MUSGRAVE PWA

GROUNDWATER LEVEL AND SALINITY STATUS REPORT

2011

Government of South Australia
Department of Environment, Water and Natural Resources

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SUMMARY 2011

The Musgrave Prescribed Wells Area (PWA) is situated in central Eyre Peninsula, approximately 120 km north-west of Port Lincoln. It is prescribed under South Australia's *Natural Resources Management Act 2004* and a Water Allocation Plan provides for the sustainable use of the groundwater resources.

The majority of groundwater extraction in the Musgrave PWA is for stock and domestic purposes, while the majority of licensed extraction is from the Bramfield lens for Elliston's town water supply. A Notice of Prohibition placed on the Polda lens has prevented pumping from this source by SA Water since November 2008 and limited extractions by other licence holders. Extractions from Polda lens totalled 1.63 ML for the purpose of irrigation. Extractions from the Bramfield lens during 2010–11 totalled 85.8 ML for the Elliston town water supply and 8.05 ML for the purpose of irrigation. This equates to only 9.68 ML extracted in 2010–11 for irrigation purposes throughout the Musgrave PWA.

After a long period of declining groundwater levels and below-average rainfall, good winter and spring rainfall in both 2009 and 2010 had increased recharge and led to watertable rises of up to 1.7 m in Polda lens and up to 2.1 m in other minor lenses. In some areas the water levels were the highest recorded for the past ten years.

During 2011, due to slightly above-average rainfall, water levels increased marginally in Polda lens up to 0.7 m. In other lenses water levels declined slightly when compared to water levels recorded at the same time during the previous year. Groundwater salinities for 2011 are stable or decreasing as a result of the recent years increased recharge.

While the status assigned below reflects the positive trends observed during 2011, it must be remembered that in the past there was a prolonged period of below-average rainfall that resulted in declining water levels in all basins and a gradual rise in groundwater salinities in the Polda lens. The possibility that such periods of low rainfall will occur again in the future must be considered in long-term planning.

ASSESSMENT OF STATUS

Based on current trends, the Polda lens has been assigned a yellow status of "Adverse trends, indicating low risk to the resource in the medium term" for 2011, while the Bramfield, Kappawanta, Sheringa and Talia lenses have been assigned a green status of "No adverse trends, indicating a stable or improving situation" for 2011. This status is supported by:

- groundwater levels have generally continued to increase in Polda lens (with the exception of Polda North and Polda East). While minor decreases in water levels have been observed in other lenses (when compared to water levels recorded at the same time during the previous year) this follows two consecutive years of groundwater level increases
- some salinity values higher than would be preferred in Polda, with stable or declining salinity levels over most of the remaining PWA.

The Polda lens has been assigned a yellow status of "Adverse trends, indicating low risk to the resource in the medium term" for 2011 because while there has been some recovery of water levels in Polda, Polda North and Polda East have displayed marginal declines when compared to the same time during the previous water use year. Long-term salinity levels have increased due to the previous lack of recharge and although some freshening occurred during 2009, 2010 and 2011, values are still higher than would be preferred in some areas.

While the status assigned reflects the positive trends observed during 2011, it must be remembered that in the past, there was a prolonged period of below-average rainfall that resulted in declining water levels in most lenses. The Quaternary Limestone aquifer has a rapid response to changes in rainfall patterns and consequently, the status of the resource may change from year to year.

STATUS 2011

Bramfield, Kappawanta, Sheringa and Talia lenses (green)	**Polda lens** (yellow)

No adverse trends, indicating a stable or improving situation

Trends are either stable (no significant change) or improving (i.e. decreasing salinity or rising water levels).

Adverse trends indicating low risk to the resource in the medium term

Observed adverse trends are gradual and if continued, will not lead to a change in the current beneficial uses of the groundwater resource for at least 15 years. Beneficial uses may be drinking water, irrigation or stock watering.

Adverse trends indicating high risk to the resource eventuating in the short to medium term

Observed adverse trends are significant and if continued, will lead to a change in the current beneficial uses of the groundwater resource in about 10 years.

Degradation of the resource compromising present use within the short term

Trends indicate degradation of the resource is occurring, or will occur within five years. Degradation will result in a change in the beneficial use (i.e. no longer suitable for drinking or irrigation purposes) and may take the form of increasing groundwater salinities, or a fall in the groundwater levels such that extractions from the aquifer may not be possible.

BACKGROUND

The Musgrave Prescribed Wells Area (PWA) is situated in central Eyre Peninsula, approximately 120 km north-west of Port Lincoln (Fig. 1). It is prescribed under South Australia's *Natural Resources Management Act 2004* and a Water Allocation Plan provides for the sustainable use of the groundwater resources.

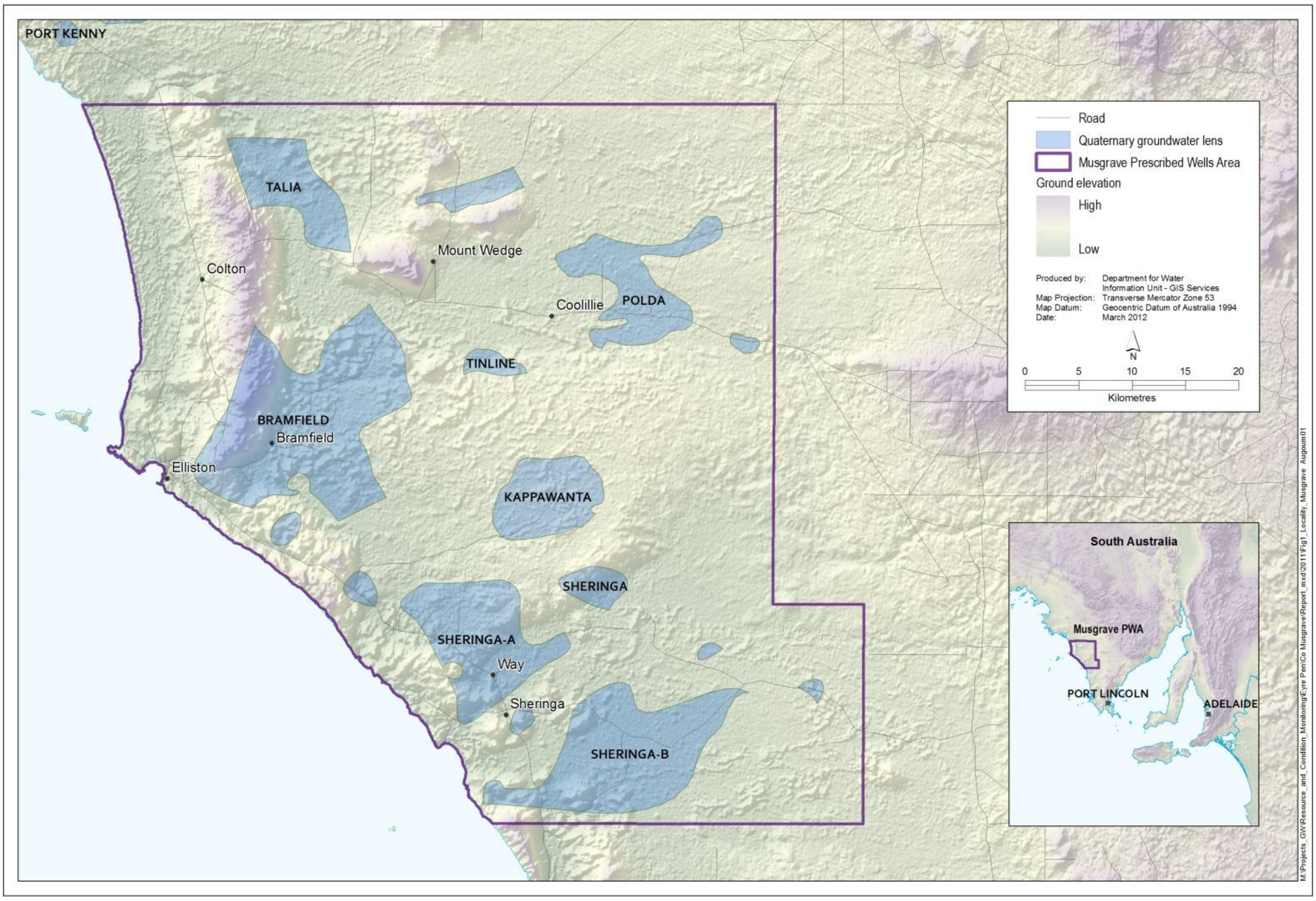

Figure 1. The Musgrave Prescribed Wells Area with the location of Quaternary fresh groundwater lenses as described in the current Water Allocation Plan and delineated in DWLBC Report 2002/23

HYDROGEOLOGY

Groundwater in the Musgrave PWA mainly occurs within two formations: an upper Quaternary Limestone Aquifer and the underlying Tertiary Sand Aquifer (Fig. 2). Underlying these aquifers are Jurassic sediments and fractured basement rocks.

Quaternary Limestone aquifer

The Quaternary Limestone aquifer generally comprises a thin veneer of aeolianite sediments of the Bridgewater Formation and is continuous across the Musgrave PWA. The Bridgewater Formation is generally unconsolidated or loosely aggregated, although hard, cemented calcrete layers exist. Secondary porosity appears to be common, evidenced by regular occurrences of surface solution features.

Groundwater flow in the Quaternary Limestone aquifer is predominantly in a westerly to south-westerly direction toward the Southern Ocean in the Musgrave PWA.

Significant volumes of low-salinity groundwater are stored in discrete basins within the Quaternary Limestone Aquifer. Within these basins, areas defined by salinity of less than 1000 mg/L are described as fresh groundwater lenses in the current Water Allocation Plan and delineated in DWLBC Report 2002/23[1]. Their extent is partly controlled by geological structures. Recharge occurs directly from rainfall, with the timing and intensity of the rainfall a major influence on the magnitude of recharge. A close relationship has been observed between rainfall and groundwater levels.

Groundwater resources within the Musgrave PWA are extracted predominantly from the Quaternary Limestone aquifer. Quaternary aquifer salinities generally range between 400 and 1800 mg/L. Well yields are generally high, ranging between 5 and 50 L/s.[2]

Tertiary Sand aquifer

The Poelpena Formation consists of poorly sorted, fine to coarse grained quartz sand, silt and clay which can be carbonaceous, micaceous and pyritic. It acts as both the Tertiary Sand aquifer and the confining layer separating it from the Quaternary Limestone aquifer. The formation has a highly variable thickness, but commonly exceeds 100 m in the eastern part of the Polda Trough. The aquifer extends over most of the Musgrave PWA but has not been developed due to it's often high salinity (up to 35 000 mg/L) and low yields. It is recharged by downward leakage from the Quaternary Limestone aquifer and lateral flow. Groundwater flow direction is predominantly south-westerly towards the Southern Ocean.

Jurassic Sand aquifer

The Jurassic Sands aquifer occurs primarily in the east of the Musgrave PWA and consists of fine-grained sands, sandstone and conglomerate of the Polda Formation. The aquifer has low yields and high salinity (30 000–50 000 mg/L).

Basement aquifer

There is limited information and conceptual understanding of the basement aquifers in Eyre Peninsula. Groundwater occurring within basement aquifers is irregular and salinities and yields are variable, which is typical of groundwater resources occurring within fractured rock environments.

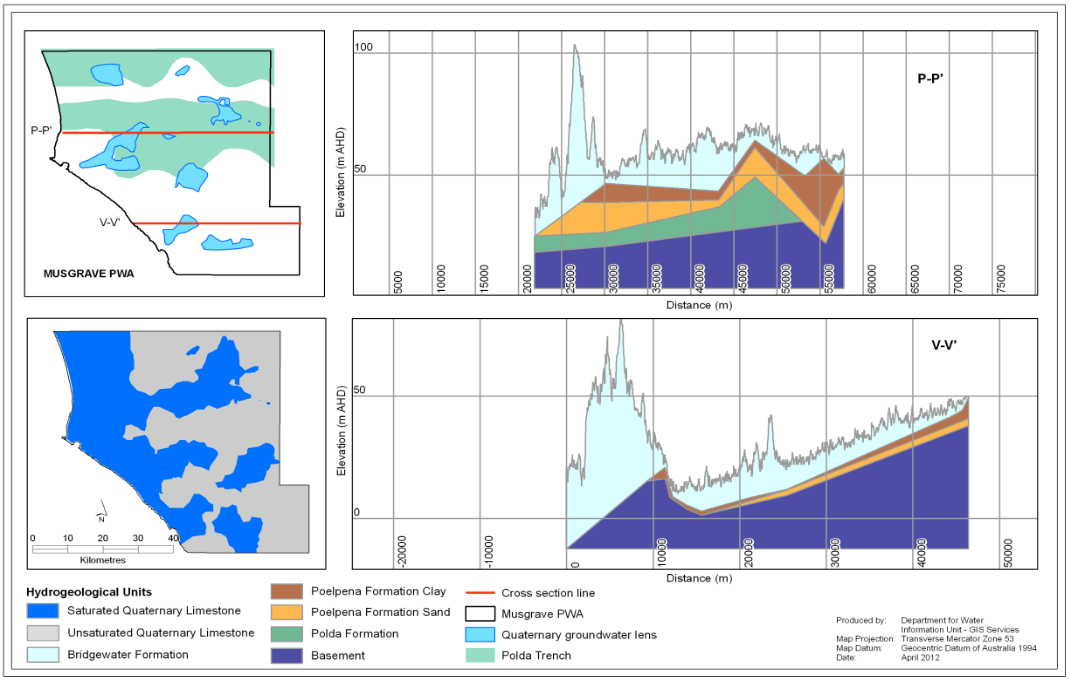

Figure 2. Geological cross-section of stratigraphic units in the Musgrave PWA aquifers (300 x vertical exaggeration)

[1] Evans, SL 2002, Musgrave Prescribed Wells Area groundwater monitoring status report 2002, Report DWLBC 2002/23
[2] Evans et al. 2009a, Monitoring review: Conceptualisation and status reporting, Musgrave PWA status report 2009, Report prepared for the Department for Water, Adelaide

GROUNDWATER DEPENDENT ECOSYSTEMS

Whilst groundwater dependent ecosystems (GDEs) have not been considered in this assessment of the status of the groundwater resource, it is important to note the presence and ecological characteristics of the GDEs found in the Musgrave PWA. GDEs can be defined as ecosystems where groundwater provides all or part of the water quantity, chemistry or temperature requirements, either permanently, seasonally or intermittently. It is generally considered that shallow watertables (less than 10 m below the surface) are more likely to support GDEs than deeper watertables.

Ecosystems that are potentially dependent on groundwater have been mapped throughout the Musgrave PWA and comprise wetlands, terrestrial plants and subsurface biota inhabiting water-filled voids (stygofauna). Direct groundwater discharge to the marine environment, which may also support marine animals and plants, occurs from the Quaternary Limestone Aquifer along the coastal margin of the Musgrave PWA.

Groundwater dependent wetlands are primarily located close to the coastal edge of the Musgrave PWA. Most of these wetlands are intermittent or seasonal and support bird populations and a wide suite of groundwater dependent terrestrial vegetation species. Lake Newland is the only permanent groundwater dependent wetland mapped within the PWA and supports a variety of aquatic and terrestrial vegetation, fish and bird species of national conservation significance that are subject to international treaties.

Comprehensive information on the condition the GDEs in the Musgrave PWA is not available; however, the regional decline in groundwater levels over the last 10 to 15 years may have increased the risks to the health of these GDEs. There have been reports of declining red gum health from the early 2000s in the Polda region by local landholders and seed collectors, with suggestions that this has been due to declining water quality or water levels or both. An initial survey of tree condition and response to recent water availability conducted by Dr Kerri Muller in 2011 (unpublished) indicates a positive response in red gum health due to recent higher winter rains, which is consistent with unpublished data from Eyre Native Seeds. Dr Muller also found that the subset of red gums surveyed in the Polda region was not showing significant signs of water stress. While this response indicates an apparent response between red gum health and winter rainfall, the exact relationship between red gum health and the groundwater regime is still largely unknown.

RAINFALL

The Musgrave region has a Mediterranean climate with warm to hot, dry summers and mild, wet winters. Rainfall is winter dominant. The location of the Elliston (18069) and Terre (18081) rainfall stations are displayed in Figure 3. It should be noted that the rainfall data shown in the figures are sourced from the SILO Climate Database, which is hosted by the Queensland Climate Change Centre of Excellence. Any missing rainfall records are typically interpolated from nearby rainfall stations as is the case for Terre (18081). More information is available at:

http://www.longpaddock.qld.gov.au/silo/about.html

The data from these stations are displayed in Figures 4 and 5 respectively.

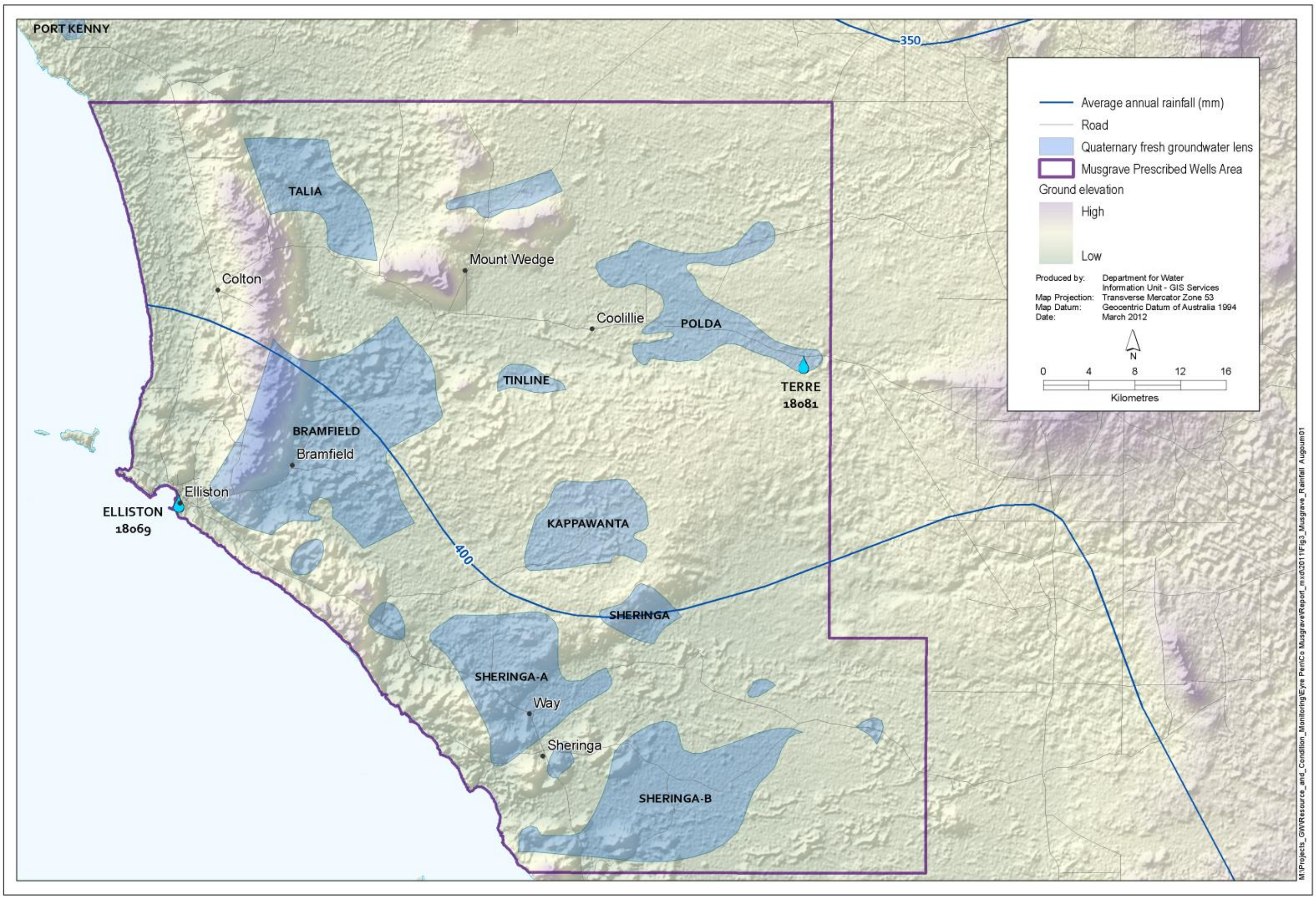

Figure 3. Location of rainfall stations in the Musgrave PWA

The cumulative deviation from average annual rainfall is graphed in orange in Figures 4 and 5 and identifies periods where the rainfall trend is above or below average. An upward slope indicates a period where the rainfall is greater than the average, while a downward slope indicates a period where the rainfall is below the average.

Figure 4 displays the annual rainfall recorded for Elliston (station 18069). For the period 1889 to 2011 the long-term average annual rainfall is 430 mm. The results for Elliston show a prolonged period of below-average rainfall from 1983 to 2008, with the exception of a very wet year in 1992. While above average rainfall years have occurred since 1993, the amount of annual rainfall has not been significantly above the long term average of 430 mm. Both 2009 and 2010 were wet years recording 76.8 mm and 116.9 mm respectively above the long term average. During 2011, the rainfall of 449.7 mm was only slightly above the long-term average.

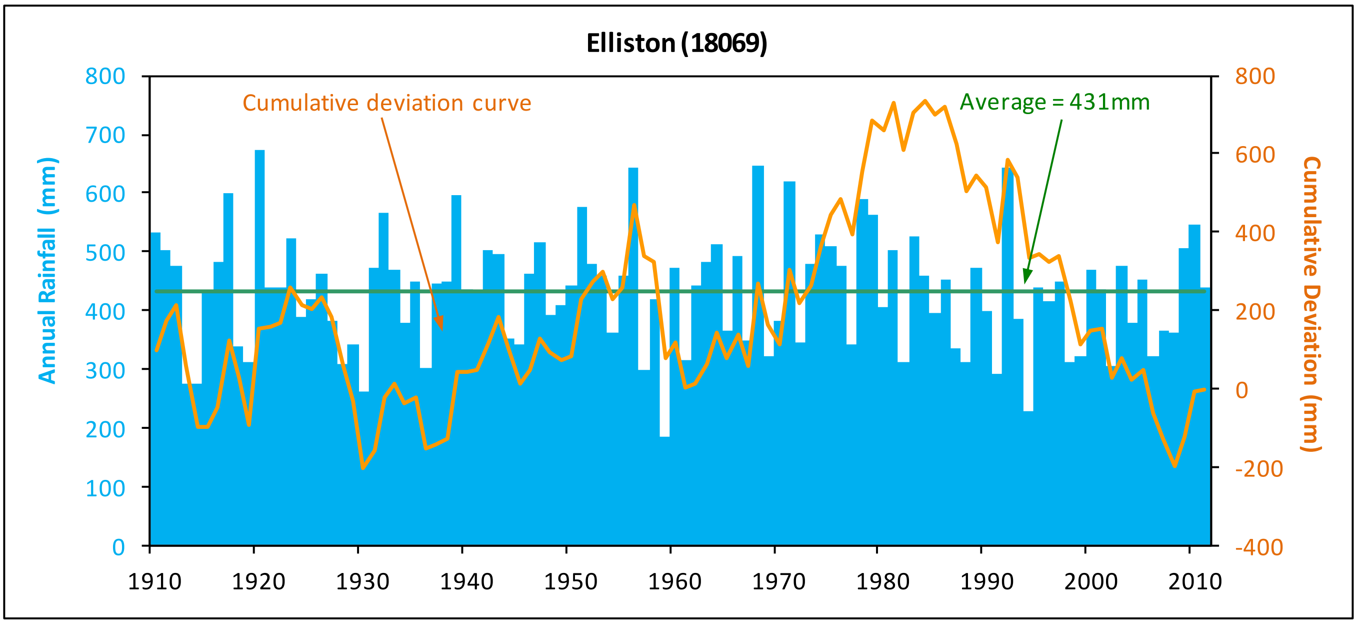

Figure 4. Annual rainfall and cumulative deviation from average annual rainfall for the Elliston station in the Musgrave PWA

Figure 5 displays the annual rainfall recorded for the Terre (18081) station. The Terre station was closed by the Bureau of Meteorology in September 2002. The SILO Climate Database has infilled rainfall records from September 2002 to December 2011 using data interpolated from nearby rainfall stations. This practise is commonly applied where data is limited. The Terre station was used as it was the only station in the area with a long historical record.

For the period 1910 to 2011 the long-term average annual rainfall is 373 mm. The cumulative deviation from the average annual rainfall displays a prolonged period of below-average rainfall from 1983 to 2008 with the exception of a very wet year in 1992. This is followed by an increasing trend from 2009 to 2011. Both 2009 and 2010 were wet years recording 26.5 mm and 103.9 mm respectively above the long term average. During 2011, rainfall was again above the long-term average with 439.9 mm recorded.

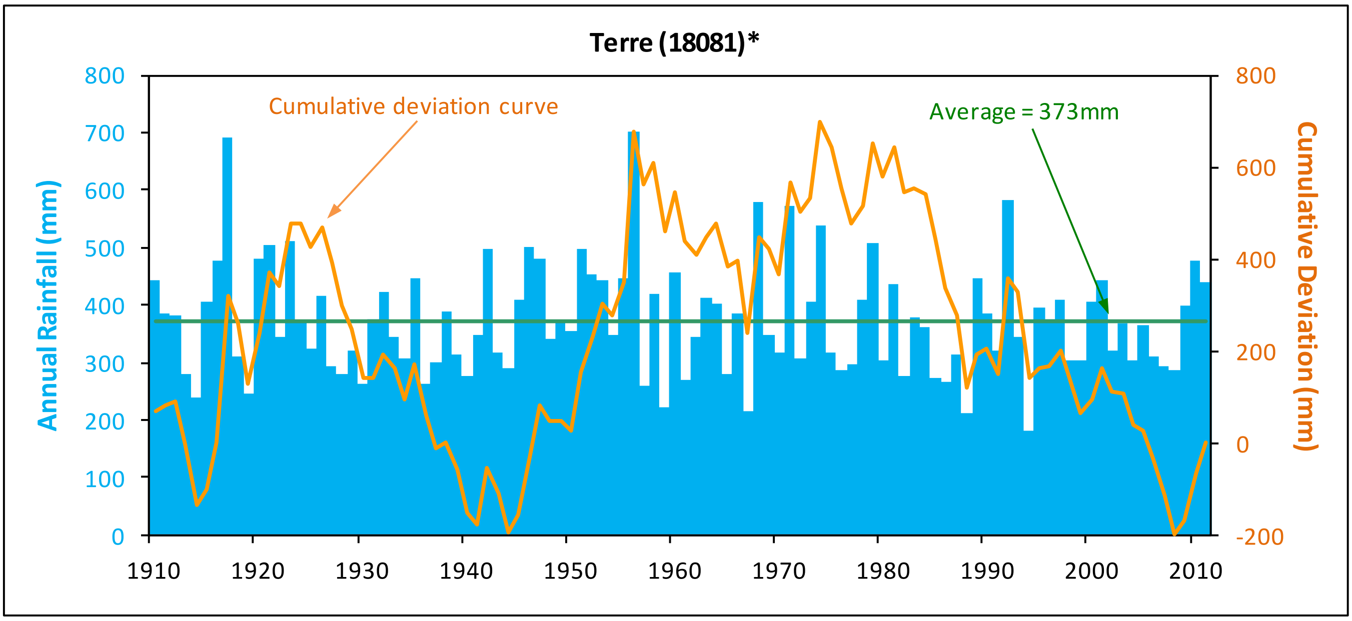

Figure 5. Annual rainfall and cumulative deviation from the average annual rainfall for the Terre station in the Musgrave PWA. *Terre closed in September 2002 so data from September 2002 to December 2011 has been interpolated by the SILO Climate Database

GROUNDWATER USE

Licensed groundwater extractions in the Musgrave PWA for 2010–11 totalled 95.5 ML (Fig. 6). This figure is derived from metered data and represents a 16% increase from the previous water-use year. The vast majority of the licensed extractions in the Musgrave PWA are for public water supply, with only 9.7 ML extracted in 2010–11 for other licensed purposes such as irrigation (Table 1). The licensed allocation limit is determined in accordance with the current Water Allocation Plan.

The steady decline in licensed extractions since 2004–05 has been the result of falling groundwater levels in the Polda lens caused by an extended period of below-average rainfall. Water restrictions imposed on the public water supply since 2008 also reduced demand.

A Notice of Prohibition has effectively reduced the volume of water that can be extracted for licensed purposes (as displayed by the black dashed line in Fig. 6).

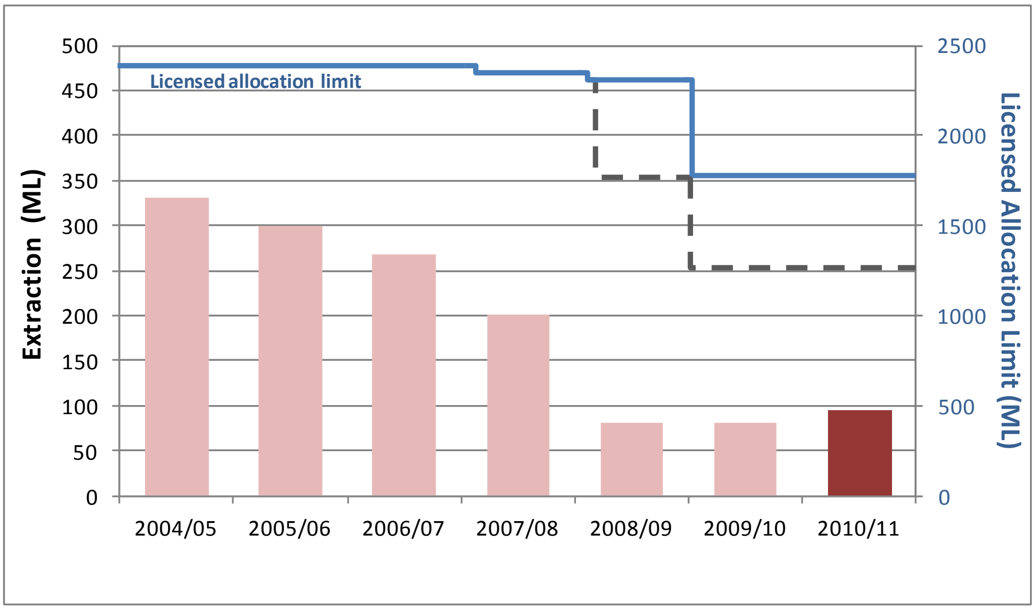

Figure 6. **Historic licensed groundwater use and licensed allocation limit in the Musgrave PWA. The dashed black line represents the licensed allocation limit under the Notice of Prohibition on the Polda lens**

While allocations have been granted for Polda, Polda North, Polda East, Sheringa, Bramfield and other minor lenses, licensed water use for 2010–11 has only occurred from Polda and Bramfield lenses. The purpose of use and volume is displayed in Table 1.

Table 1. **Licensed groundwater use per lens in the Musgrave PWA for 2010–11**

Lens	Extraction (ML)
Polda	
Public supply	0
Irrigation	1.6
Bramfield	
Public supply	85.8
Irrigation	8.1
Total	**95.5 ML**

GROUNDWATER OBSERVATION NETWORKS

WATER LEVEL NETWORK

The groundwater level observation network for the Musgrave PWA can be seen in Figure 7. Groundwater level monitoring of the various Musgrave Basins began in 1962. There are currently 127 wells monitoring water levels, with 66 monitoring the Quaternary Limestone aquifer (Table 2). A significant number of these wells are currently monitored on a monthly basis to enable the assessment of both the long and short-term trends.

Table 2. Groundwater level observation wells per aquifer in the Musgrave PWA

Aquifer	Number of wells	Monitoring frequency
Quaternary (Bridgewater Formation)	66	43 x monthly & 23 x 6 monthly
Tertiary (Poelpena Formation)	58	33 x monthly & 25 x 6 monthly
Quaternary and Tertiary	1	6 monthly
Basement	2	6 monthly
Total	**127**	

SALINITY NETWORK

The salinity observation network consists of 120 wells (Fig. 8), the majority of which are monitored annually. Of this total, 62 monitor the Quaternary Limestone aquifer and 55 monitor the Tertiary Sand aquifer (Table 3).

Table 3. Groundwater salinity observation wells per aquifer in the Musgrave PWA

Aquifer	Number of wells	Monitoring frequency
Quaternary (Bridgewater Formation)	62	39 x yearly & 23 x every three years
Tertiary (Poelpena Formation)	55	31 x yearly & 24 x every three years
Quaternary and Tertiary	1	Every three years
Basement	2	Every three years
Total	**120**	

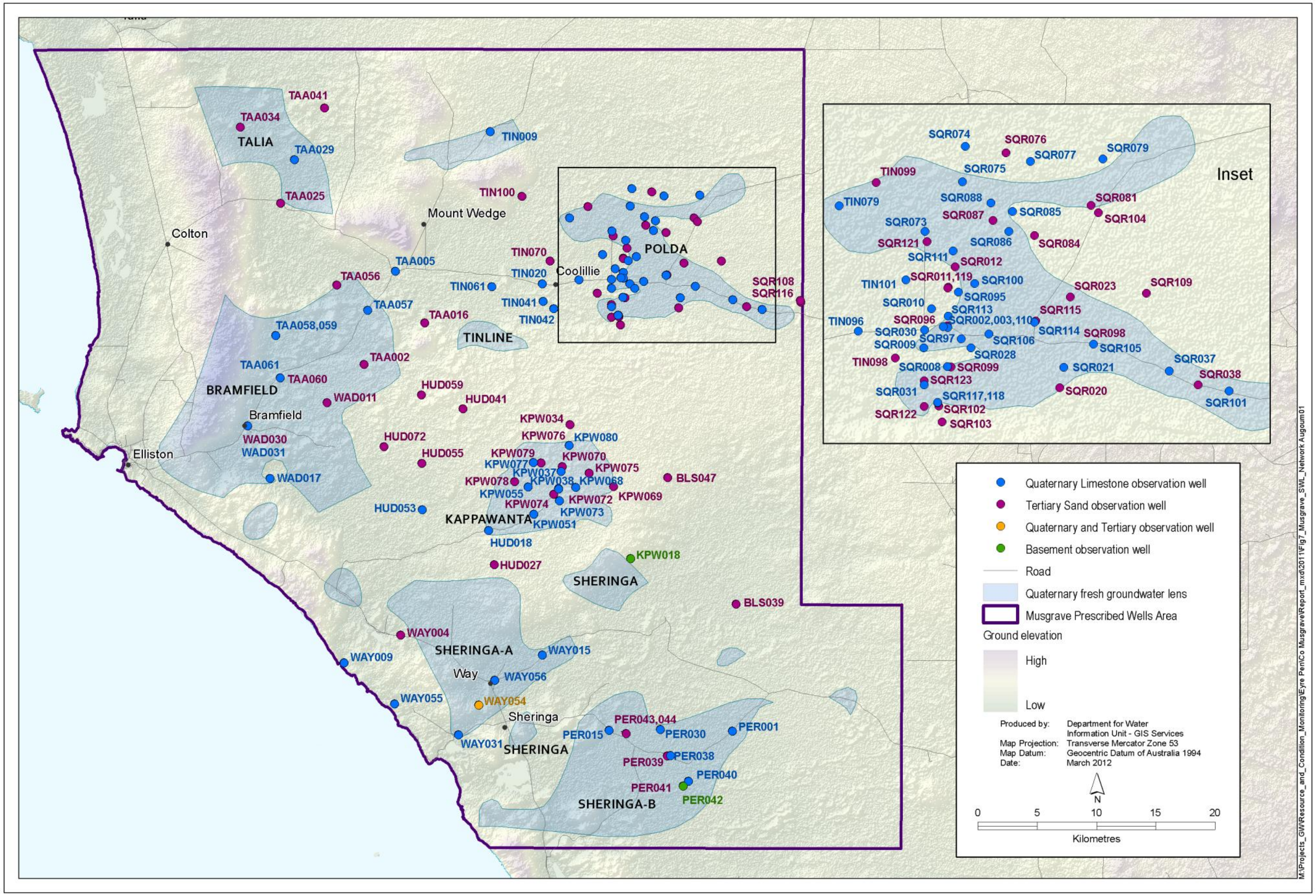

Figure 7. Location of groundwater level observation wells in Musgrave PWA

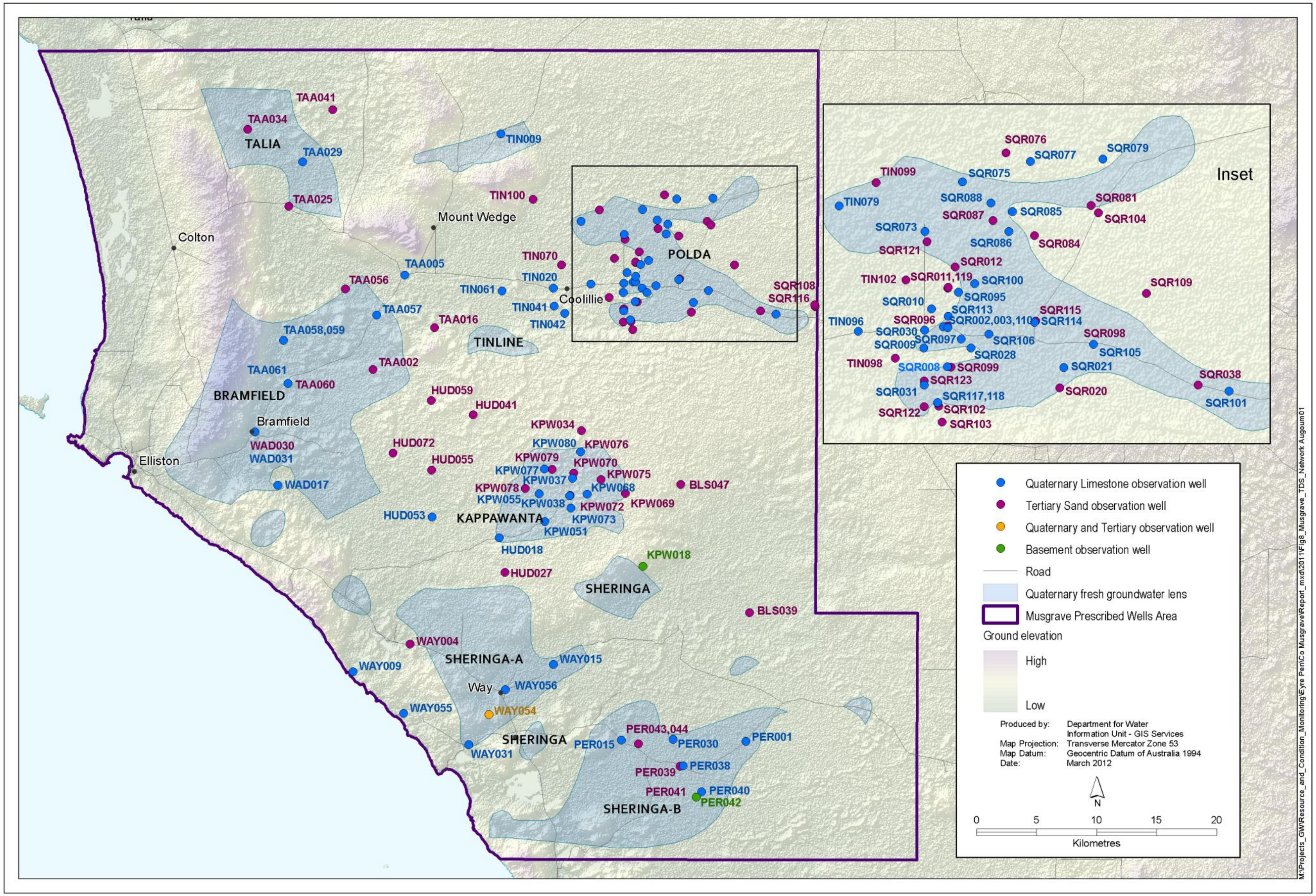

Figure 8. Location of groundwater salinity observation wells in Musgrave PWA

GROUNDWATER TRENDS

Within the Musgrave PWA there are several basins that contain groundwater in the Quaternary Limestone Aquifer. Within these basins, there are lenses with salinities of less than 1000 mg/L (Fig. 9). The extent of these lenses may cover most of the recognised basin areas or, in some cases, only part of a basin which may otherwise contain generally higher salinity groundwater. The extent of the lenses may also change over time depending on long-term trends in rainfall (and hence recharge). The different basins have been used for extraction to varying degrees and trends from groundwater monitoring data for each basin are discussed in turn.

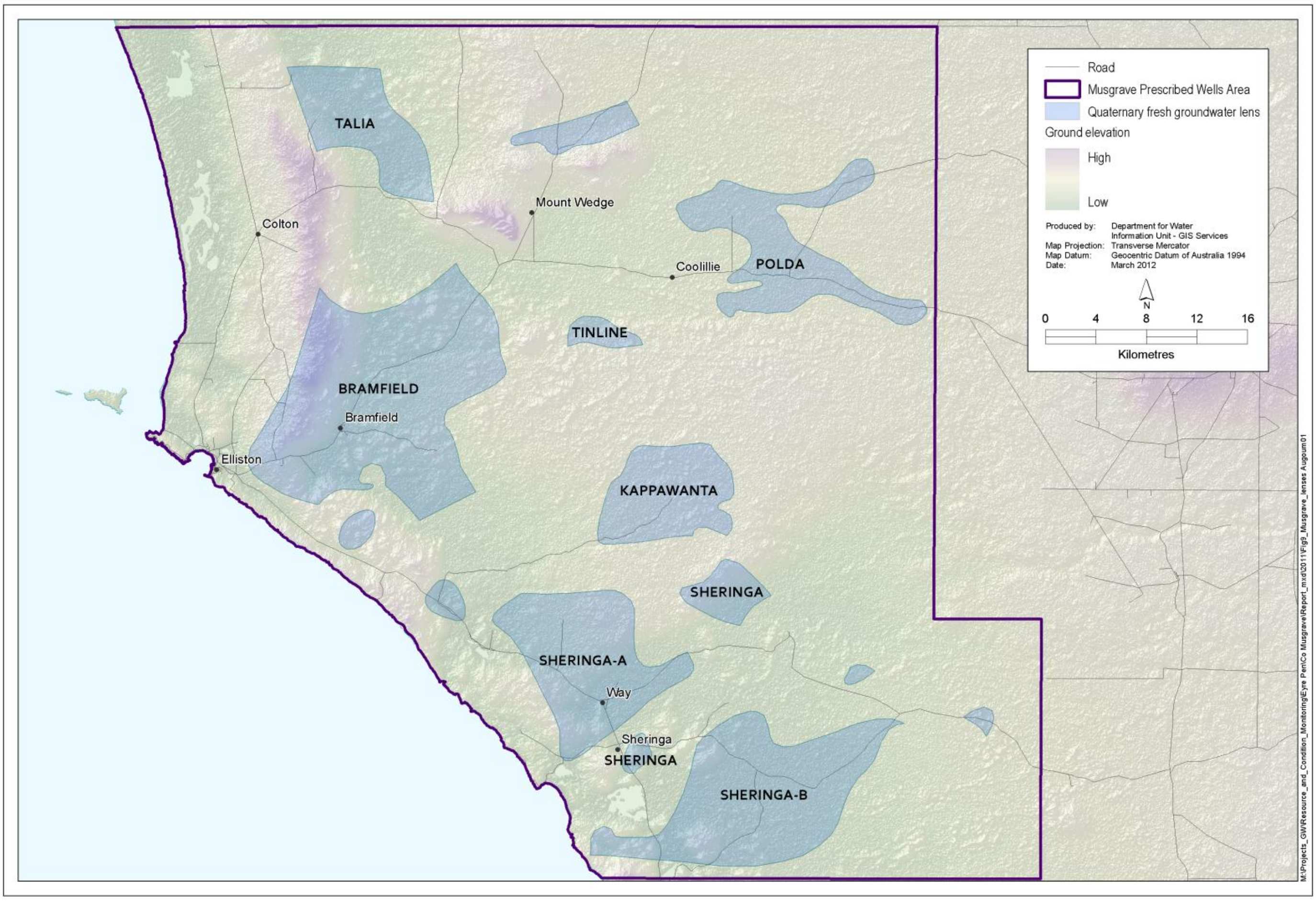

Figure 9. Location of freshwater lenses within the Musgrave PWA as outlined in the current WAP

POLDA LENS

The Polda lens has provided groundwater for the Eyre Peninsula reticulated water supply system since 1963. Before 2000, this contribution averaged about 15% of the total supply. Due to continued low effective recharge, increasing groundwater salinity and the characteristics of the extraction infrastructure, groundwater extraction by SA Water (the main user of groundwater in the lens) ceased from Polda lens in mid-2008 and is currently prevented by a Notice of Prohibition. This Notice also significantly restricts extractions by other licence holders.

Based on hydrogeology and groundwater flow direction, the current Water Allocation Plan divides the Polda lens into three sub-lenses for management purposes, the indicative locations as shown by the blue dashed lines in Figure 12.

GROUNDWATER USE

Figure 10 shows the extraction history since 2004–05, which displays a decreasing trend in use. Extractions for this period have always been well below the licensed allocation limit (i.e. less than 50%). This licensed allocation limit is determined by a process outlined in the Water Allocation Plan. Data labels are displayed (Fig. 10) from 2008-09 through to 2010–11 and represent the volume of water used expressed in megalitres (ML).

During the 2010–11 water-use year, extractions from the Polda basin increased by 0.77 ML from the previous water-use year. The dashed line in Figure 10 displays the maximum volume of groundwater extraction allowed under the current Notice of Prohibition being 1.4 ML.

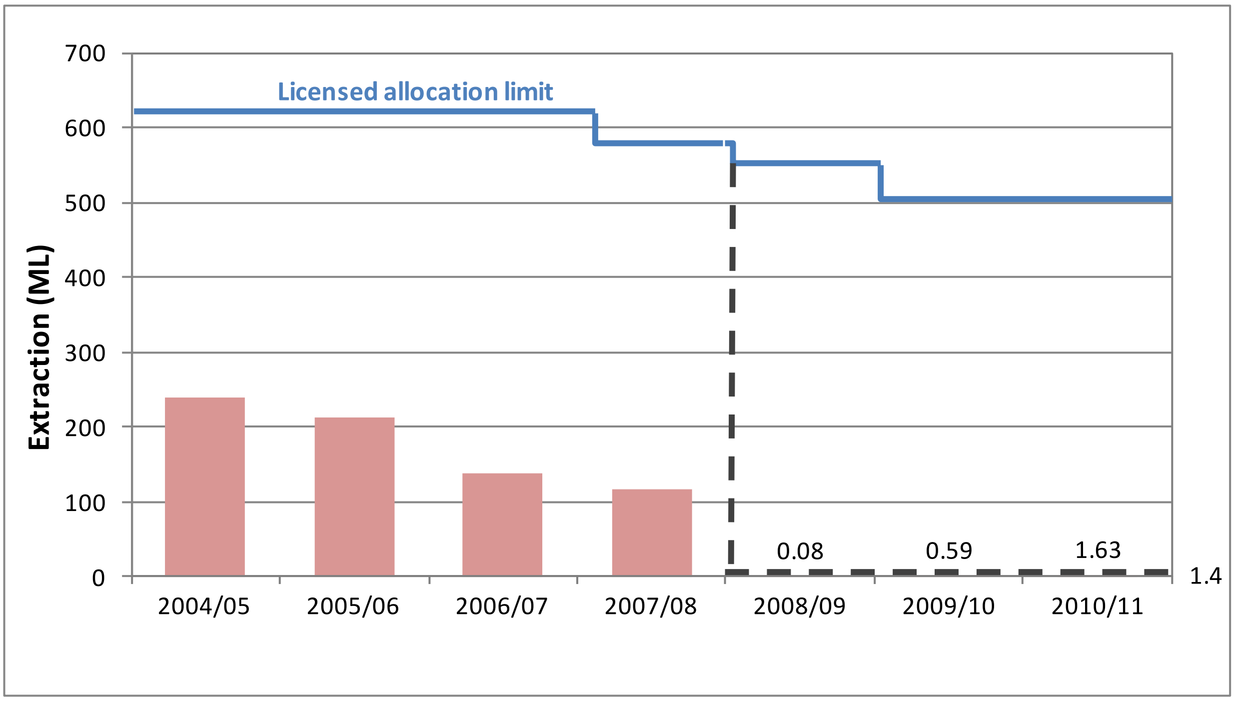

Figure 10. Historic licensed groundwater use and licensed allocation limit in the Polda lens. The dashed blacked line represents the maximum extraction allowed under the Notice of Prohibition (1.4 ML)

WATER LEVEL TRENDS

Long-term groundwater level trends can be observed using wells which have long monitoring records and have a representative distribution throughout the basin. Figure 11 displays trends from the Quaternary Limestone Aquifer in each of the three lenses within the Polda lens (the extent of each lens is shown in Fig. 12). A consistent, gradual long-term decline in groundwater levels of up to 3 m is apparent from 1980 to 2009. This decline shows a very close correlation with below-average rainfall as can be seen by the graph of cumulative deviation from average annual rainfall for the Terre* station plotted in orange in Figure 11.

Higher rainfall in 2009 and 2010 has led to a rise in groundwater levels throughout most of the basin. These levels however, are still lower than those recorded prior to the early 1990s. For 2011, a rise in groundwater levels is evident in the majority of wells but to a lesser degree than the previous year.

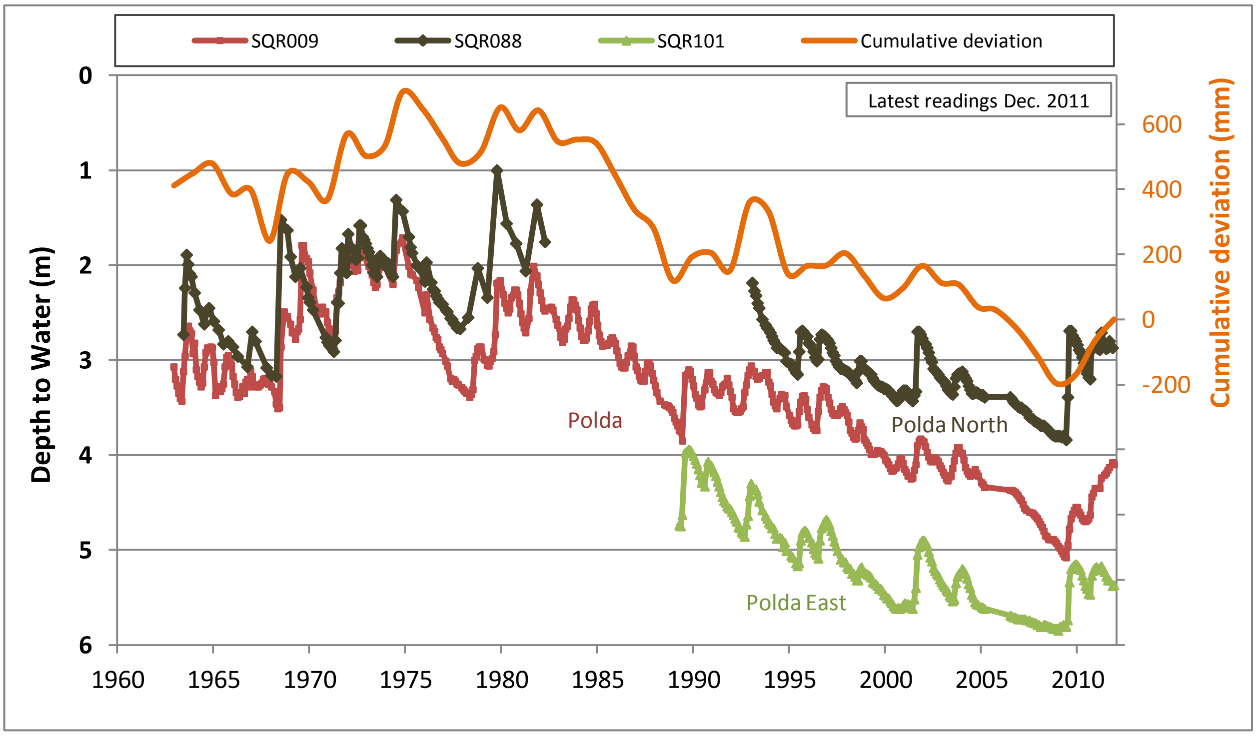

Figure 11. Groundwater level trends for the Polda lens

Figure 12 shows the observed groundwater level rise (in metres) for each observation well completed in the Quaternary Limestone Aquifer within the Polda lens from December 2010 to December 2011. Over half of the wells throughout the basin show rises of over 0.2 m, with a maximum of 0.72 m recorded at observation well TIN101.

* Terre station data from September 2002 to December 2011 is interpolated from nearby rainfall stations as calculated by the SILO Climate Database

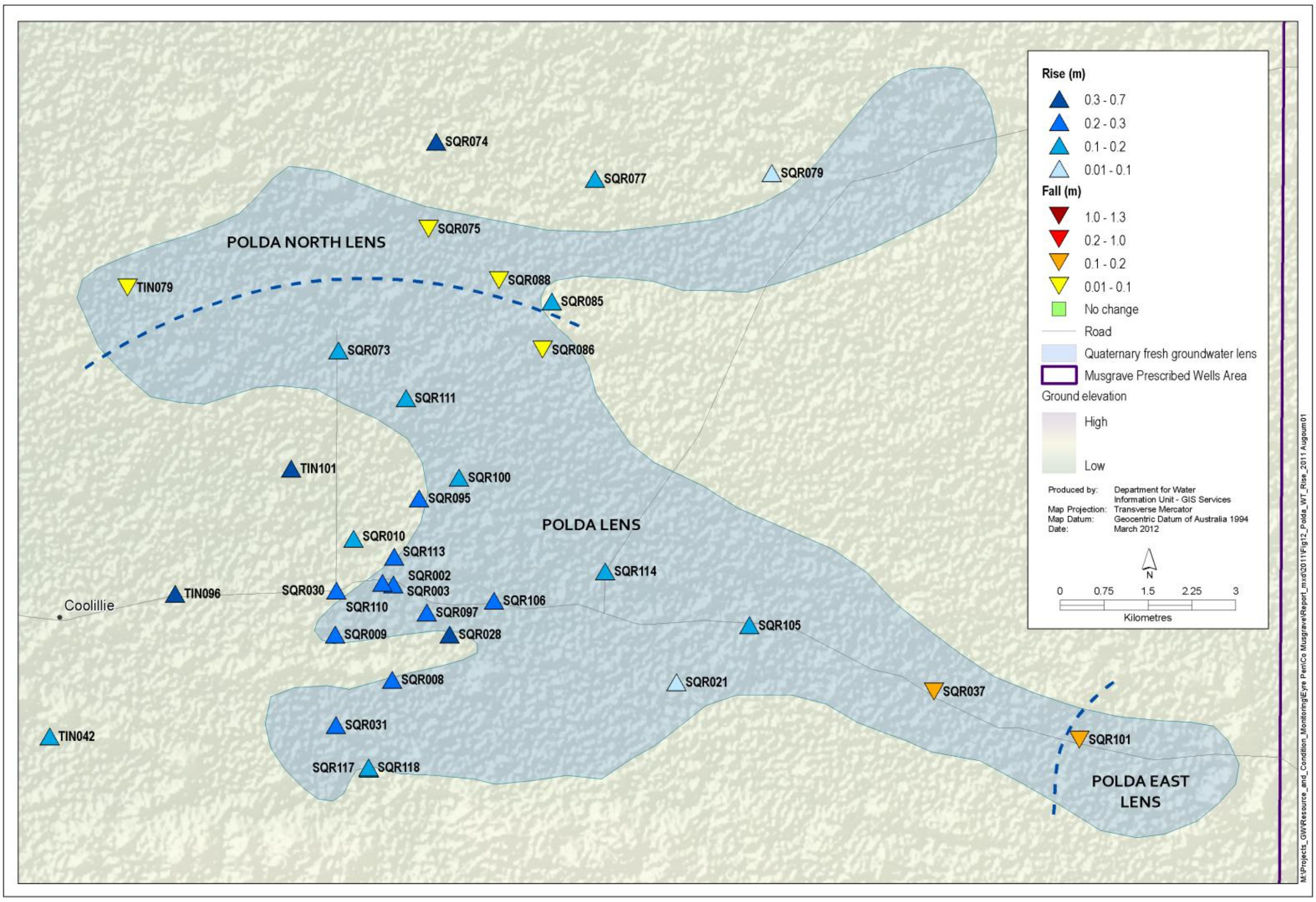

Figure 12. Overall 12-month change in watertable elevation for Polda lenses (December 2010 to December 2011)

SALINITY TRENDS

Figure 13 shows the observed groundwater salinity trends from representative Quaternary Limestone aquifer observation wells located in the three sub-lenses of the Polda lens. Observation well SQR101 (black) is in the Polda East lens, observation wells SQR031 (in orange) and SQR106 (in red) in the Polda lens, while observation well TIN079 (in green) is located in the Polda North lens. All show a rise in salinity after 2005, compared to the previous measurements taken in the mid to late 1990s. The widespread increase in groundwater salinity measured in most observation wells coincided with a prolonged period of below-average rainfall, reduced recharge and declining groundwater levels. The increases from all the monitored wells ranged up to 350 mg/L, which represents a 70% increase in salinity.

The evidence so far suggests concentration of salt by evapotranspiration (whereby water is discharged from the aquifer but the salt remains behind) as a possible mechanism.

The majority of the monitored wells within the Polda lens show a freshening trend after June 2009 in response to the increased recharge caused by above-average rainfall experienced in 2009, 2010 and 2011. An exception to this is TIN079 which shows a sharp increase in salinity following November 2009. This may be the result of salt being flushed down into the aquifer. Well SQR101 does not have a complete sampling record in recent years due to the falling groundwater level in the well preventing sampling when the well was visited.

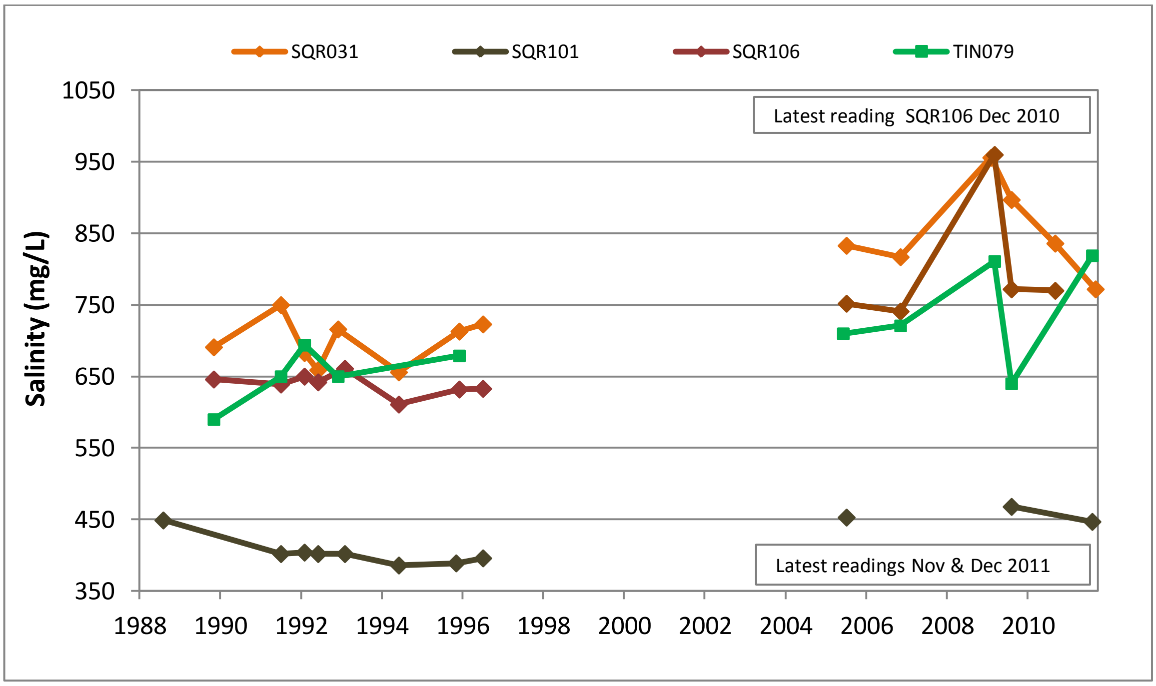

Figure 13. Groundwater salinity trends for the Polda lens

BRAMFIELD LENS

Extractions from the Bramfield lens, which lies just to the east of Elliston, commenced in 1974 with the commissioning of the Elliston town water supply. Volumes of licensed extraction from the basin since 2004–05 are presented in Figure 14. In 2010–11, SA Water extracted 85.8 ML for the Elliston town water supply, with an additional 8.05 ML extracted by other licence holders for irrigation purposes.

Licensed groundwater use from the Bramfield lens has been relatively stable as indicated in Figure 14. Typically, licensed groundwater use equates to around 10% of the licensed allocation limit displayed in blue in Figure 14 (the scale is shown on the right hand axis). For 2010–11, groundwater use from the Bramfield lens increased by approximately 16% from the previous year (2009–10). The licensed allocation limit is determined in accordance with the current Water Allocation Plan.

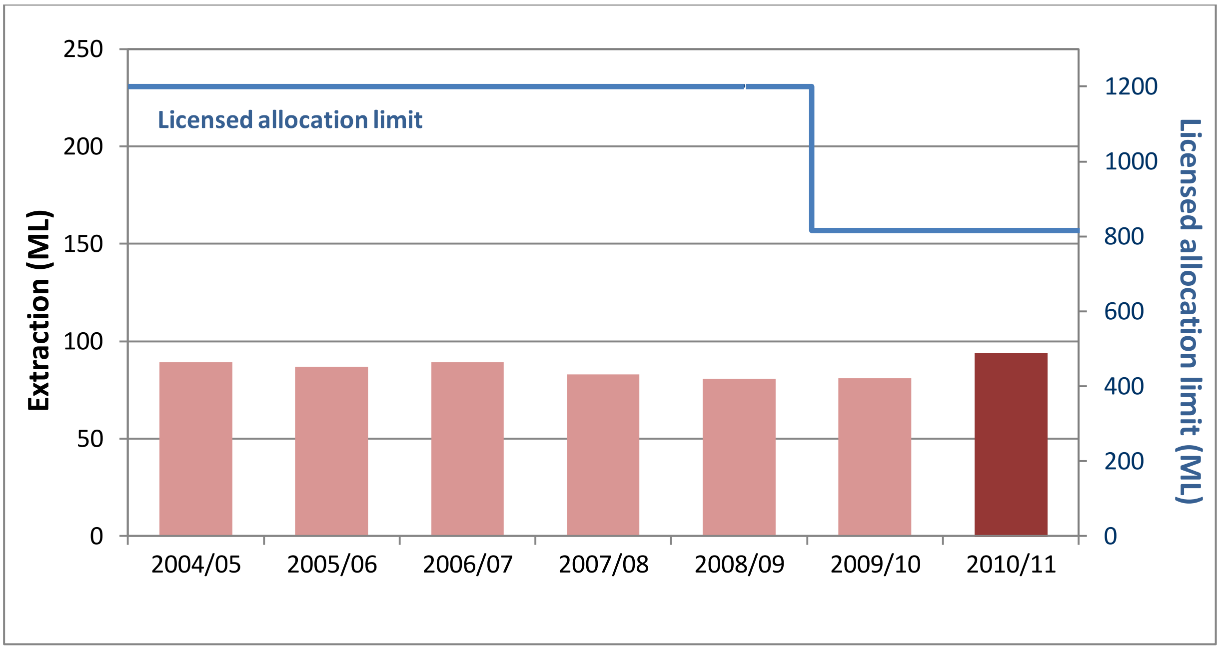

Figure 14. Historic licensed groundwater use and licensed allocation limit from the Bramfield lens

WATER LEVEL TRENDS

Long-term groundwater level trends in Quaternary Limestone aquifer observation wells from various locations within the Bramfield lens show a steady decline in groundwater levels of 2 to 3 m over the past 20 years, until the wetter period of 2009 and 2010 resulted in a significant rise in water levels. There is a close relationship between water level trends and rainfall patterns with recharge (and water level rises) occurring primarily in very wet years.

The above-average rainfall in 2009 and 2010 resulted in significant groundwater level rises in the Bramfield lens due to the increase in recharge to the aquifer. With only slightly above-average rainfall recorded at the Elliston rainfall station in 2011, hydrographs show little to no water level response and have continued to decline throughout 2011.

Figure 16 presents the changes in water level from December 2010 to December 2011 in Bramfield lens. The water level dropped by between 0.08 and 1.30 m with the biggest decline recorded in well WAD017 in the south of the lens. An increase in the water level of 0.2 m is recorded in the north-east of the lens in well TAA0057. While groundwater levels have declined during 2011 compared to the previous year, the current levels are similar to those experienced during 2004 (or earlier as is the case for well TAA061).

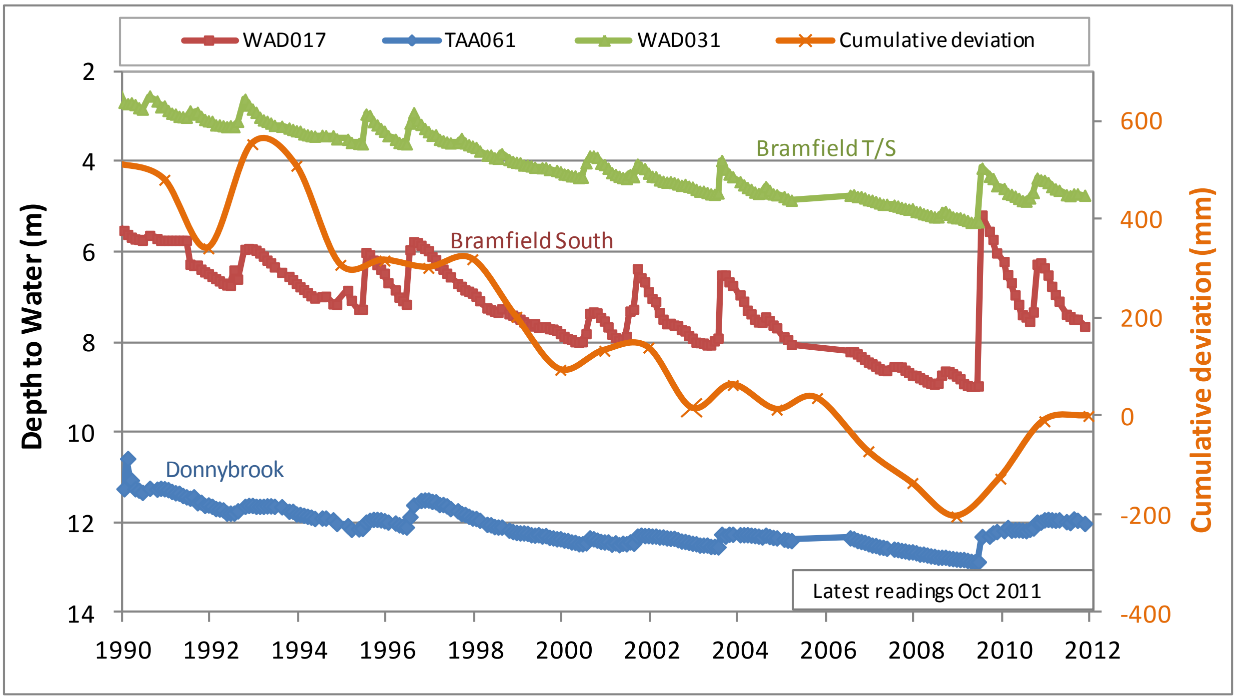

Figure 15. Groundwater level trends for the Bramfield lens

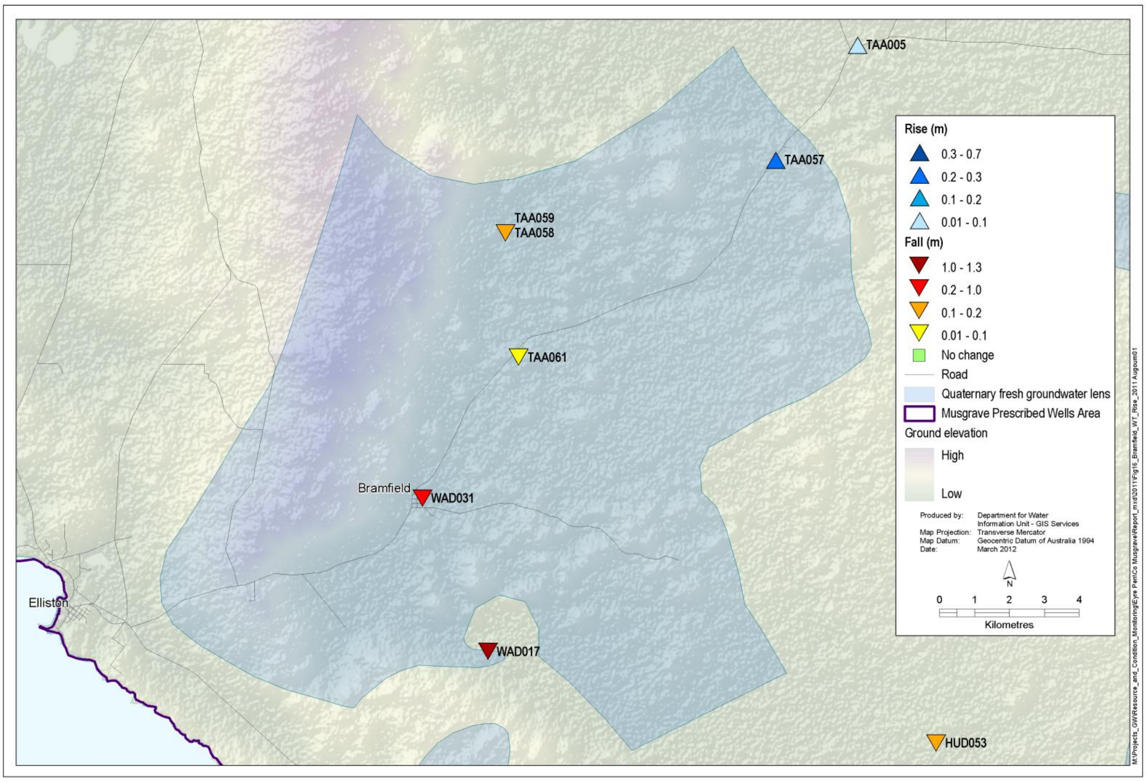

Figure 16. Overall 12-month change in watertable elevation for Bramfield lens (December 2010 to December 2011)

SALINITY TRENDS

Figure 17 shows the observed long-term salinity trends in the Bramfield lens since 1990. Observation wells TAA061 and WAD031 are characterised by a gradual increasing salinity trend of 4 mg/L/y since 1990. While the long term trend is increasing, during 2011 salinity decreased in both wells. Observation well TAA058 appears stable from 2010 to 2011.

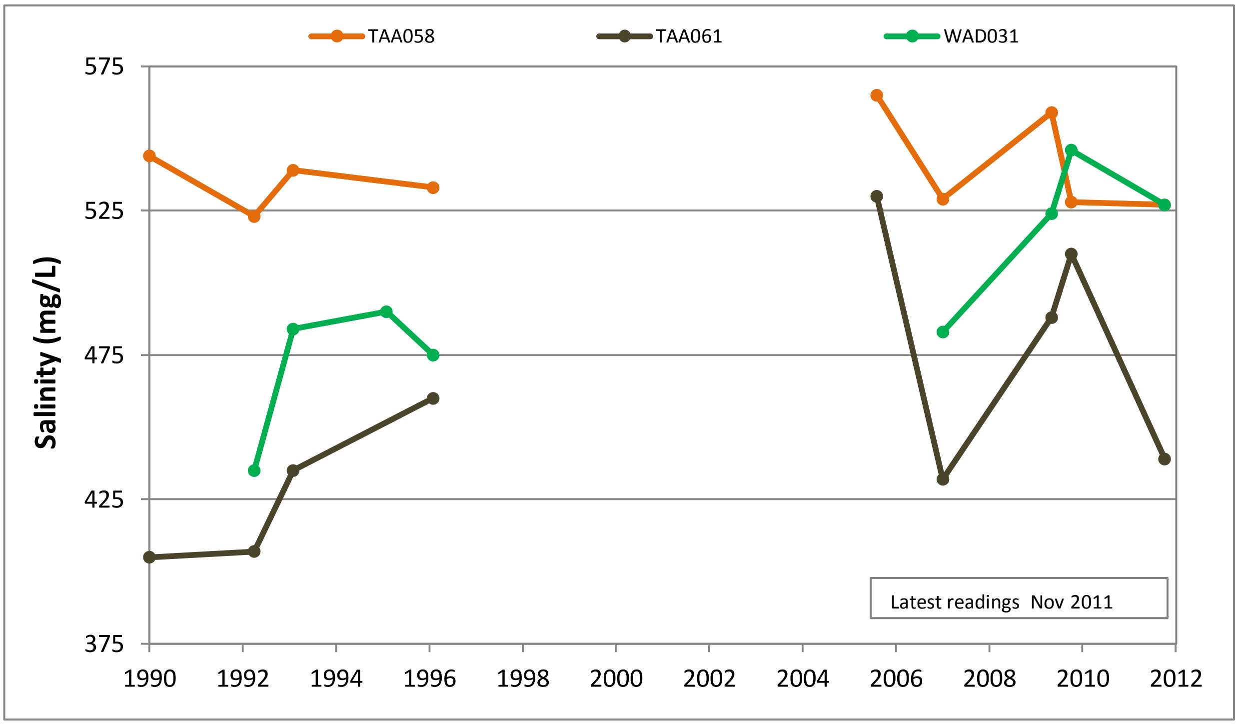

Figure 17. Groundwater salinity trends for Bramfield lens in the Musgrave PWA

MINOR LENSES

Monitoring data for the Kappawanta, Sheringa and Talia lenses are analysed as a whole, rather than individually. Stock and domestic use is the main purpose for groundwater extraction in these lenses.

WATER LEVEL TRENDS

Long-term groundwater level trends from representative observation wells within the minor lenses of the Musgrave PWA are presented in Figure 18. The observed trends are consistent and show significant declines in groundwater levels over the past 20 years. Water levels in all minor lenses indicate a response to the wetter period since 2009. Groundwater level trends show a good correlation with the rainfall cumulative deviation (Terre station[1] was used for its central location to the lenses) and the pattern of decline observed in the other lenses. This clearly demonstrates that all lenses, irrespective of extraction occurring, are showing significantly similar trends indicating that recharge is the major driver of the system.

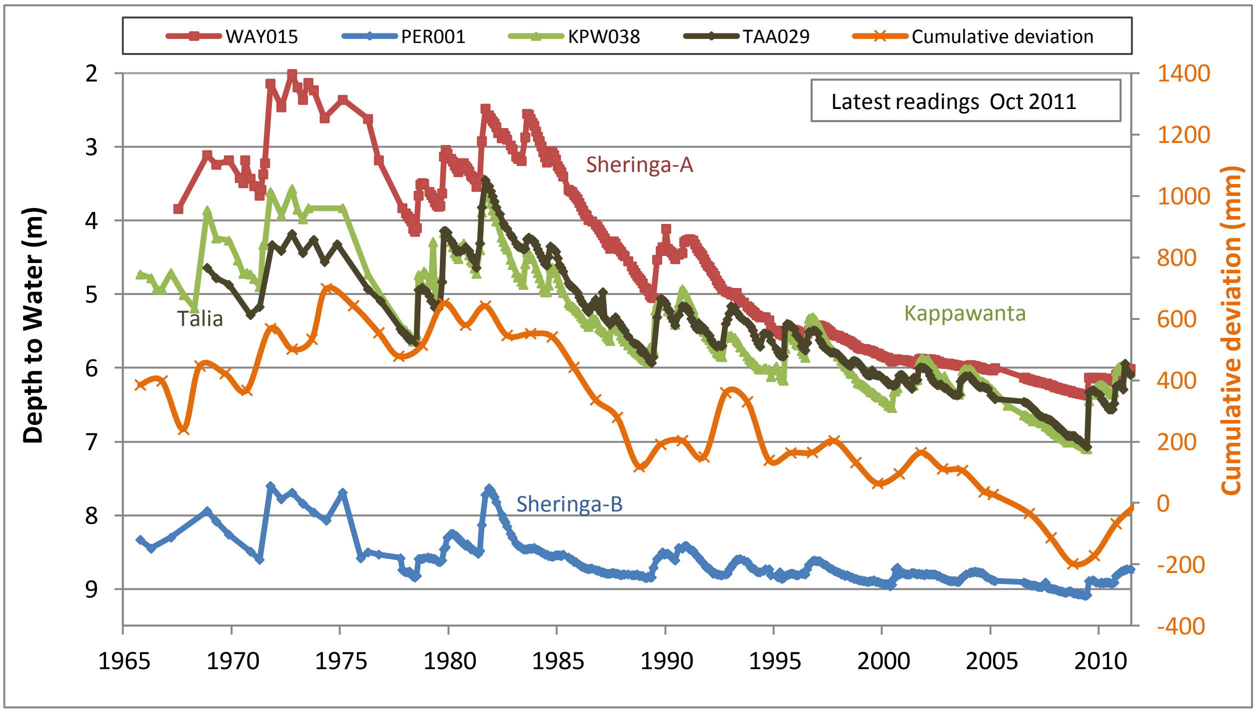

Figure 18. Groundwater level trends for minor lenses in the Musgrave PWA

[1] Rainfall data shown in this figure are sourced from the SILO Climate Database, which is hosted by the Queensland Climate Change Centre of Excellence. Any missing rainfall records are interpolated from nearby rainfall stations. Refer to page 6 of this report for further details.

Figure 19 shows the observed water level changes in the Quaternary Limestone aquifer for the minor lenses from December 2010 to December 2011. Only four of the wells show a rise in the groundwater levels, from 0.01 to 0.16 m. The majority of wells recorded a fall in groundwater levels, which ranged between 0.01 and 1.09 m but is difficult to observe at the scale presented in Figure 18. While declines are evident when compared to last year's groundwater levels, levels have recovered since late 2008 and early 2009.

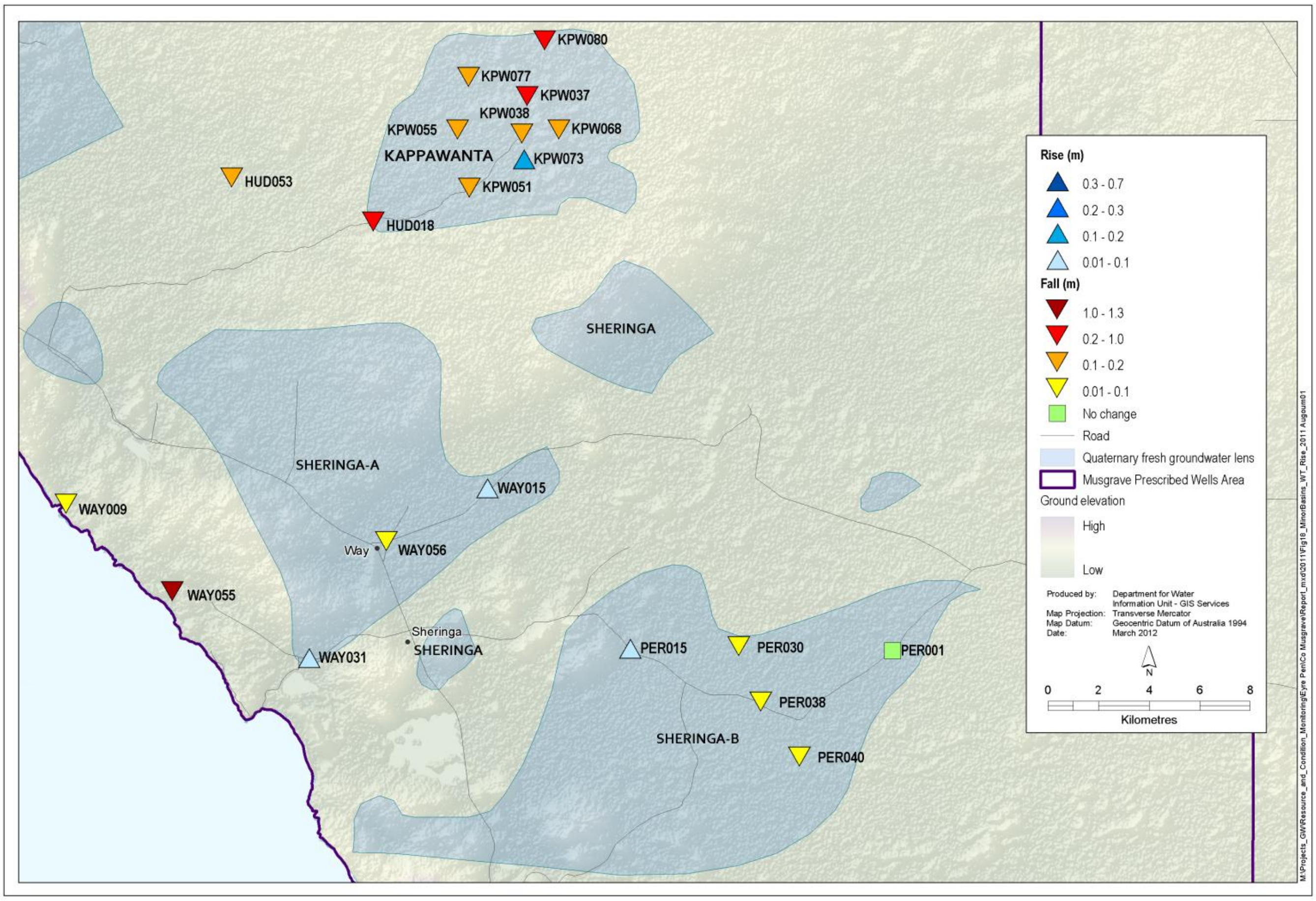

Figure 19. Overall 12-month change in watertable elevation for the minor lenses (December 2010 to December 2011)

SALINITY TRENDS

Figure 20 shows groundwater salinity trends from wells located in the various minor lenses. The graph shows that salinity levels are relatively stable over the longer term. Future monitoring of salinity is anticipated to be conducted once every three years given the minimal change in salinity and the limited use of the groundwater resource.

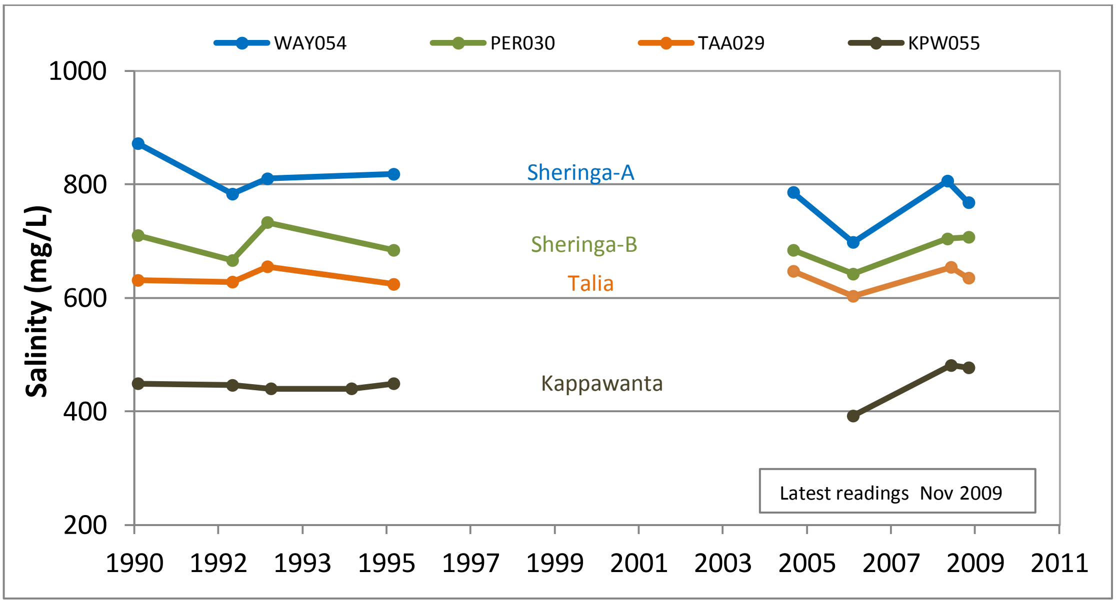

Figure 20. Groundwater salinity trends for minor lenses in the Musgrave PWA

TERTIARY SAND AQUIFER

There are no licensed extractions from the Tertiary Sand aquifer, with the majority of groundwater extracted for stock and domestic use.

WATER LEVEL TRENDS

Long-term groundwater level trends in the Tertiary Sand aquifer, for representative observation wells from various basins within the Musgrave PWA, are presented in Figure 21. The trends in each lens are virtually identical to those observed in the overlying Quaternary Limestone aquifer. For the water levels for observation well KPW079, refer to the right hand axis in blue.

The hydrographs in Figure 21 generally show a water level decline of several metres since the wet year in 1993. All wells show an increase in groundwater level indicating a significant response to the wetter 2009 and 2010 period, with rises ranging from 0.84 to 1.75 m since July 2009. The near-identical trends indicate a hydraulic connection between the Quaternary Limestone and Tertiary Sand aquifers in areas where the clay confining layer is thin or absent.

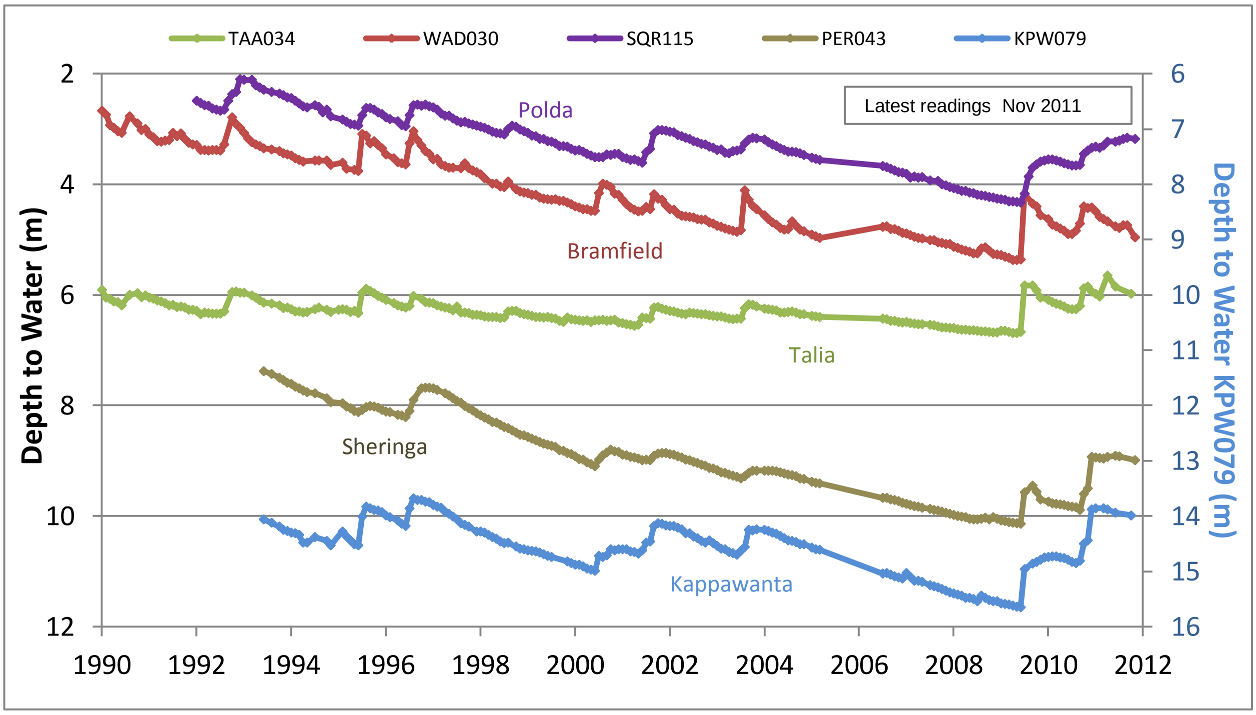

Figure 21. Groundwater level trends for the Tertiary Sand Aquifer in the Musgrave PWA

SALINITY TRENDS

Long-term groundwater salinity trends in the Tertiary Sand Aquifer are presented in Figure 22. There are a limited number of observation wells with suitable data for salinity analysis. Despite the lack of monitoring between 1996 and 2006, the trends show no significant changes in salinity.

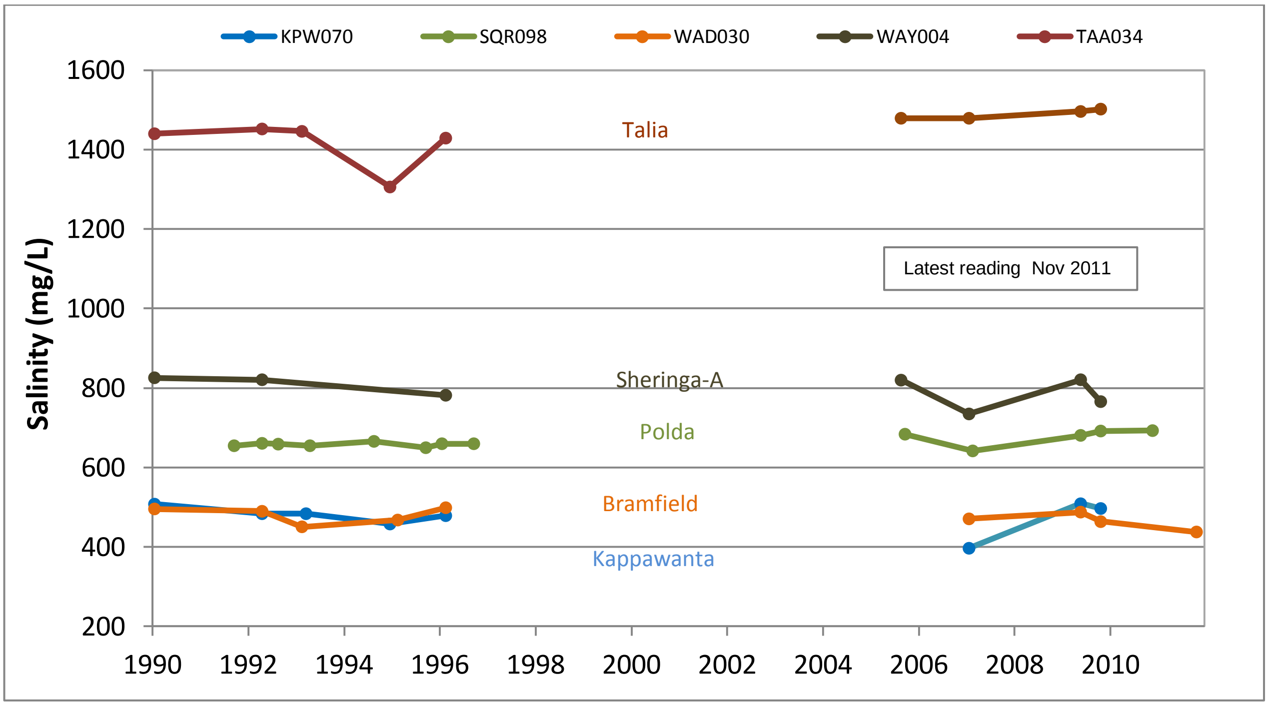

Figure 22. Groundwater salinity trends for the Tertiary Sand Aquifer in the Musgrave PWA