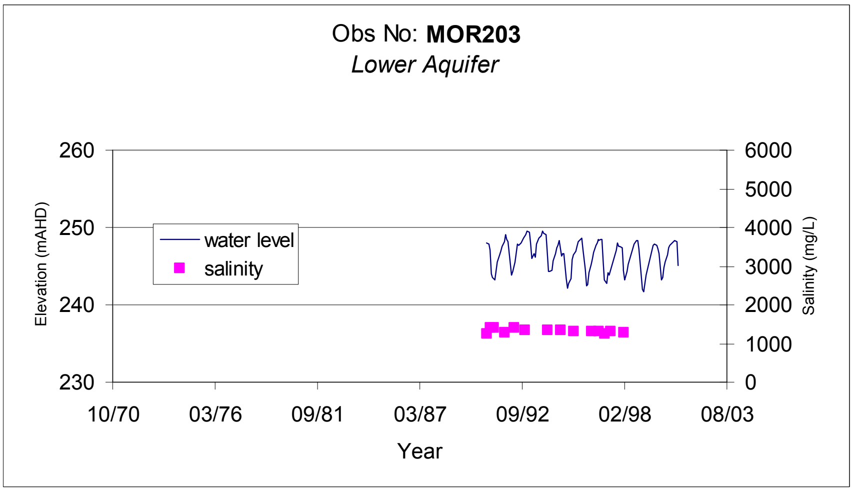

Obs No: MOR198
Lower Aquifer
Salinity (mg/L)
6000
5000
4000
3000
2000
1000
0
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

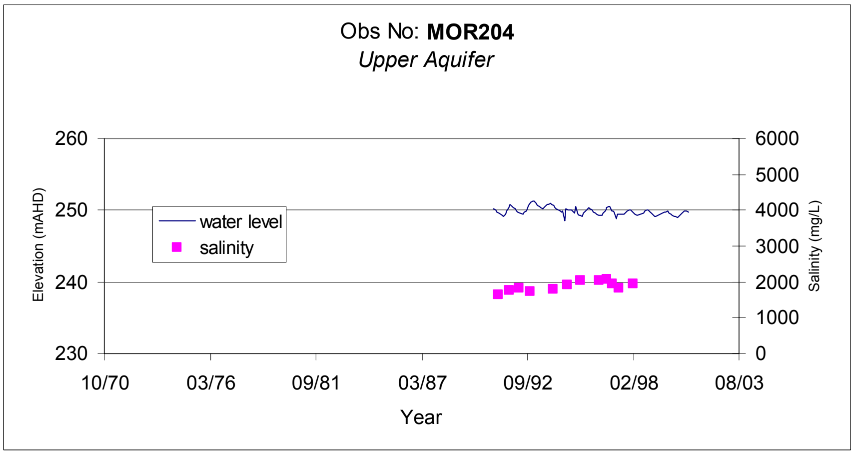

Obs No: MOR199
Upper Aquifer
280
270
260
250
6000
5000
4000
3000
2000
1000
0
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

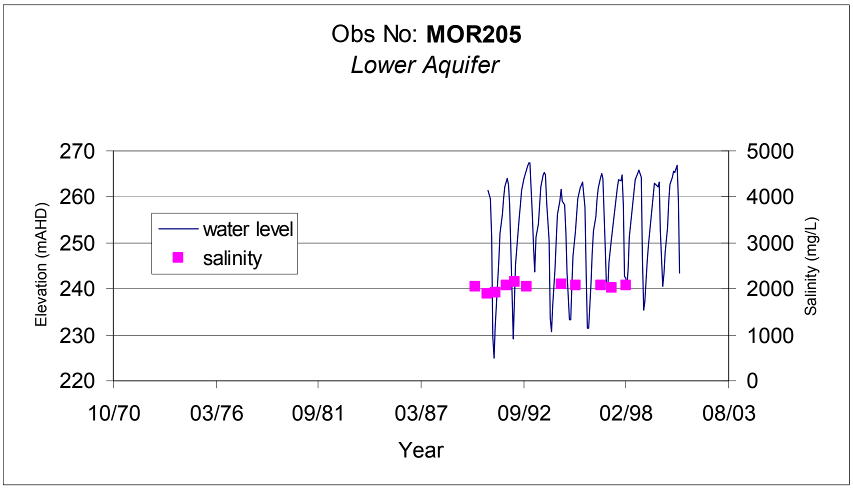

Obs No: MOR200
Lower Aquifer
280
270
260
250
6000
5000
4000
3000
2000
1000
0
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

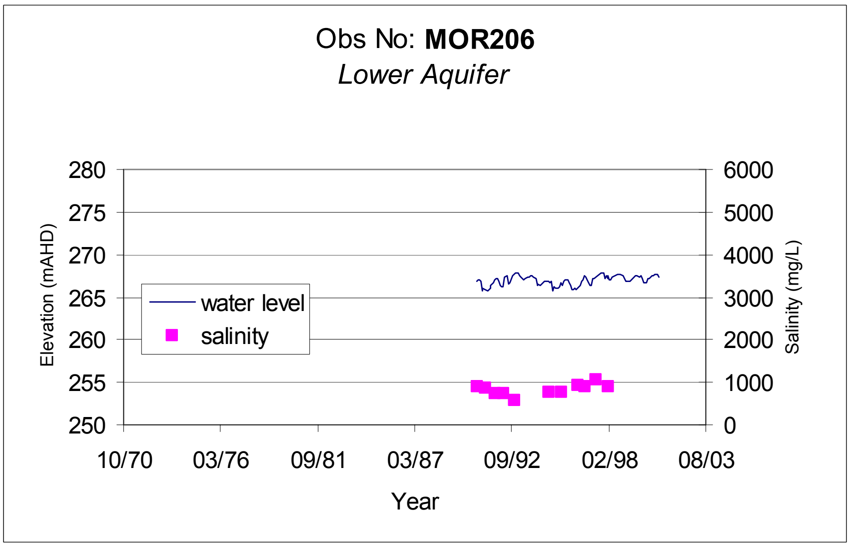

Obs No:MOR201
Lower Aquifer
240
230
220
210
6000
5000
4000
3000
2000
1000
0
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

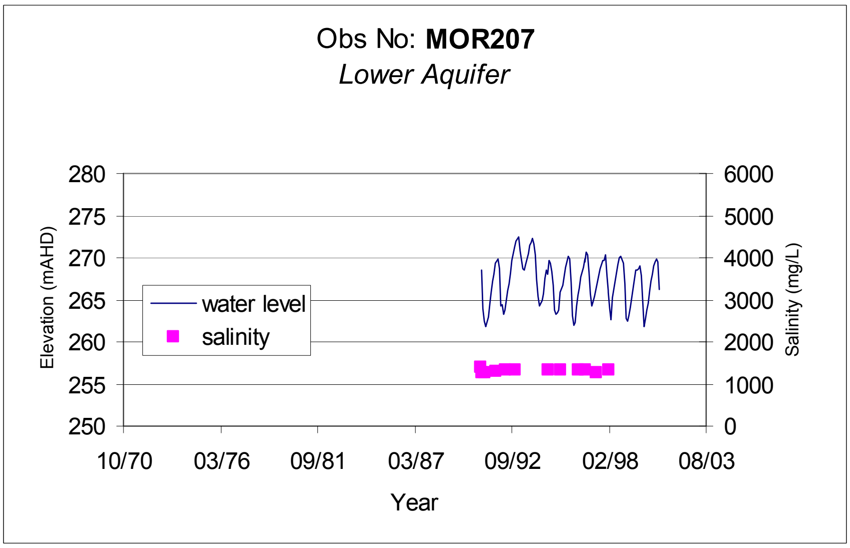

Obs No: MOR202
Lower Aquifer
250
240
230
220
Elevation (mAHD)
water level
salinity
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

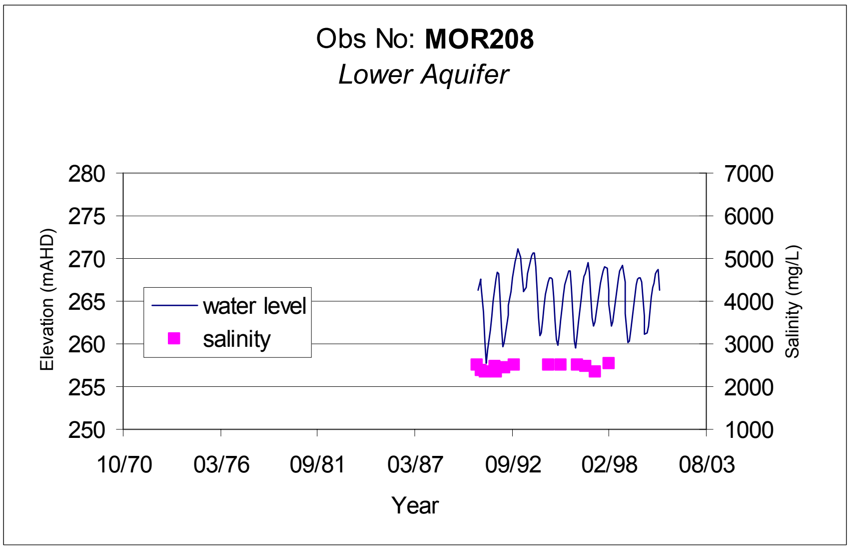

Obs No: MOR203
Lower Aquifer
260
250
240
230
Elevation (mAHD)
water level
salinity
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

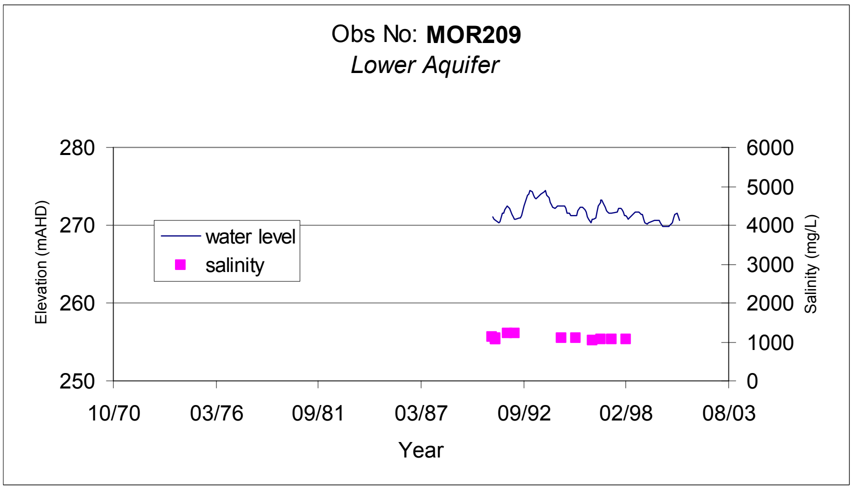

Obs No: MOR204
Upper Aquifer
260
250
240
230
Elevation (mAHD)
water level
salinity
6000
5000
4000
3000
2000
1000
0
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

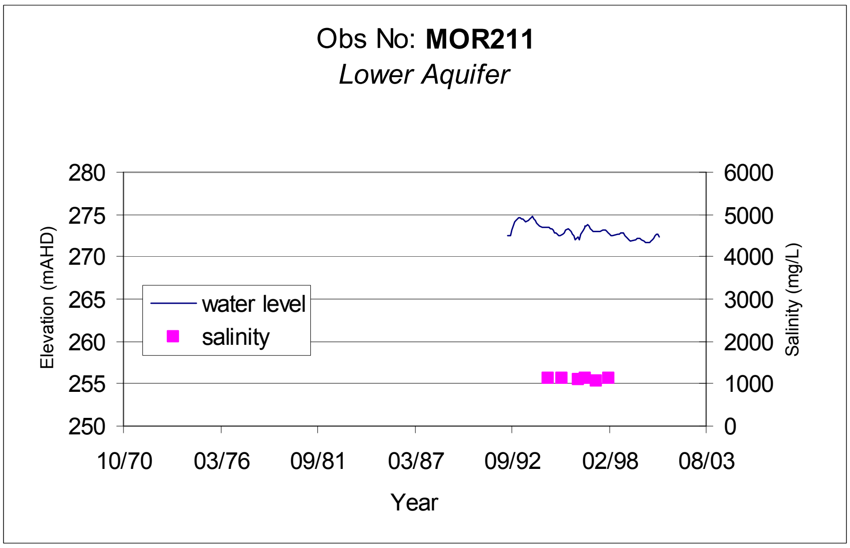

Obs No: MOR205
Lower Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
270
260
250
240
230
220
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

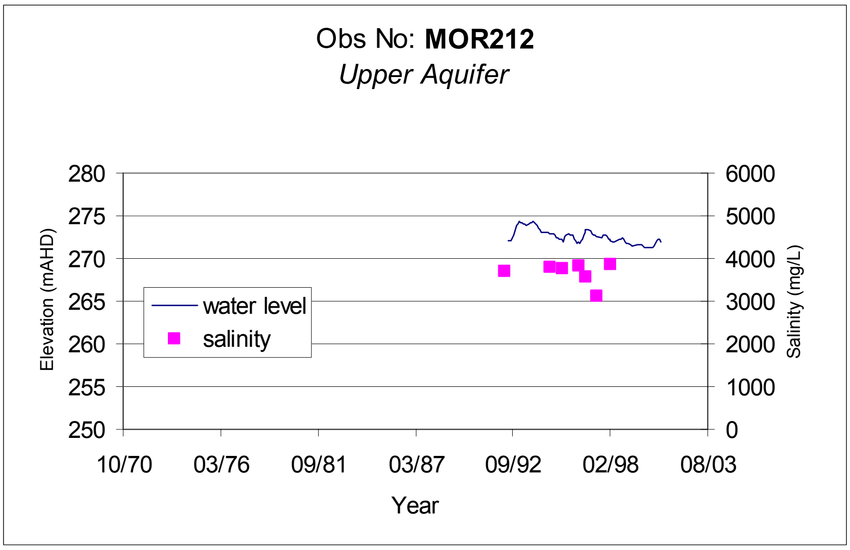

Obs No: MOR206
Lower Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
280
275
270
265
260
255
250
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

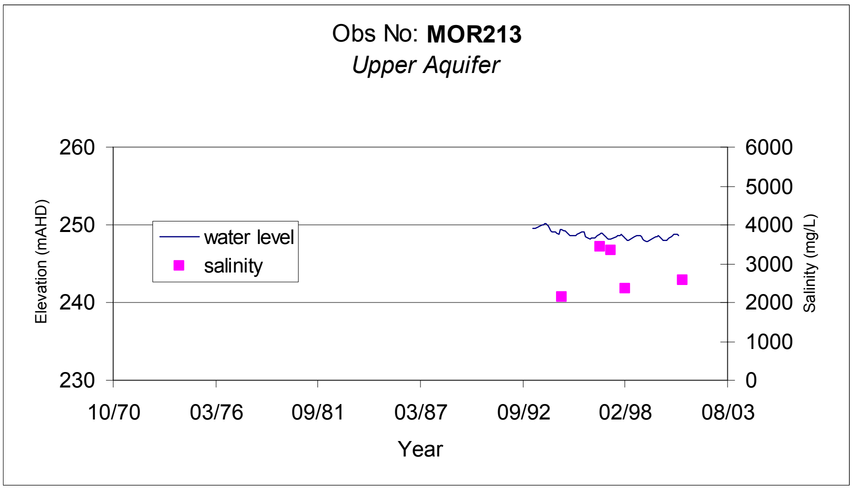

Obs No: MOR207
Lower Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
280
275
270
265
260
255
250
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

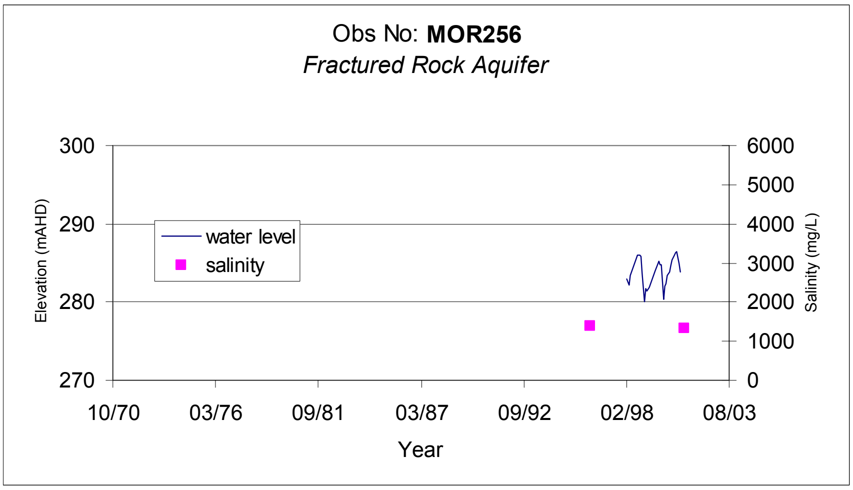

Obs No: MOR208
Lower Aquifer
280
275
270
265
260
255
250
7000
6000
5000
4000
3000
2000
1000
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

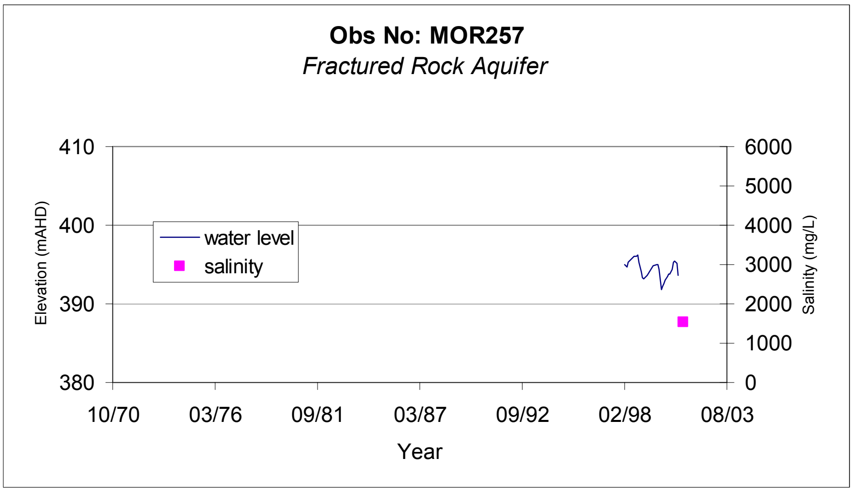

Obs No: MOR209
Lower Aquifer
280
270
260
250
6000
5000
4000
3000
2000
1000
0
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

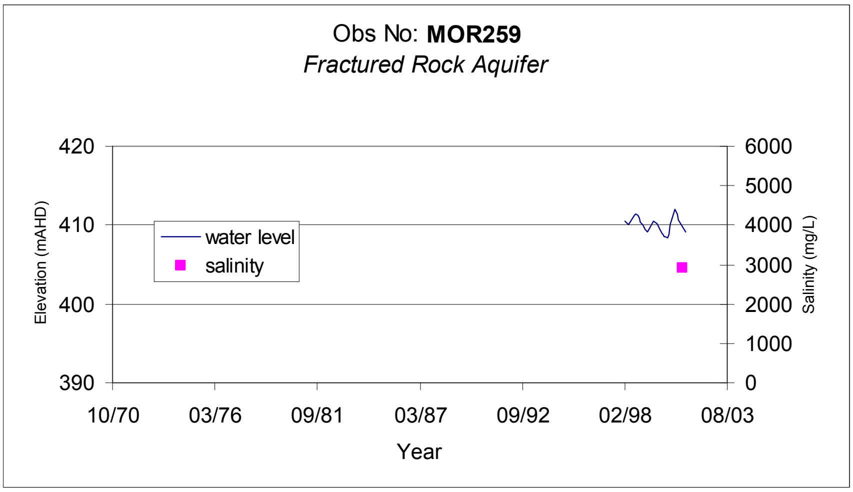

Obs No: MOR211
Lower Aquifer
280
275
270
265
260
255
250
6000
5000
4000
3000
2000
1000
0
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

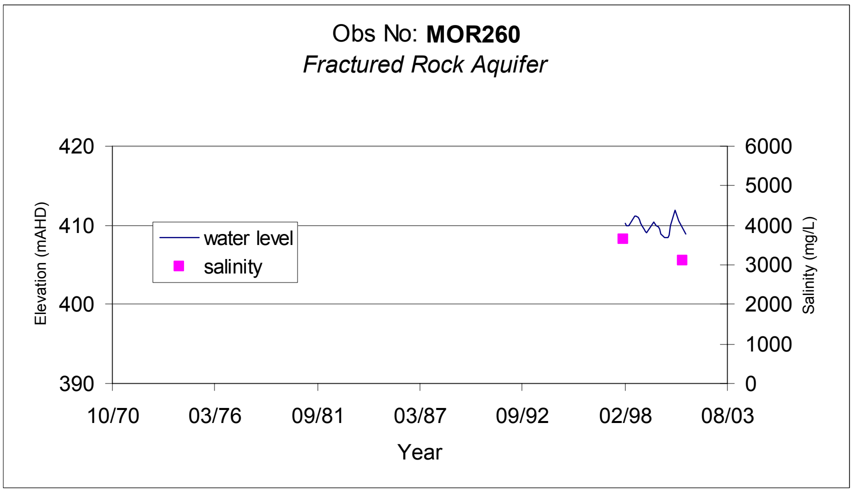

Obs No: MOR212
Upper Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
280
275
270
265
260
255
250
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

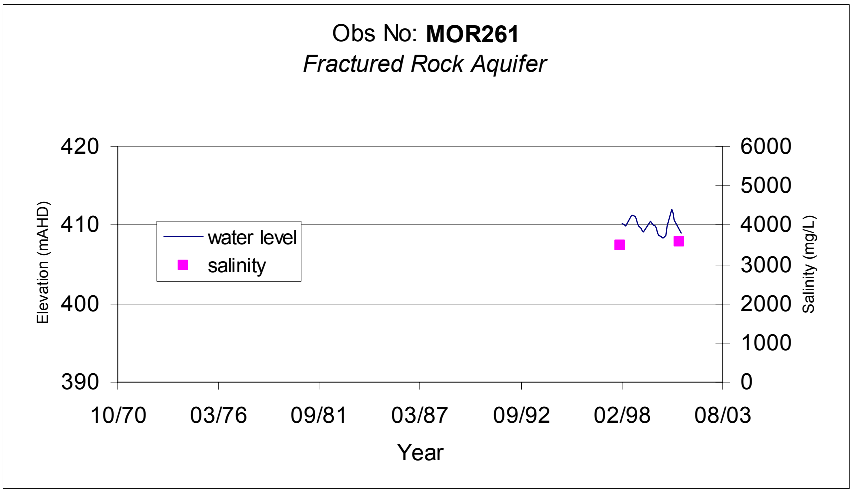

Obs No: MOR213
Upper Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
260
250
240
230
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

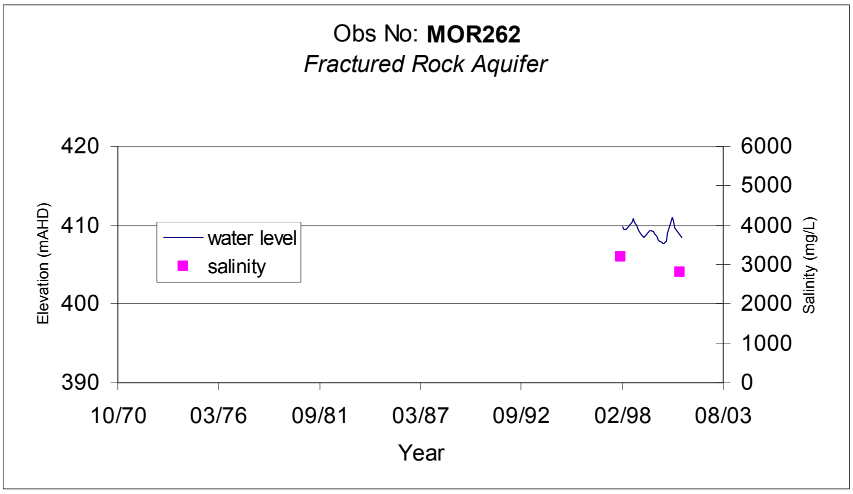

Obs No: MOR256
Fractured Rock Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
300
290
280
270
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

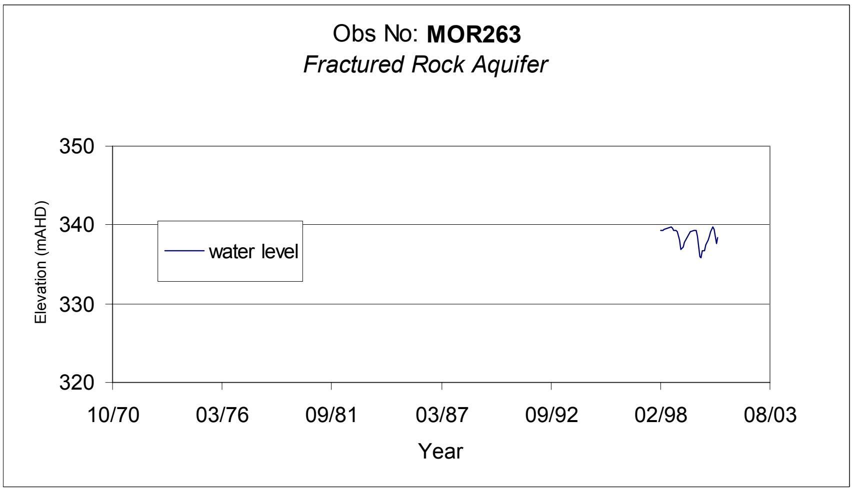

Obs No: MOR257
Fractured Rock Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
410
400
390
380
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

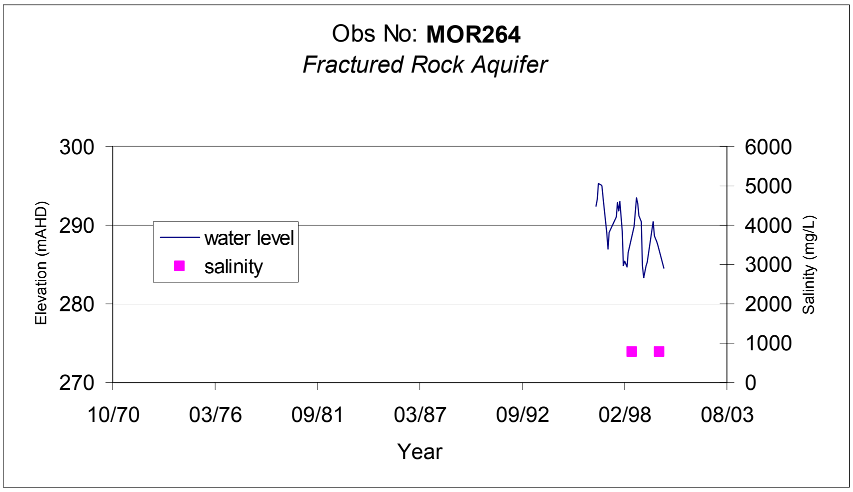

Obs No: MOR259
Fractured Rock Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
420
410
400
390
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year


Obs No: MOR260
Fractured Rock Aquifer
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
420
410
400
390
6000
5000
4000
3000
2000
1000
0
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

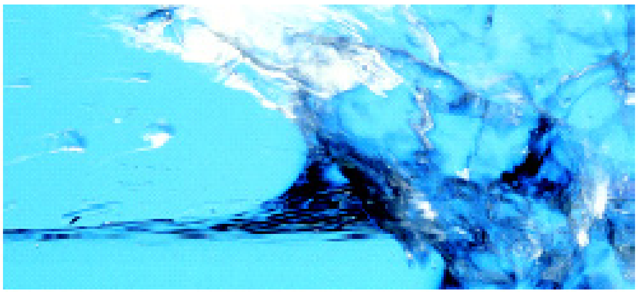

Obs No: MOR261
Fractured Rock Aquifer
420
410
400
390
6000
5000
4000
3000
2000
1000
0
water level
salinity
Elevation (mAHD)
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year


Obs No: MOR262
Fractured Rock Aquifer
420
410
400
390
6000
5000
4000
3000
2000
1000
0
water level
salinity
Elevation (mAHD)
Salinity (mg/L)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year


Obs No: MOR263
Fractured Rock Aquifer
350
340
330
320
water level
Elevation (mAHD)
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year


Obs No: MOR264
Fractured Rock Aquifer
300
290
280
270
6000
5000
4000
3000
2000
1000
0
Elevation (mAHD)
Salinity (mg/L)
water level
salinity
10/70
03/76
09/81
03/87
09/92
02/98
08/03
Year

10 APPENDIX C



CURRENT OBSERVATION WELL NETWORK

Observation well	Unit number	Easting	Northing	Hydro. unit monitored	Monitoring network		DWLBC–Other
					Water level	Salinity	
BLV 2	6729-369	320180	6188854	Lower	y	y	DWLBC
BLV 4	6729-344	318280	6190583	Upper	y	y	DWLBC
BLV 5	6729-371	317232	6187393	Upper	y	y	DWLBC
BLV 7	6629-328	313786	6188131	Fract. Rock	y	n	DWLBC
BLV 8	6729-1672	317035	6186891	Upper	y	y	P. Kordahi
BLV 9	6729-1673	317617	6192235	Upper	y	y	P. Kordahi
BLV 10	6729-1674	317608	6188504	Upper	y	y	P. Kordahi
BRS 6	6628-13078	309299	6169689	Fract. Rock	y	y	P. Kordahi
BRS 7	6628-13111	306582	6168855	Upper	y	y	DWLBC
BRS 10	6628-12503	307290	6165902	Upper	y	y	DWLBC
BRS 12	6628-2835	308643	6168783	Fract. Rock	n	y	DWLBC
BRS 13	6628-12578	308669	6166220	Fract. Rock	y	y	P. Kordahi
BRS 15	6628-6092	305202	6170293	Fract. Rock	y	n	DWLBC
BRS 17	6628-12105	309595	6166895	Fract. Rock	y	y	P. Kordahi
BRS 18	6628-15183	305906	6163683	Fract. Rock	y	y	P. Kordahi
BRS 19	6628-15211	310027	6172478	Fract. Rock	y	n	DWLBC
BRS 20	6628-20432	310882	6171680	Lower	y	y	P. Kordahi
BRS 21	6628-20352	306949	6167750	Upper	y	y	P. Kordahi
BRS 22	6628-20690	306769	6167916	Upper	y	y	P. Kordahi

Observation well	Unit number	Easting	Northing	Hydro. unit monitored	Monitoring network		DWLBC– Other
					Water level	Salinity	
BRS 23	6628-20691	306997	6165654	Upper	y	y	P. Kordahi
BRS 24	6628-20693	306868	6167003	Upper	y	y	P. Kordahi
BRS 25	6628-20694	305255	6170699	Upper	y	y	P. Kordahi
MOR 10	6629-4	314345	6181049	Upper	y	n	DWLBC
MOR 32	6729-669	318537	6183819	Upper	y	n	DWLBC
MOR 58	6628-5941	313161	6176460	Upper – Fract. Rock	y	n	DWLBC
MOR 62	6628-6031	314335	6178582	Lower	y	y	DWLBC
MOR 64	6628-6007	315326	6178205	Upper	y	n	DWLBC
MOR 65	6628-6002	316220	6177909	Upper	y	n	DWLBC
MOR 68	6629-10	314935	6180785	Upper	y	y	DWLBC
MOR 69	6629-11	314933	6180786	Upper	y	y	DWLBC
MOR 70	6629-12	314932	6180787	Upper	y	y	DWLBC
MOR 72	6728-1717	317203	6180078	Upper	y	y	DWLBC
MOR 74	6729-778	317425	6181109	Upper	y	y	DWLBC
MOR 77	6729-725	318903	6181965	Upper	y	y	DWLBC
MOR 80	6729-746	316961	6182559	Upper	y	y	DWLBC
MOR 81	6729-745	316959	6182559	Upper	y	y	DWLBC
MOR 83	6629-72	316065	6183056	Upper	y	y	DWLBC
MOR 84	6629-73	316065	6183055	Upper	y	y	DWLBC
MOR 93	6729-782	317383	6181106	Lower	y	y	DWLBC
MOR 94	6729-696	317559	6183009	Lower	y	y	DWLBC

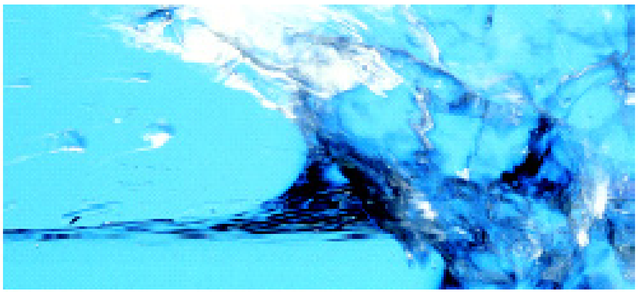
Observation well	Unit number	Easting	Northing	Hydro. unit monitored	Monitoring network		DWLBC–Other
					Water level	Salinity	
MOR 95	6729-783	317352	6181103	Upper	y	y	DWLBC
MOR 96	6729-784	317323	6181099	Lower	y	y	DWLBC
MOR 97	6729-780	317427	6181110	Lower	y	n	DWLBC
MOR 100	6729-521	320505	6186288	Lower	y	y	DWLBC
MOR 102	6729-678	319500	6183207	Upper	y	y	DWLBC
MOR 106	6729-1496	317011	6183191	Upper	n	y	P. Kordahi
MOR 107	6628-17545	311428	6174882	Fract. Rock	y	y	DWLBC
MOR 126	6729-885	321348	6183818	Fract. Rock	y	n	DWLBC
MOR 129	6729-805	320670	6181784	Fract. Rock	y	n	DWLBC
MOR 131	6729-808	319957	6182491	Fract. Rock	y	n	DWLBC
MOR 135	6729-1532	317781	6183119	Fract. Rock	y	y	DWLBC
MOR 136	6628-17220	315020	6178538	Fract. Rock	y	n	DWLBC
MOR 151	6628-4788	310997	6173604	Fract. Rock	y	y	P. Kordahi
MOR 155	6628-5938	314067	6175772	Lower	n	y	P. Kordahi
MOR 156	6628-8984	314672	6177327	Fract. Rock	y	y	P. Kordahi
MOR 161	6728-2038	316822	6178969	Lower	n	y	P. Kordahi
MOR 163	6628-6095	314654	6179982	Fract. Rock	y	y	P. Kordahi
MOR 164	6629-13	314460	6181010	Fract. Rock	n	y	P. Kordahi
MOR 176	6729-1111	319675	6184957	Upper	n	y	P. Kordahi
MOR 177	6729-775	316909	6181057	Lower	y	y	DWLBC
MOR 184	6729-1179	318405	6184595	Upper	n	y	P. Kordahi

Observation well	Unit number	Easting	Northing	Hydro. unit monitored	Monitoring network Water level	Monitoring network Salinity	DWLBC–Other
MOR 190	6629-1261	314725	6181881	Upper	n	y	P. Kordahi
MOR 198	6729-966	318269	6186543	Lower	n	y	P. Kordahi
MOR 199	6729-1399	319074	6184310	Upper	y	y	DWLBC
MOR 200	6729-1400	319083	6184307	Lower	y	y	DWLBC
MOR 201	6628-14328	312604	6173312	Lower	y	y	DWLBC
MOR 202	6628-15393	314698	6176261	Lower	y	y	DWLBC
MOR 203	6628-15394	314700	6176268	Lower	y	y	DWLBC
MOR 204	6628-15398	314702	6176273	Upper	y	y	DWLBC
MOR 205	6729-1430	318281	6183237	Lower	y	y	DWLBC
MOR 206	6629-1458	316063	6183059	Lower	y	y	DWLBC
MOR 207	6729-1432	319808	6184071	Lower	y	y	DWLBC
MOR 208	6729-1429	318753	6184731	Lower	y	y	DWLBC
MOR 209	6729-1431	318857	6184668	Lower	y	y	DWLBC
MOR 211	6729-1449	317591	6184840	Lower	y	y	DWLBC
MOR 212	6729-1448	317598	6184855	Upper	y	y	DWLBC
MOR 213	6628-16133	314327	6178582	Upper	y	y	DWLBC
MOR 256	6729-1552	321092	6184460	Fract. Rock	y	y	DWLBC
MOR 257	6728-3069	320012	6178053	Fract. Rock	y	y	DWLBC
MOR 259	6728-3238	321936	6175904	Fract. Rock	y	y	DWLBC
MOR 260	6728-3192	321936	6175904	Fract. Rock	y	y	DWLBC
MOR 261	6728-3193	321936	6175904	Fract. Rock	y	y	DWLBC

Observation well	Unit number	Easting	Northing	Hydro. unit monitored	Monitoring network		DWLBC–Other
					Water level	Salinity	
MOR 262	6728-3194	321936	6175904	Fract. Rock	y	y	DWLBC
MOR 263	6728-3071	319388	6179847	Fract. Rock	y	n	DWLBC
MOR 264	6729-985	320791	6184082	Fract. Rock	y	y	DWLBC
MOR 265	6728-3166	321882	6176293	Fract. Rock	y	y	DWLBC
MOR 266	6728-3167	321882	6176293	Fract. Rock	y	y	DWLBC
MOR 267	6728-3165	321882	6176293	Fract. Rock	y	y	DWLBC
MOR 268	6728-3195	321792	6176338	Fract. Rock	y	y	DWLBC
MOR 269	6728-3196	321792	6176338	Fract. Rock	y	y	DWLBC
MOR 270	6728-3197	321792	6176338	Fract. Rock	y	y	DWLBC
MOR 271	6728-3198	321792	6176338	Fract. Rock	y	y	DWLBC
MOR 272	6628-20692	314798	6178433	Upper	y	y	P. Kordahi
MOR 273	6729-1671	318075	6184661	Upper	y	y	P. Kordahi
MOR 274	6628-20695	314652	6179689	Upper	y	y	P. Kordahi
NTP 5	6628-5897	311952	6179471	Fract. Rock	y	n	DWLBC
NTP 6	6628-15539	309732	6172253	Fract. Rock	y	y	DWLBC
NTP 7	6628-17398	309681	6174745	Fract. Rock	y	y	DWLBC
NTP 8	6629-1811	309024	6182768	Upper	y	y	P. Kordahi
NTP 9	6629-1812	313897	6181156	Upper	y	y	P. Kordahi
NTP 10	6629-1813	314223	6182400	Upper	y	y	P. Kordahi
NTP 11	6629-1814	310086	6180765	Upper	y	y	P. Kordahi

11 APPENDIX D





HISTORICAL AND CURRENT OBSERVATION WELL COMPLETION DETAILS

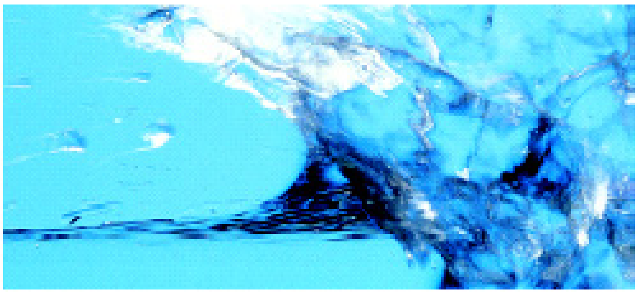
Observation well number	Unit number	Well owner	Log	Aquifer	Aquifer reclass	Interval (m)	Current monitoring network					Geophysical log	Log number	Full chemical analysis	Reliability
							Water level	Frequency (month)	Salinity	Frequency (month)	Last sample date				
BLV 2	6729-369	DWLBC	Driller	B?	Lower	96–98	y	1	y	random		y	1603	n (drill samp. only)	poor
BLV 3	6729-370	DWLBC	Driller	UG	Upper	19–21	n	1	n	random		n	as above	as above	poor
BLV 4	6729-344	DWLBC	Driller	UG	Upper	28–30	y	1	y	random		y	4481	n (drill samp. only)	OK
BLV 5	6729-371	DWLBC	Driller	MCA	Lower	35–35.5	y	1	y	random		y	1604	n (drill samp. only)	good
BLV 7	6629-328	Private	Driller	FRA	FRA	72–114	y	1	n	–	Jan–1995	n	–	n	good
BRS 5	6628-8965	Private	Driller	BS	Lower	–	n	–	n	–	–	y	–	–	poor
BRS 6	6628-13078	Private	Driller	FRA	FRA	multi	y	1	y	random	Mar–2001	n	–	n	–
BRS 7	6628-13111	Private	Driller	UG	Upper	4–10	y	1	y	random	Feb–1998	n	–	n	good
BRS 8	6628-2091	Private	Driller	WT	–	–	n	–	n	–	–	–	–	–	–
BRS 9	6628-13342	Private	Driller	UG	Upper	17.5–29.5	n	1	n	random	Mar–2001	n	–	n	poor
BRS 10	6628-12503	Private	Driller	FRA	Upper	28–34	y	1	y	random	Mar–2001	n	–	n	good
BRS 11	6628-13681	Private	Driller	FRA	Upper	20–60	y	1	y	random	Mar–2001	n	–	n	good
BRS 12	6628-2835	Private	Driller	FRA	FRA	50–84.6	y	1	y	random	Mar–2001	n	–	n	good
BRS 13	6628-12578	Private	Driller	FRA	FRA	30–77	y	1	y	random	Apr–2001	n	–	n	good
BRS 14	6628-11674	Private	Driller	FRA	FRA	52–62	n	–	n	random	Feb–1998	n	–	n	–
BRS 15	6628-6092	Private	Driller	FRA	FRA	6–34	y	1	n	random	Jun–2000	n	–	n	good
BRS 16	6628-11945	Private	Driller	FRA	FRA	3–218	n	1	n	random	Mar–1991	n	–	y	good
BRS 17	6628-12105	Private	Driller	FRA	FRA	0–63	y	1	y	random	Jan–2001	n	–	n	good
BRS 18	6628-15183	Private	Driller	FRA	FRA	30–55	y	1	y	random	Mar–2001	n	–	n	good
BRS 19	6628-15211	Private	Driller	FRA	FRA	23–87	y	1	n	random	Jun–1999	n	–	n	good
BRS 20	6628-20432	Private	Driller	–	Lower	48–54	y	1	y	random	none	n	–	n	good
BRS 21	6628-20352	Private	Driller	–	Upper	16–21	n	–	n	random	Apr–1998	y	5476	–	good
MOR 10	6629-4	Private	Driller	WT	Upper	0–24.4	y	–	n	–		n	–	n	–
MOR 32	6729-669	Private	Driller	UG	Upper	29.9–35.05	y	1	n	–	–	n	–	y	good
MOR 58	6628-5941	DWLBC	Geologist	BS/FR	Upper/FRA	12–20	y	1	y	random	Feb–1998	y	1609	y	unknown
MOR 62	6628-6031	DWLBC	Geologist	MCA	Lower	33–50	y	–	y	random	Feb–1998	y	3934	n (drill samp. only)	–
MOR 64	6628-6007	DWLBC	Driller	MA	Upper	20–26	y	1	n	random	Feb–1998	y	1607	n (drill samp. only)	good
MOR 65	6628-6002	DWLBC	Driller	MA	Upper	25–31	y	1	n	–	May–1997	y	1608	n (drill samp. only)	OK
MOR 68	6629-10	DWLBC	Geologist	MA	Upper	30.4–32	y	1	y	random	Feb–1998	y	1598	y	good
MOR 69	6629-11	DWLBC	Driller	MA	Upper	22–28	y	1	y	random	Feb–1998	y	1599	y	good
MOR 70	6629-12	DWLBC	Geologist	UG	Upper	14–16	y	1	y	random	Feb–1998	n	–	y	good
MOR 71	6728-1716	DWLBC	Geologist	BS	Lower	96–106	n	–	n	–	Oct–1992	y	not on datbase	n	–
MOR 72	6728-1717	DWLBC	Geologist	MA	Upper	40–46	y	1	y	random	Feb–1998	y	1601	–	good
MOR 73	6728-1729	DWLBC	Driller	WT	Upper	17–21	n	1	n	random	Feb–1998	n	–	n	–
MOR 74	6729-778	DWLBC	Geologist	UG	Upper	20–24	y	1	y	random	Feb–1998	n	–	y	good

Observation well number	Unit number	Well owner	Log	Aquifer	Aquifer reclass	Interval (m)	Current monitoring network: Water level	Frequency (month)	Salinity	Frequency (month)	Last sample date	Geophysical log	Log number	Full chemical analysis	Reliability
MOR 76	6729-724	DWLBC	Geologist	MA	Upper	54–60	n	–	n	–		y	not on datbase	n (drill samp. only)	–
MOR 77	6729-725	DWLBC	Geologist	MA	Upper	26–28	y	1	y	random	Feb–1998	n	–	n (drill samp. only)	–
MOR 80	6729-746	DWLBC	Geologist	UG	Upper	29–34	y	1	y	random	Feb–1998	n	–	y	good
MOR 81	6729-745	DWLBC	Geologist	UG	Upper	16–18	y	1	y	random	Feb–1998	n	–	n (drill samp. only)	good
MOR 82	6629-71	DWLBC	Geologist	MA&MCA	Lower	30–36	n	–	n	–	Oct–1988	n	–	n (drill samp. only)	–
MOR 83	6629-72	DWLBC	Driller	UG	Upper	20–24	y	1	y	random	Feb–1998	n	–	y	good
MOR 84	6629-73	DWLBC	Geologist	WT	Upper	7–10	y	1	y	random	Feb–1998	n	–	y	good
MOR 85	6729-689	DWLBC	Geologist	BS	Lower	106–120	n	–	n	–	Jun–1978	y	not on datbase	n	–
MOR 92	6729-781	DWLBC	Geologist	MA	Lower	104–114	n	–	n	–		y	2114	n (drill samp. only)	–
MOR 93	6729-782	DWLBC	Geologist	MCA	Lower	54–64	y	1	y	random	Feb–1998	y	3935	n (drill samp. only)	good
MOR 94	6729-696	DWLBC	Geologist	MCA	Lower	75–80	y	1	y	random	Mar–2001	y	2117	y	good
MOR 95	6729-783	DWLBC	Geologist	UG	Upper	23.6–25	y	1	y	random	Feb–1998	n	–	n	unknown
MOR 96	6729-784	DWLBC	Geologist	MCA	Lower	55–67	y	1	y	random	Feb–1998	y	3936	n (drill samp. only)	good
MOR 97	6729-780	DWLBC	Geologist	BS	Lower	115–117	y	1	n	–	Nov–1992	y	1994	n	good
MOR 99	6729-592	DWLBC	Geologist	BS	Lower	125–131	n	–	n	–		y	3938	n (drill samp. only)	–
MOR 100	6729-521	DWLBC	Geologist	BS	Lower	136.5–138.5	y	1	y	random	Feb–1998	n	–	n (drill samp. only)	OK
MOR 101	6729-522	DWLBC	Geologist	WT	Upper	10.3–12	n	1	n	random	Feb–1998	n	–	n	poor
MOR 102	6729-678	DWLBC	Driller	MA	Upper	55–56	y	1	y	random	Mar–2001	n	–	n (drill samp. only)	good
MOR 103	6729-679	DWLBC	Driller	UG	Upper	37–38	n	1	n	–	Feb–1998	n	–	n	OK
MOR 106	6729-1496	Pirsa	Driller	UG	Upper	16.5–19	n	–	y	random	Feb–2001	n	–	n	OK
MOR 107	6628-17545	Private	Geologist	FRA	FRA	55–85	y	1	y	random	Feb–1998	n	–	y	good
MOR 117	6729-971	Unknown	–	WT	–	–	–	–	–	–	–	–	–	–	–
MOR 121	6729-675	Private	unknown	MA/BS	–	0–49.4	n	1	n	random	Feb–1997	n	–	n	poor
MOR 126	6729-885	Private	none	FRA	FRA	0–15?	y	1	n	random	Feb–1994	n	–	n	good
MOR 129	6729-805	Private	none	FRA	FRA	0–7.24	y	1	n	–	Sep–1994	n	–	n	good
MOR 131	6729-808	Private	none	FRA	FRA	0–28.96	y	1	n	random	Mar–2001	n	–	not reliable	good
MOR 132	6729-830	Private	none	FRA	FRA	0–16.76	n	1	n	–	Apr–1996	n	–	n	good
MOR 133	6729-1370	Private	Driller	BS/FRA	Lower/FRA	58–76	n	1	n	random	Mar–2001	n	–	n	–
MOR 134	6628-6008	Private	Driller	BS	Lower	82–86	n	–	n	–	Feb–1997	n	–	n (drill samp. only)	–
MOR 135	6729-1532	DWLBC	Geologist	FRA	FRA	125.5–176	y	1	y	random	Feb–1998	n	–	n	–
MOR 136	6628-17220	DWLBC	Geologist	FRA	FRA	95–121.1	y	1	n	random	Feb–1998	y	4677	n	good
MOR 151	6628-4788	Private	Geologist	FRA	FRA	32–104	y	1	y	random	Mar–2001	n	–	y	good
MOR 155	6628-5938	Private	Geologist	BS	Lower	66–69	n	–	y	random	Jan–2001	n	–	y	good
MOR 156	6628-8984	Private	Driller	FRA	FRA	90–120	y	1	y	random	Feb–2001	n	–	y	good

Observation well number	Unit number	Well owner	Log	Aquifer	Aquifer reclass	Interval (m)	Current monitoring network					Geophysical log	Log number	Full chemical analysis	Reliability
							Water level	Frequency (month)	Salinity	Frequency (month)	Last sample date				
MOR 160	6628-9453	Private	Driller	B	Lower	111.5–115.5	n	–	n	–	Feb–1997	n	–	y	good
MOR 161	6728-2038	Private	Driller	B	Lower	103.5–116	n	–	y	random	Dec–2000	n	–	y	unknown
MOR 163	6628-6095	Private	Driller	FRA	FRA	43–96	y	1	y	random	Apr–2001	n	–	n	good
MOR 164	6629-13	Private	Driller	FRA	FRA	51–104	n	–	y	random	Mar–2001	y	4420	y	–
MOR 176	6729-1111	Private	Driller	UG	Upper	25.4–28.4	n	–	y	random	Mar–2001	n	–	n	good
MOR 177	6729-775	Private	Driller	BS	Lower	100–106	n	1	y	random	Apr–2001	n	–	y	good
MOR 184	6729-1179	Private	Geologist	UG	Upper	24–30	n	–	y	random	Jan–2001	n	–	n	good
MOR 189	6628-12026	Private	Driller	MCA	All 3	74–86	n	–	n	–		n	–	n	–
MOR 190	6629-1261	Private	Driller	UG	Upper	20–24	n	–	y	random	Feb–2001	n	–	n	good
MOR 192	6728-2462	Private	Driller	FRA	FRA	81–76	y	1	y	random	Mar–2001	y	4531	y	
MOR 195	6729-726	Private	Driller	BS	Lower	119–122	n	–	n	–	Feb–1998	n	–	n	–
MOR 198	6729-966	Private	Driller	BS	Lower	56–60	n	–	y	random	Feb–2001	n	–	n	good
MOR 199	6729-1399	DWLBC	Driller	UG	Upper	21–24	y	1	y	random	Mar–2001	y	959	y	good
MOR 200	6729-1400	DWLBC	Driller	MCA	Lower	43–45	y	1	y	random	Dec–1998	y	1993	y	good
MOR 201	6628-14328	DWLBC	Geologist	BS	Lower	87–89.5	y	1	y	random	Feb–1998	y	962	y	good
MOR 202	6628-15393	DWLBC	Driller	MCA	Lower	44–46	y	1	y	random	Feb–1998	y	1298	y	good
MOR 203	6628-15394	DWLBC	Driller	MA	Lower	23–25.5	y	1	y	random	Feb–1998	n	–	y	good
MOR 204	6628-15398	DWLBC	Driller	MA	Upper	13–15	y	1	y	random	Feb–1998	n	–	y	good
MOR 205	6729-1430	DWLBC	Driller	BS	Lower	119–122	y	1	y	random	Feb–1998	n	–	n	good
MOR 206	6629-1458	DWLBC	Driller	MCA	Lower	32.5–34.5	y	1	y	random	Feb–1998	y	1296	n	good
MOR 207	6729-1432	DWLBC	Driller	BS	Lower	110–115	y	1	y	random	Feb–1998	y	1364	n (drill samp. only)	good
MOR 208	6729-1429	DWLBC	Geologist	BS	Lower	110–112	y	1	y	random	Feb–1998	y	1300	y	good
MOR 209	6729-1431	DWLBC	Geologist	MCA	Lower	48–51	y	1	y	random	Mar–2001	y	1365	y	good
MOR 210	6628-15396	Private	Driller	FRA	FRA	40–145	n	–	n	–	Jan–2001	n	–	n	poor
MOR 211	6729-1449	DWLBC	Driller	MA	Lower	56–58	y	1	y	random	Feb–1998	n	–	n	good
MOR 212	6729-1448	DWLBC	Driller	WT	Upper	19–21	y	1	y	random	Feb–1998	n	–	n	good
MOR 213	6628-16133	DWLBC	Driller	MA	Upper	26–28	y	1	y	random	Feb–1998	n	–	n	good
MOR 256	6729-1552	DWLBC	Geologist	FRA	FRA	5–71	y	1	y	random	Mar–2001	y	Rpt 97/621	n	good
MOR 257	6728-3069	DWLBC	Geologist	FRA	FRA	23.8–65.8	y	1	y	random	Mar–2001	y	Rpt 97/621	n	good
MOR 259	6728-3238	DWLBC	Geologist	FRA	FRA	102–109	y	1	y	random	Apr–2001	n	–	n	good
MOR 260	6728-3192	DWLBC	Geologist	FRA	FRA	88–93	y	1	y	random	May–2001	n	–	n	good
MOR 261	6728-3193	DWLBC	Geologist	FRA	FRA	75–80	y	1	y	random	Jun–2001	n	–	n	good
MOR 262	6728-3194	DWLBC	Geologist	FRA	FRA	55–59	y	1	y	random	Jul–2001	n	–	n	good
MOR 263	6728-3071	DWLBC	Geologist	FRA	FRA	9–39.2	y	1	n	–	–	y	Rpt 97/621	n	good
MOR 264	6729-985	–	–	FRA	FRA	–	y	1	y	random	Mar–2001	–	–	n	poor

Observation well number	Unit number	Well owner	Log	Aquifer	Aquifer reclass	Interval (m)	Current monitoring network					Geophysical log	Log number	Full chemical analysis	Reliability
							Water level	Frequency (month)	Salinity	Frequency (month)	Last sample date				
MOR 265	6728-3166	DWLBC	Geologist	FRA	FRA	9–11	y	1	y	random	Aug–2001	n	–	n	good
MOR 266	6728-3167	DWLBC	Geologist	FRA	FRA	3.5–7.5	y	1	y	random	Sep–2001	n	–	n	good
MOR 267	6728-3165	DWLBC	Geologist	FRA	FRA	14–16	y	1	y	random	Oct–2001	n	–	n	good
MOR 268	6728-3195	DWLBC	Geologist	FRA	FRA	43–46	y	1	y	random	Nov–2001	n	–	n	good
MOR 269	6728-3196	DWLBC	Geologist	FRA	FRA	35–38	y	1	y	random	Dec–2001	y	Rpt 97/621	n	good
MOR 270	6728-3197	DWLBC	Geologist	FRA	FRA	27–29	y	1	y	random	Jan–2002	y	Rpt 97/622	n	good
MOR 271	6728-3198	DWLBC	Geologist	FRA	FRA	19–21	y	1	y	random	Feb–2002	y	Rpt 97/623	n	good
NTP 5	6628-5897	Private	Driller	FRA	FRA	51–160	y	1	n	–	Feb–1978	y	1612	n	
NTP 6	6628-15539	Private	Driller	FRA	FRA	58–198	y	1	y	random	Jan–2001	n	–	n	good
NTP 7	6628-17398	DWLBC	Geologist	FRA	FRA	51–72	y	1	y	random	Feb–1998	n	–	y	good
BRS 22	6628-20690	BIL	Geologist	–	Upper	5–8	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/22	n	good
BRS 23	6628-20691	BIL	Geologist	–	Upper	8–14	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/23	n	good
MOR 272	6628-20692	BIL	Geologist	–	Upper	8–14	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/24	n	good
BRS 24	6628-20693	BIL	Geologist	–	Upper	7–10	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/25	n	good
MOR 273	6729-1671	BIL	Geologist	–	Upper	6–9	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/26	n	good
NTP 8	6629-1811	BIL	Geologist	–	Upper	6–9	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/27	n	good
BRS 25	6628-20694	BIL	Geologist	–	Upper	5.5–8.5	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/28	n	good
BLV 8	6729-1672	BIL	Geologist	–	Upper	6–12	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/29	n	good
NTP 9	6629-1812	BIL	Geologist	–	Upper	4–10	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/30	n	good
NTP 10	6629-1813	BIL	Geologist	–	Upper	5–8	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/31	n	good
NTP 11	6629-1814	BIL	Geologist	–	Upper	5–8	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/32	n	good
BLV 9	6729-1673	BIL	Geologist	–	Upper	5–8	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/33	n	good
BLV 10	6729-1674	BIL	Geologist	–	Upper	7–10	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/34	n	good
MOR 274	6628-20695	BIL	Geologist	–	Upper	9–15	y	3	y	six month	Nov–2001	n	WaterSearch Rpt 2001/35	n	good

12 APPENDIX E

OBSERVATION WELLS REMOVED FROM NETWORK

Observation well	Unit number	Reason
BLV 3	6729-370	Dual completion cement up
BRS 5	6628-8965	Backfilled
BRS 8	6628-2091	Backfilled replaced by BRS 21
BRS 9	6628-13342	Used to recharge mains water
BRS 11	6628-13681	Used as recharge well
BRS 14	6628-11674	Historical, no reason given; BRS 18 close by
BRS 16	6628-11945	Recharge well
MOR 73	6728-1729	Removed from network dry
MOR 101	6729-522	Dual completion cement
MOR 103	6729-679	Dual completion cement
MOR 121	6729-675	Completion details indicate well is completed over more than one aquifer
MOR 131	6729-808	Remove from salinity network — well over 2 m in diameter
MOR 132	6729-830	No access Penrice quarry
MOR 133	6729-1370	Stockwell oval — no access
MOR 136	6628-17220	remove from salinity
MOR 177	6729-775	remove from water level
MOR 192	6728-2462	Used as recharge well
MOR 210	6628-15396	Well is used as a recharge well and therefore data is not representative of the aquifer