Padthaway Water Allocation Plan review 2019–20: Groundwater science support

Department for Environment and Water

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Foreword

The Department for Environment and Water (DEW) is responsible for the management of the State's natural resources, ranging from policy leadership to on-ground delivery in consultation with government, industry and communities.

High-quality science and effective monitoring provides the foundation for the successful management of our environment and natural resources. This is achieved through undertaking appropriate research, investigations, assessments, monitoring and evaluation.

DEW's strong partnerships with educational and research institutions, industries, government agencies, Landscape Boards and the community ensures that there is continual capacity building across the sector, and that the best skills and expertise are used to inform decision making.

John Schutz
CHIEF EXECUTIVE
DEPARTMENT FOR ENVIRONMENT AND WATER

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Summary

The Padthaway Prescribed Wells Area (PWA) is located in the south east of South Australia and is separated into the elevated Padthaway Ranges and the lower lying Padthaway Flats. The Padthaway Water Allocation Plan (WAP) was adopted in 2009 and is currently undergoing review. The 2009 WAP was informed by extensive technical investigations and a numerical groundwater flow and solute transport model. These investigations and modelling described how past clearance of native vegetation in the Padthaway Ranges had led to flushing of unsaturated zone salt into the aquifer, with observed impacts on groundwater salinity.

The Padthaway irrigation community was consulted during the 2009 WAP process and Resource Condition Limits (RCLs) were developed to help underpin groundwater management goals (South East Natural Resources Management Board – SENRMB 2011). The RCLs comprised:

- no increases in groundwater salinity (e.g. through irrigation recycling).
- water tables no lower than June 2004 levels (to prevent reduced bore yield as groundwater levels decline).
- no reduction in lateral throughflow to ensure continued flushing of salt from the range.

Since adoption of the 2009 WAP, groundwater levels have fluctuated in response to yearly variations in groundwater extraction and rainfall recharge. Generally, groundwater levels are above the resource condition limit described in the 2009 WAP. Groundwater salinity increases are still being observed in parts of the PWA; however, these increases may relate to continued flushing of unsaturated zone salinity from the Padthaway Ranges and movement through the aquifer. Cycling of irrigation water—that is drainage of groundwater used for irrigation, which has been subjected to evapotranspiration, back into the aquifer—may also be impacting salinity in the PWA.

As part of the WAP review, the Padthaway groundwater flow and solute transport model has been revised and updated to include metered groundwater extraction data from 2007 to 2018. The model has also been re-calibrated with the addition of this data, and demonstrates a good fit to measured groundwater levels. Model updates have also resulted in some improvements in the solute transport simulation. However, the model does not fit observed groundwater salinities consistently throughout the PWA.

Scenarios have been run in the model to assess the impact of continued groundwater extraction at average current rates (35 GL/y) and full allocation rates (55 GL/y). Both scenarios have been run separately assuming average 2008–2018 recharge and reduced recharge from climate change. The results show that continued extraction at current levels will likely result in stable groundwater levels, with some declines and recoveries associated with fluctuations in rainfall recharge. If extraction at full allocation rates occurs repeatedly for several years, then declines in groundwater levels are likely to occur resulting in reduced flow out of the Padthaway Flats, with potential adverse impacts on groundwater salinity. These scenarios are consistent with the previous modelling studies. It should also be noted that previous studies showed that extracting at less than 35 GL/y could lead to rising groundwater levels and further salinisation, indicating that a careful balance must be struck between extraction volumes and RCLs.

While the upper allocation of 55 GL/y was developed to provide a buffer for increased extraction in low rainfall years, if this extraction rate is sustained it will likely have an adverse impact on groundwater level and flow through the aquifer. Therefore, it is recommended that groundwater extraction and groundwater level should be reviewed annually, to ensure that sustained extraction of high volumes is not impacting upon the resource. These findings can be used to inform ongoing discussions as part of the Padthaway WAP review.

1 Introduction

1.1 Background

The Padthaway Prescribed Wells Area, located in the South East of South Australia, has been an area of significant groundwater development and investigation (Harris 1972). More recently it is an area where detailed field investigations (Harrington, van den Akker and Brown 2006), numerical modelling (Aquaterra 2008) and community consultation (SENRMB 2011) have informed groundwater management. The Padthaway Water Allocation Plan (SENRMB 2009) is cited as a good example of combining science and community consultation in developing groundwater management options (Richardson, Evans and Harrington 2011).

The 2009 Padthaway Water Allocation Plan (WAP) is due for review. As part of the review process, the former Natural Resources South East (NRSE; now Limestone Coast Landscape Board) commissioned the Department for Environment and Water (DEW) to review and update the Padthaway groundwater flow and solute transport model. The purpose of the model update is to assess the current condition of the resource, and provide recommendations to inform the WAP review. Although no significant technical investigations have been carried out since the original model development, several years of metered groundwater extraction data are now available. Such data was not available when the model was originally developed and it is very useful to help improve model performance and reduce key uncertainties.

1.2 Objectives

The objectives of this report are to:

- review the current condition of the groundwater resource in the Padthaway Prescribed Wells Area.
- update and re-run the Padthaway groundwater model with groundwater extraction data from the last 10 years.
- use the updated Padthaway groundwater model to assess the potential future impact of different groundwater extraction and recharge scenarios. These scenarios include continued extraction at current average rates, extraction at full allocation, and testing the impact of reduced pumping from full allocation when a groundwater level resource condition limit (RCL) is triggered.
- provide recommendations to help inform the Water Allocation Plan review process.

2 Groundwater resource condition

2.1 Climate and land use

The Padthaway Prescribed Wells Area (PWA) is situated in the South East of South Australia. The climate is characterised by hot, dry summers and cool, wet winters. Mean annual rainfall measured at Padthaway (Marcollat station # 26017) is 517 mm. Long term rainfall records show a decline in the frequency of above average rainfall during the 1990s and 2000s, as depicted by the declining cumulative deviation in mean annual rainfall plot in Figure 2.1.

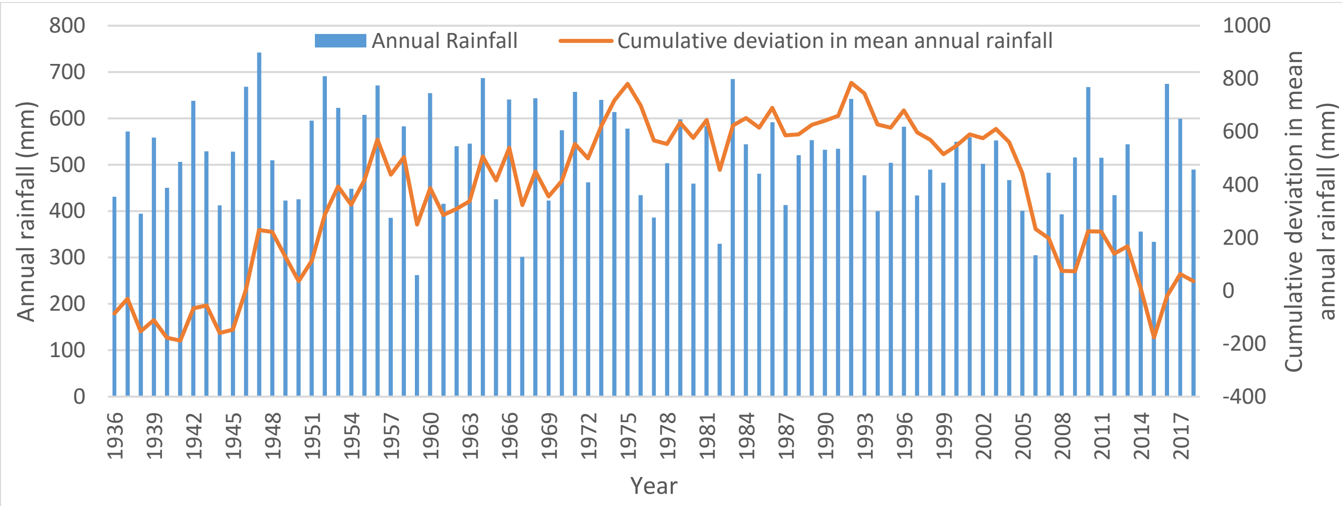


Figure 2.1. Annual rainfall and cumulative deviation in mean annual rainfall measured at Padthaway (26017)

Irrigation in the area is a mixture of drip-irrigated vineyards and flood-irrigated pastures, as well as some pivot-irrigated areas. The majority of the irrigation activity occurs on the Padthaway Flats (Figure 2.2). Irrigation commenced around 1956, and the area was considered well-developed by the late 1960s, with estimated groundwater extraction in 1970–71 of 37,000 ML/y (Harris 1972).

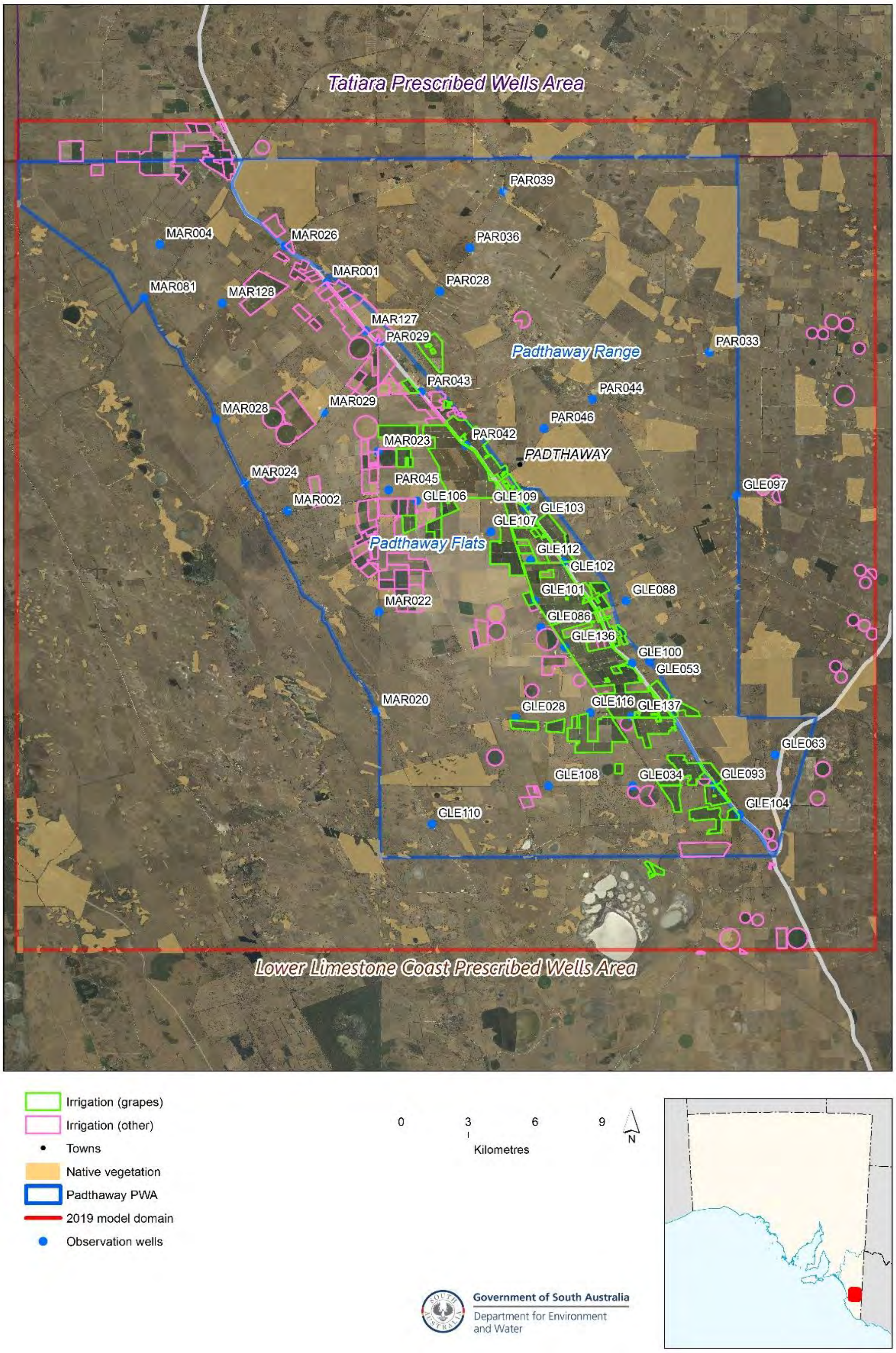


Figure 2.2. Irrigation types in the Padthaway Prescribed Wells Area

2.2 Geology

The Padthaway PWA is divided into the elevated Padthaway Range and the lower-lying Padthaway Flats with the two areas separated by the Kanawinka lineament (Harris 1972; Brown 1998). The Padthaway Range is part of the extended Naracoorte Range east of the Kanawinka lineament, while the Padthaway Flats is part of a series of inter-dunal coastal flats separated by remnant dune ridges. The Padthaway Flat is bordered to the west by the Harper Range (Figure 2.3).

The Padthaway Range is dominated by the Quaternary Bridgewater Formation, a stranded coastal dune of Aeolian and littoral deposits, formed during a marine transgression ~800,000 years ago. The Bridgewater Formation consists predominantly of calcareous sands and sandstones. This is underlain by the Tertiary Gambier Limestone, a fossiliferous marine limestone with marl inter-beds.

The geology transitions onto the Flat, as the Padthaway Formation becoming the dominant surface formation (Figure 2.3). The Padthaway Formation is Quaternary, lacustrine deposit, consisting of hard limestone with silt interbeds. Secondary porosity is present in parts which makes the formation a highly transmissive aquifer unit. In some areas the base of the Padthaway Formation consists of the Keppoch Clay, a green-brown mottled clay which acts as an aquitard. The Padthaway Formation is underlain by the Coomandook Formation, a Quaternary marine deposit of calcareous sand and sandstone, which is similar to the Bridgewater Formation (Brown 1998).

The Tertiary and Quaternary deposits of the Padthaway Flats and Range are underlain by further Tertiary marls, sands, calcarenites and clays (e.g. the Ettrick and Mepunga Formations as described by Brown (1998) which are underlain by the Tertiary sands of the Dilwyn Formation (the regional confined aquifer), which is thought to be thin beneath the Padthaway PWA (Brown 1998). These deeper units are typically not accessed in the Padthaway region, and are not considered as part of the groundwater flow model (Aquaterra 2008) and hence they are not considered further in this report. The Dilwyn Formation is underlain by granite which forms the regional hydraulic basement, and outcrops in small areas in the Padthaway region as the Marcollat Granite (Wohling 2009; Aquaterra 2009; Figure 2.4).

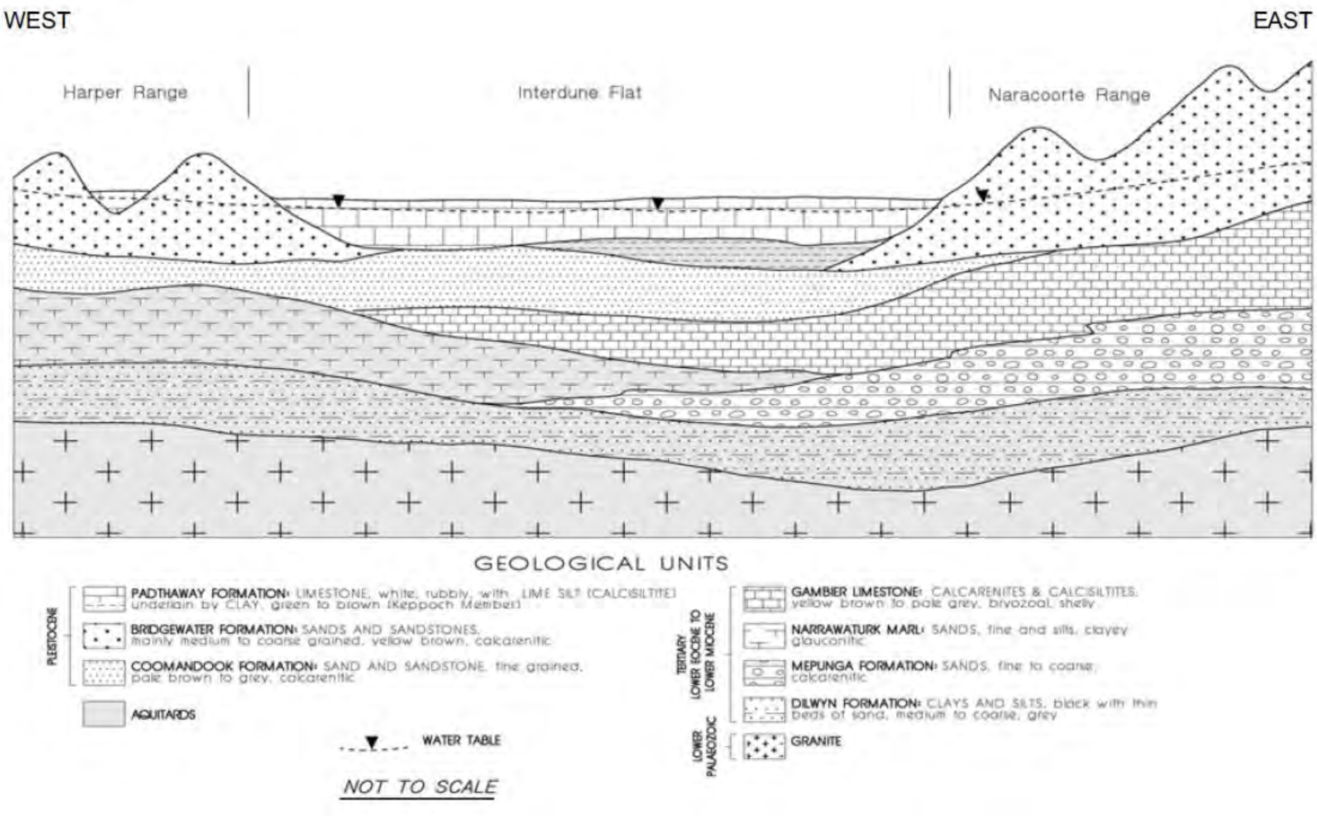


Figure 2.3. Hydrogeology of the Padthaway PWA (from Harrington et al., 2006)

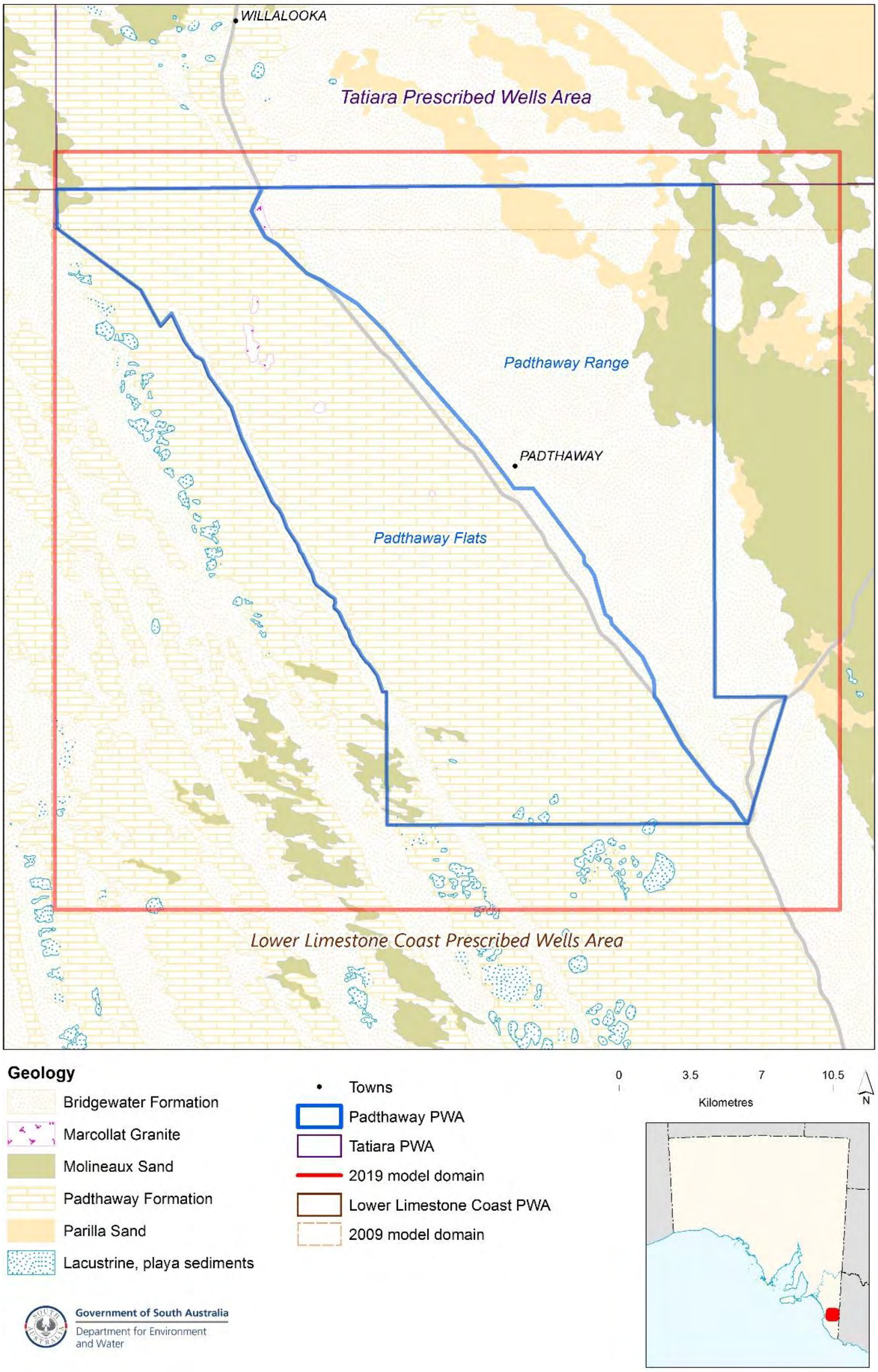


Figure 2.4. Geology of the Padthaway Prescribed Wells Area

2.3 Hydrogeology and previous studies

For groundwater management purposes, the Quaternary Padthaway, Bridgewater and Coomandook Formations and the Tertiary Gambier Limestone are considered one continuous, unconfined aquifer. However, the majority of groundwater extraction and monitoring wells in the Padthaway PWA are screened in the Padthaway and Bridgewater Formations. Groundwater flows from the east in the Naracoorte Range towards the west to north-west along the flats. Potentiometric contours show a steep gradient approaching the break in slope along the Naracoorte Range, which is a consistent regional feature along the Kanawinka lineament. Contours become much flatter on the Padthaway Flats, reflecting the higher transmissivity of the Padthaway Formation and the low topographic relief.

Aquifer parameters, based on pump test analysis, are summarized in Table 2.1. These data are based on reports by Harris (1972), Bowering (1974) and Reed (1975). In general, the Padthaway Formation displays higher transmissivities owing to the development of secondary porosity; hence much of the irrigation activity is developed on the Padthaway Flats, where well yields are high. Brown (1998) reported issues with low well yields and production of sand when pumping from the Bridgewater Formation in some locations in the Naracoorte Ranges; however good well yields may still be encountered. Reported transmissivity from pump tests in the Bridgewater Formation range from 320 to 2400 m^2/d.

Table 2.1. Aquifer parameters for the Padthaway PWA

Formation	Description	Transmissivity (m^2/d)	Hydraulic conductivity (m/d)	Specific yield	Thickness (m)
Padthaway Formation	Hard limestone, secondary porosity	1123 to 13,000	2 to 498	0.05 to 0.19	6 to 14
Keppoch Clay	Mottled clay	-	0.001*	0.2*	2 to 7.5
Bridgewater Formation	Calcareous sand and sandstone	320 to 2400	16 to 107	0.035 to 0.24	6 to 107
Coomandook Formation	Calcareous sand and sandstone		10*	0.2*	
Gambier Limestone	Fossilifeous marine limestone		1 to 250**	0.1 to 0.2	33+

* based on Aquaterra (2008)

** based on other models for the South East (Li and Cranswick 2017; Wood 2017)

Estimates of recharge in the Padthaway PWA have varied over time. Harris (1972) used the water table fluctuation method to estimate recharge to be 73 mm/y on the flats and 39 mm/y on the range. Allison and Hughes (1975) further investigated recharge to the flats using tritium measurements, and estimated recharge to be 27 mm/y to the flats, significantly lower than the estimate from Harris. Despite different recharge estimates, both Harris (1972) and Allison and Hughes (1975) estimated the groundwater resources to be at maximum capacity in terms of the level of groundwater extraction at the time.

Ongoing concerns related to increased levels of groundwater salinity in the irrigation district led to the Padthaway Salt Accession Project in 2003. The project aimed to investigate key mechanisms thought to be driving increases in groundwater salinity in the region, including:

- pumping in excess of recharge and drainage of irrigation water back to the water table (e.g. under flood irrigation) leading to salt cycling.

- flushing of unsaturated zone salt in the range following clearance of native vegetation, resulting in increased groundwater salinity.

The project ran for three years collecting detailed information related to these processes, including: measuring groundwater level and salinity; rainfall and evaporation monitoring under various types of irrigation and land use; soil coring to assess unsaturated zone salinity levels; modelling the rate of salinisation in the Padthaway Range following land clearance; and, developing conceptual models for the entire Padthaway PWA (Harrington et al. 2004; van den Akker 2005; van den Akker, Harrington & Brown 2006). The project made several important findings which improved understanding about the groundwater resources in Padthaway (Harrington, van den Akker and Brown 2006), including:

- Clearance of native vegetation in the Padthaway Range in 1960 had resulted in increased recharge on the Range, which led to mobilisation of unsaturated zone salt into the groundwater system. As groundwater flows from the ranges to the flats, this unsaturated zone flushing on the range is thought to be the main mechanism driving groundwater salinity increases on the flats. Modelling in collaboration with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was used to estimate how recharge and salinity flushing in the range may change over time (Figure 2.5). In some areas the unsaturated zone is flushed and 'fresh' groundwater is now being recharged, which is thought to be of long-term benefit to the groundwater resource. However, in other areas the unsaturated zone remains un-flushed, and thus salinity impacts may continue in the future in parts of the Padthaway PWA.

- Soil water salinity was found to be high under drip and pivot irrigation due to concentration of salt from crop water use, although it did not appear that this high soil water salinity was being flushed to groundwater on an annual basis. However, the high soil water salinity did pose a risk of being flushed in high rainfall years.

- Flood irrigation was contributing to increased salinity, due to the evapotranspiration (and hence salt concentration) of irrigation water which then drains back to the aquifer.

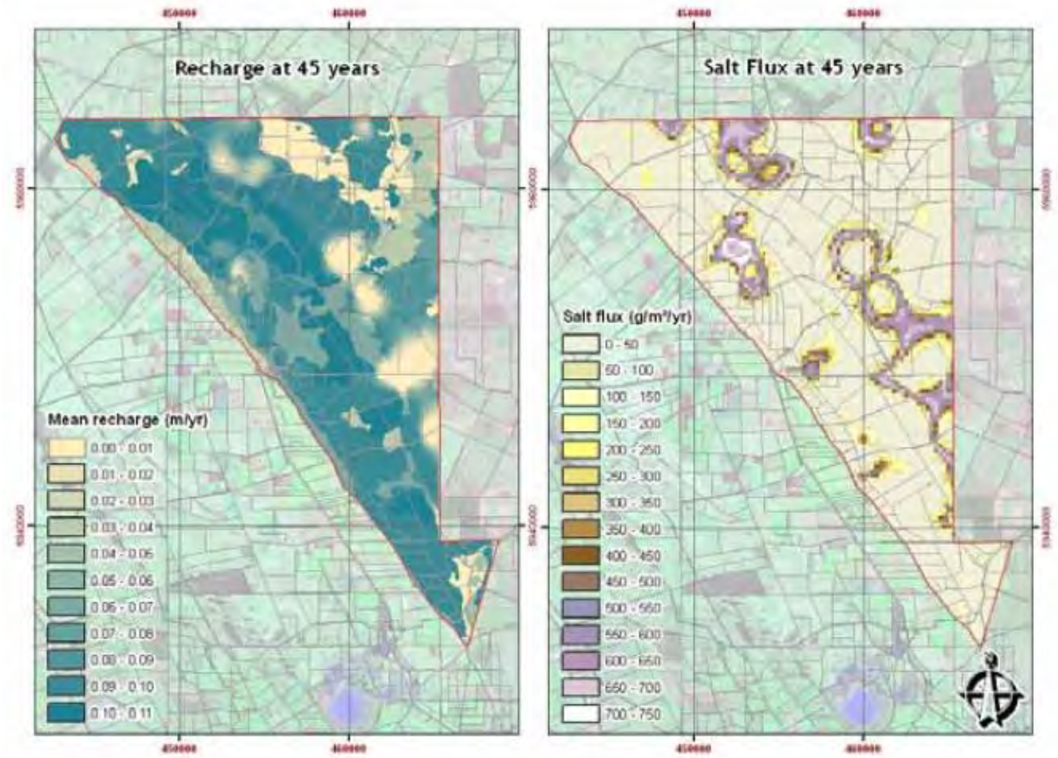


Figure 2.5. Estimated rates of recharge and salt flushing in the Padthaway Range in 2005 (Wohling et al. 2006)

Rates of estimated and potential drainage and salinity impact from these studies were made, and conceptual models of water and salt flux in the Padthaway PWA were developed. This detailed conceptualisation was then used to develop a numerical groundwater flow and solute transport model for the Padthaway PWA (Aquaterra 2008). Further details regarding the numerical model will be provided in Chapter 3, which details the current update of the model.

The numerical model was used to quantify the water balance for the Padthaway PWA (Figure 2.6), underpinned by the Salt Accession Study recharge estimates, and to simulate the potential impact of different extraction scenarios. Results from the model showed that extracting the full volumetric allocation from the aquifer (78 GL/y) would likely lead to adverse groundwater level declines; however extracting less than 35 GL/y (under the assumptions considered in the model) could lead to rising groundwater levels and further salinisation. Further to this, the Padthaway irrigation community was consulted and Resource Condition Limits (RCLs) were developed, to help set groundwater management goals that model scenarios could be compared to (SENRMB 2011). The RCLs for the Padthaway PWA were:

- no increases in groundwater salinity.
- water tables no lower than June 2004 levels.
- no reduction in lateral throughflow to ensure continued flushing of salt from the range.

Further refinements to the model were made (Wohling 2008; Aquaterra 2009) and further modelling was done in order to determine a level of extraction that had the least impact on resource condition. Through this approach and consultations with the community on the modelling results, an acceptable level of extraction of 48,000 ML/y was determined, and a process was worked through to reduce allocations to this level. It should be noted that at the time, available metered extraction data (from 2003 to 2006) suggested that extraction varied between 33,000 to 40,000 ML/y (SENRMB 2011).

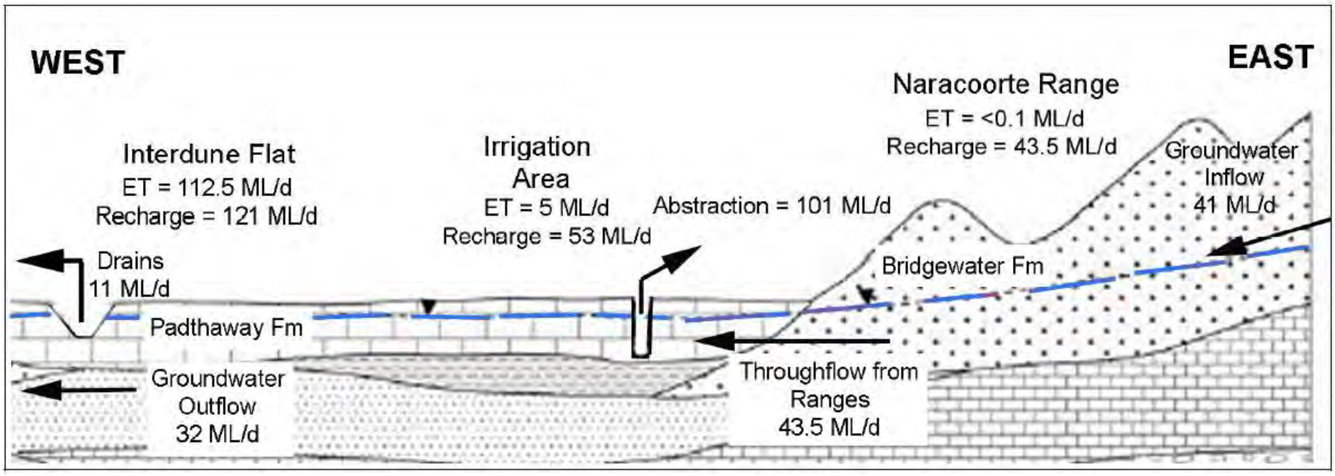


Figure 2.6. Groundwater model simulated water balance for 2005 for the Padthaway PWA (from Aquaterra 2008).

2.4 Current resource condition

2.4.1 Groundwater levels and trends

Long-term groundwater level trends are generally consistent in the Padthaway Ranges, where the water table is 10 to 30 m below ground level. Groundwater levels rose 2 to 4 m during the 1980s and 1990s, which can be attributed to a time-lagged increase in recharge as described in the Padthaway Salt Accession studies (Figure 2.7). The timing and magnitude of water table rise has varied across the ranges according to soil type and time of land clearance. In general, hydrographs in the ranges peaked in the 2000s and have either stabilised after a small amount of decline (e.g. PAR033, PAR044 and GLE063) or continue to decline (e.g. PAR039). See Figure 2.7.

Groundwater levels in Figure 2.7 are plotted against the Resource Condition Limit (RCL) specified in the 2009 WAP, which relates to maintaining groundwater levels above June 2004 levels. June 2004 water levels were chosen as an RCL based on anecdotal evidence obtained in community consultation that flood irrigators experienced poor well yields in 2004 as groundwater levels declined (SENRMB 2011).

In the ranges, groundwater levels have declined past this RCL. However, this is due to the long-term adjustment to new recharge rates following land clearance. Many wells in the ranges now show stable trends, possibly in a new quasi-equilibrium. Hence the decline in water levels beyond the RCL in the ranges is unlikely to be of concern, although this should be considered during future WAP reviews using the latest data.

In the flats, where the water table can occur 0.5 to 5 m below ground level, groundwater levels have historically shown large seasonal fluctuations of up to 2 m. This is in response to recharge during winter–spring and the combination of pumping and evapotranspiration in summer. In addition to seasonal fluctuations, longer-term trends are apparent, in particular declining groundwater levels during the mid to late-2000s. These declines correspond with below-average rainfall during this period (Figure 2.1). Metered extraction data shows that extraction is also generally higher during lower rainfall periods (Figure 2.8); hence declines are likely a result of both reduced recharge and increased extraction. Above average rainfall in 2010, 2013, 2016 and 2017 has resulted in variable levels of groundwater level recovery (Figure 2.7).

On the flats, groundwater levels declined below the RCL during the late 2000s when rainfall was low; however many groundwater levels have since recovered close to or above the RCL in response to above average rainfall and reduced extraction. The RCLs were designed with community consultation to help set an acceptable level of extraction (48,000 ML/y), and were quantitatively tested through the groundwater model. The observed groundwater levels show that the acceptable level of extraction may not be suitable for maintaining groundwater levels above the RCL during extended low rainfall periods. However, groundwater levels may recover following above average rainfall; hence performance of groundwater levels against the RCL should be assessed over a period of 5 to 10 years, taking into account variations in rainfall and extraction. Appendices A and B plot all groundwater levels against RCLs for the flats and the ranges respectively.

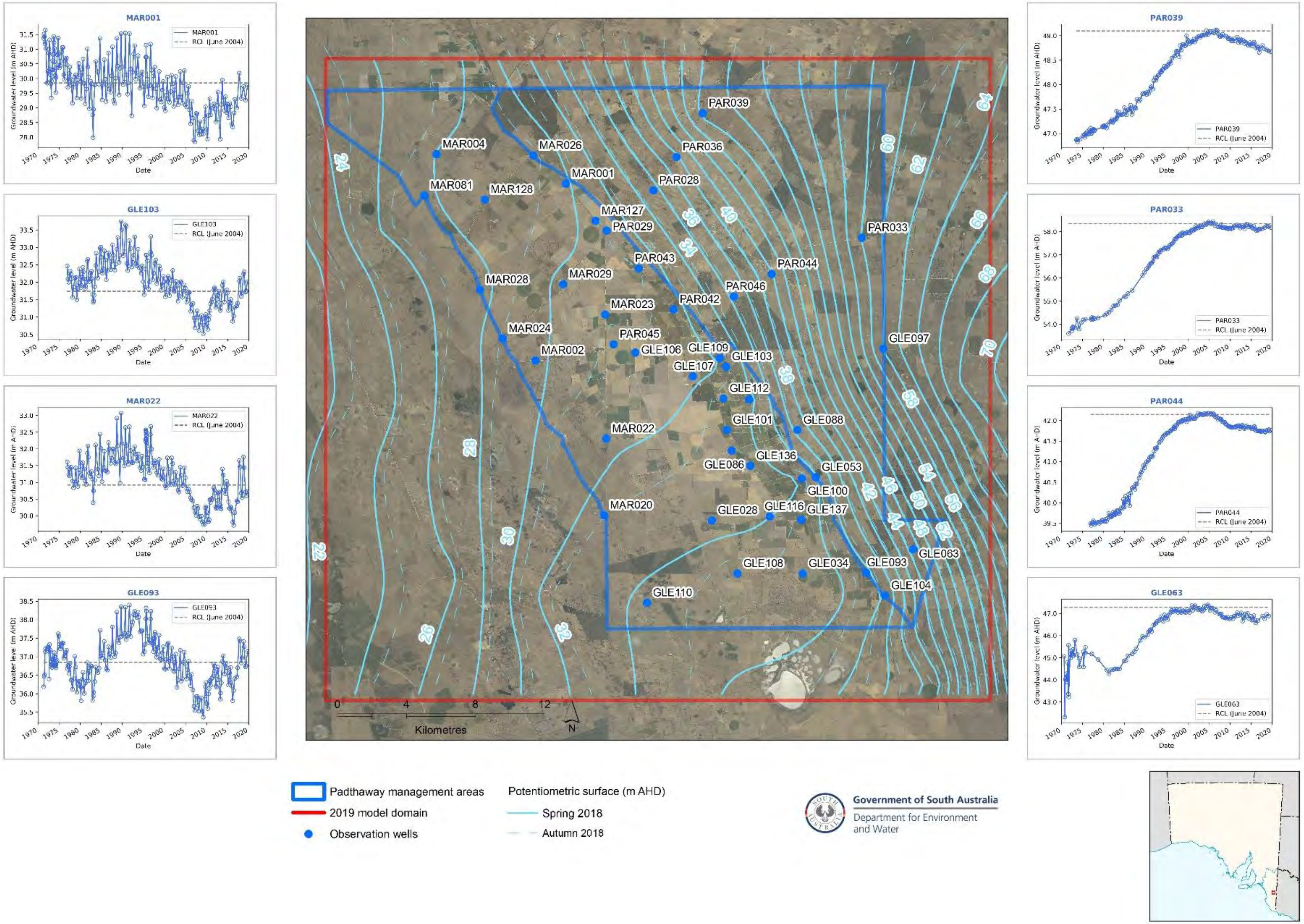


Figure 2.7. Groundwater levels in the Padthaway Prescribed Wells Area

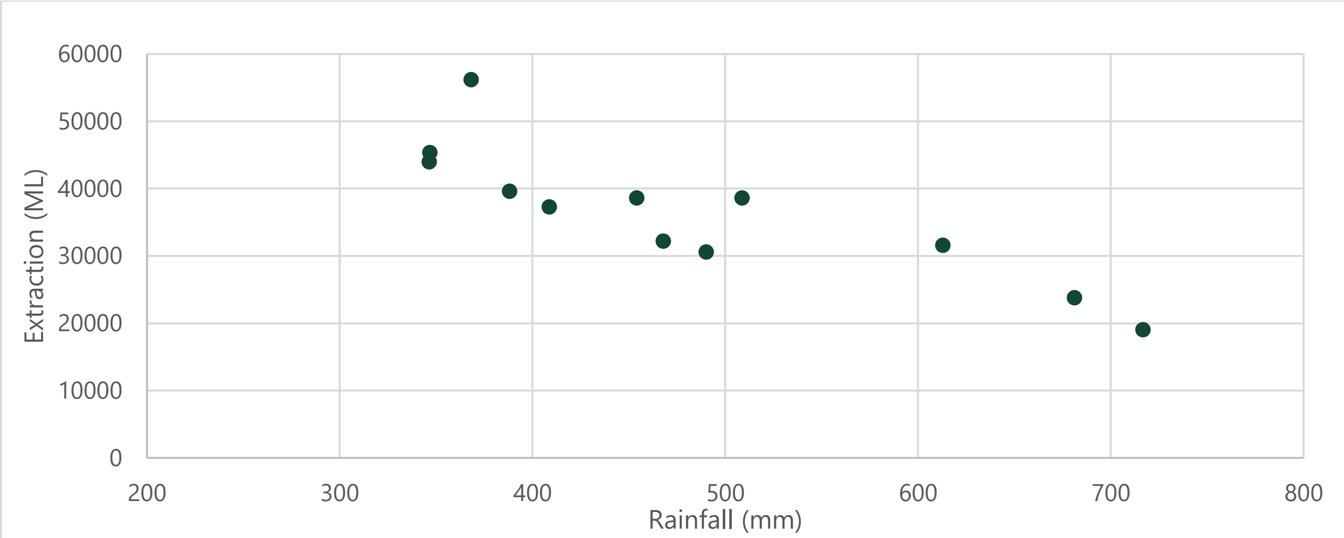


Figure 2.8. Relationship between annual metered groundwater extraction and annual rainfall for the Padthaway PWA

2.4.2 Groundwater salinity and trends

Groundwater salinity trends are variable across the Padthaway PWA. Some wells have shown declining or stable salinity trends since the adoption of the 2009 WAP (e.g. PAR044, GLE042, MAR029 in Figure 2.9). Elsewhere groundwater salinity has shown a rising trend since the adoption of the WAP (e.g. GLE028, MAR022 in Figure 2.9). Rises in groundwater salinity are likely related to one or a combination of processes, as discussed by Innovative Groundwater Solutions (IGS 2018), including:

- ongoing flushing of unsaturated zone salt from the Naracoorte Ranges, and mobilisation of this salt through the aquifer.
- evapotranspiration of groundwater where the water table is shallow, which was demonstrated to cause salinity increases through groundwater modelling (Aquaterra, 2008).
- evaporation and drainage of irrigation water (irrigation re-cycling) under flood irrigation, which was demonstrated to occur in the Padthaway PWA (Van den Akker, Harrington and Brown 2006), and has been demonstrated to occur in the neighbouring Tatiara PWA (Wohling 2008).
- flushing of high salinity soil water under drip and pivot irrigation during periods of high rainfall (Harrington, van den Akker and Brown 2006).

Evidence of flushing of high salinity soil water can be seen in GLE103, an observation well located close to the break of slope between the ranges and the flats, and adjacent to vineyards, watered by drip irrigation (Figure 2.10). Salinity in GLE103 peaked in the early 1990s, as high salinity soil water was flushed from the ranges, consistent with the conceptual model developed by the salt accession studies. Since then, salinity has decreased to a relatively stable level. However increases in salinity are observed in recent years when groundwater levels peak following high rainfall. The water table is 6 to 7 m below ground level in GLE103, and the well is screened 8 to 10 m below ground level. Hence it is unlikely that the salinity spikes are related to evapotranspiration.

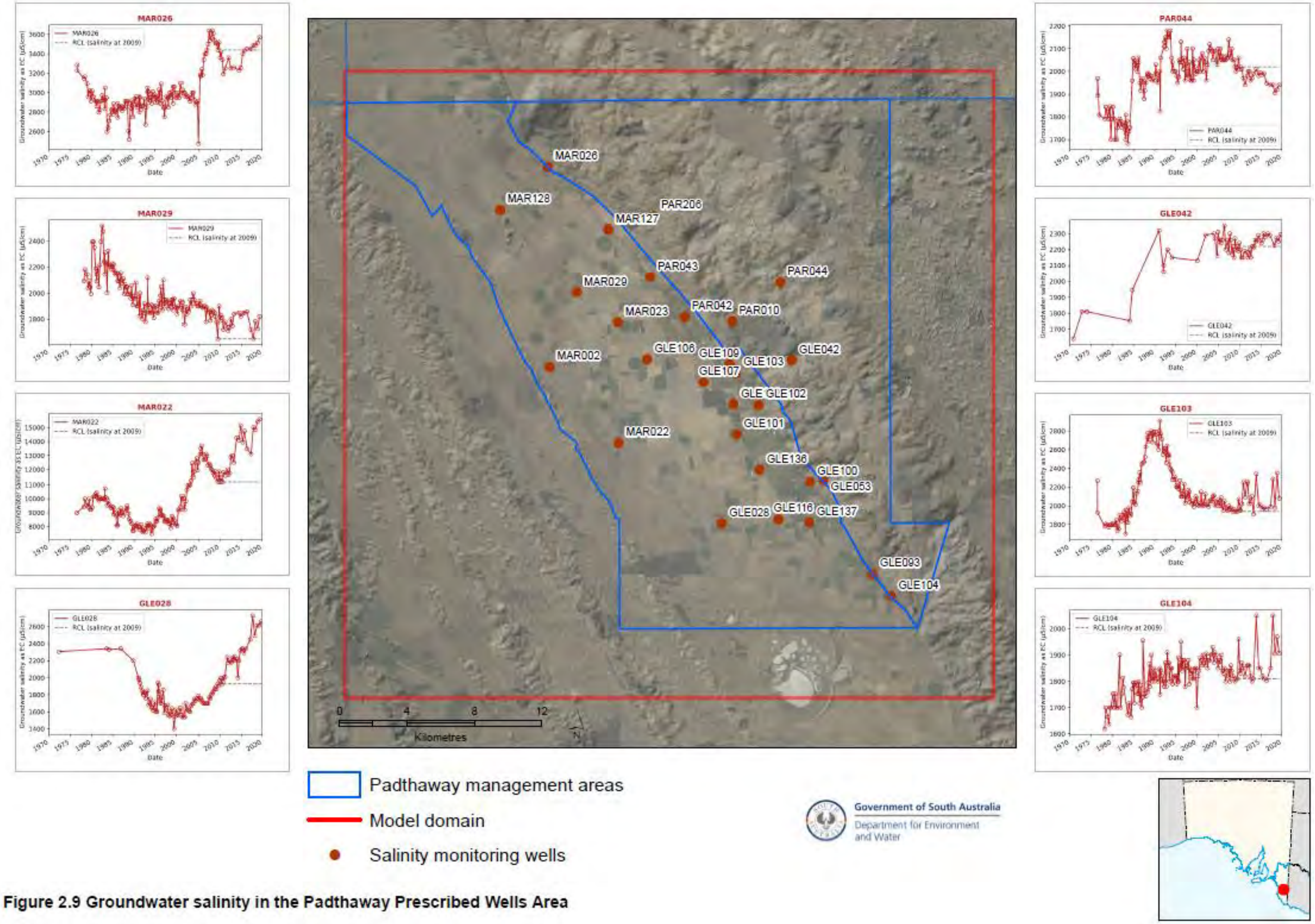


Figure 2.9. Groundwater salinity in the Padthaway Prescribed Wells Area

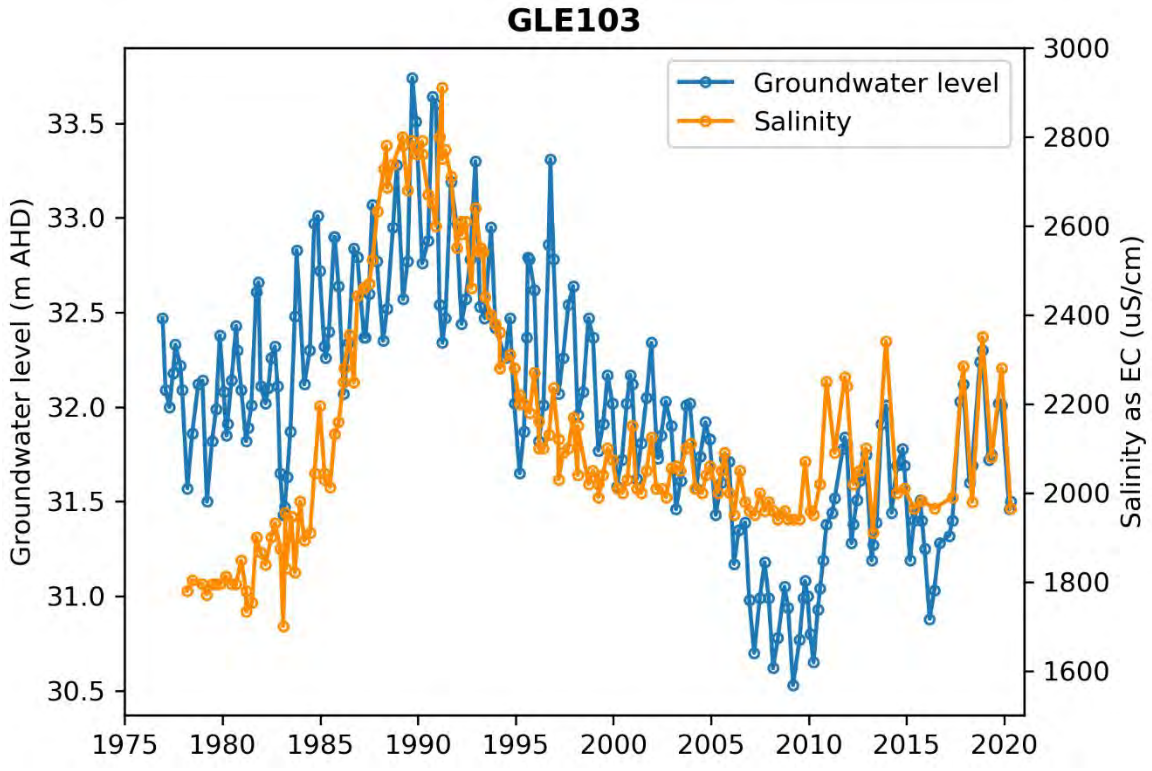


Figure 2.10. Groundwater level and salinity in GLE103

2.5 Groundwater dependent ecosystems

The 2009 Padthaway WAP included an assessment of the needs of water dependent ecosystems. Ecosystems of high to very high ecological importance identified in the WAP are Cockatoo Lake and Swede Flat (Figure 2.11). Swede Flat was characterised as unlikely to be groundwater dependent, based on the depth to water at this location. Cockatoo Lake was characterised as having some likelihood of groundwater dependence, however the WAP also noted that salinity in the lake suggested there was minimal groundwater discharge. More recently Cranswick and Herpich (2018) reviewed the likelihood of groundwater dependence for wetlands across the South East, by comparing the elevation of the water table for representative time periods with Lidar based surface elevations. For water table elevations based on average 2015-17 conditions, the authors found Cockatoo Lake to have a very high likelihood of groundwater dependence (Figure 2.11).

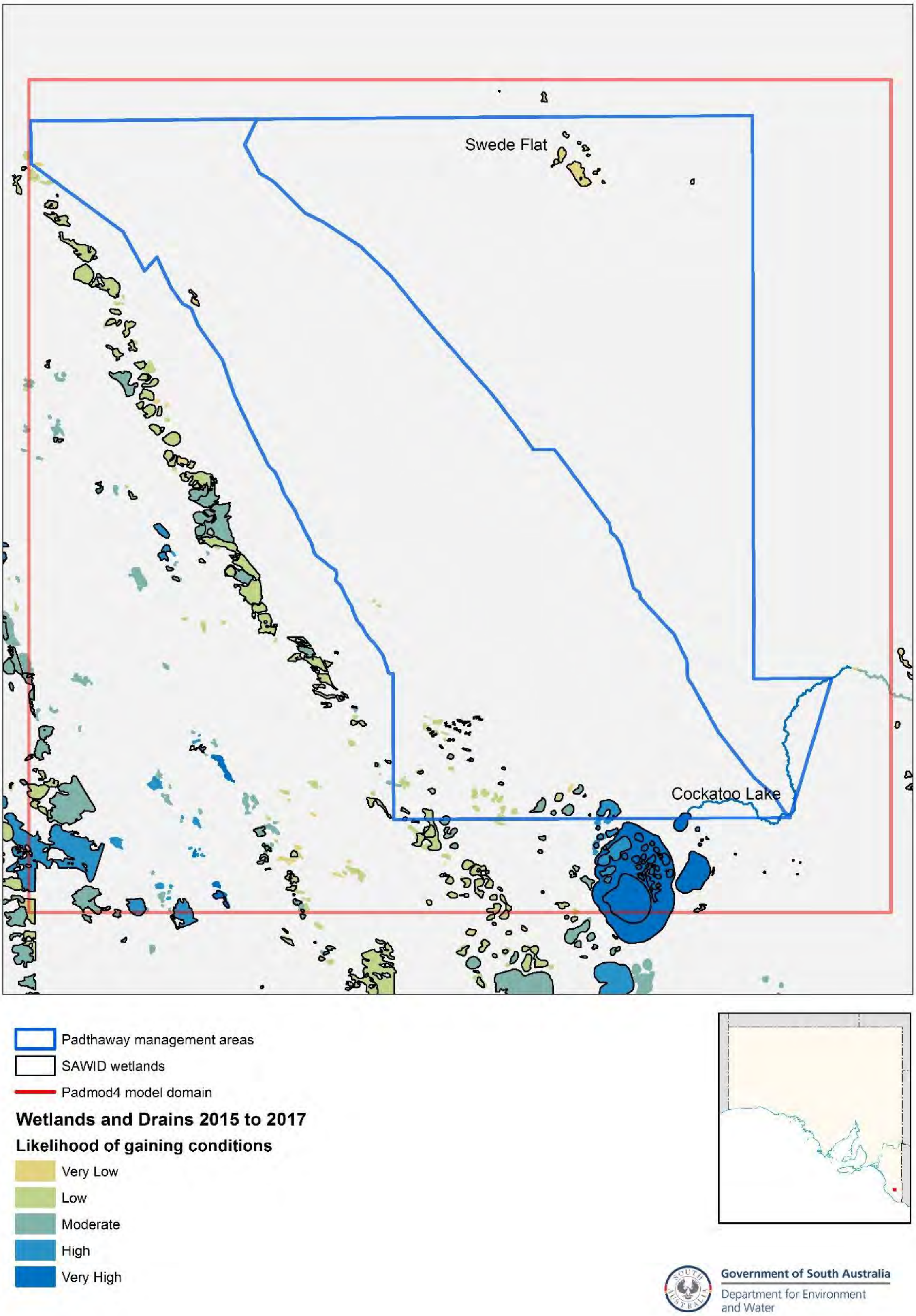


Figure 2.11. Likelihood of groundwater dependence for wetlands in the Padthaway PWA

2.6 Summary

In total, 9 out of 40 groundwater level observation wells show levels below the RCL at the time of reporting, based on measurements in spring 2018. However, all forty of these wells had shown declines below the RCL at some point since 2004. This demonstrates that the current level of extraction in Padthaway is likely to be acceptable for maintaining the groundwater level RCL, provided years of above average rainfall (and reduced extraction) are experienced. Water table mapping for 2015-17 conditions by Cranswick and Herpich also suggests that Cockatoo Lake is has a very high likelihood of receiving groundwater discharge. However groundwater levels can be expected to decline below the RCL again in future.

With regards to salinity, 23 out of 29 monitoring wells have salinity levels above the level when the WAP was adopted in 2009. Hence the salinity RCL is being breached throughout the PWA. However, the reasons for salinity increases are likely to vary across the PWA and may be difficult to attribute to a single process (e.g. a process that could be mitigated by management intervention). Groundwater salinity can be expected to change and potentially continue to rise in parts of the Padthaway PWA in the future.

3 Groundwater model update

3.1 Previous Padthaway models (Padmod, Padmod2, Padmod3)

Following the Padthaway Salt Accession Studies (Harrington, van den Akker and Brown 2006), a groundwater flow and solute transport model for the area was developed by Aquaterra (2008). The reader is referred to Aquaterra (2008) for full details of the numerical groundwater flow model. Model details, as they are relevant to this study, will be described further in Section 3.2.

Following the development of the Padthaway model in 2008 (referred to as Padmod1), two updates were made to the model by Wohling (2008) – Padmod2 and Aquaterra (2009) – Padmod3. These updates included updates to recharge and salinity inputs based on updated studies, as well as inclusion of outcropping Marcollat granite in the model domain as areas of low hydraulic conductivity. Wohling (2008) made several recommendations for further improvement to the model, including:

- extending the model domain to the north to cover the entire Padthaway PWA
- updating the model with metered extraction data and adjusting the model calibration accordingly.

Further to these recommendations, Aquaterra (2009) noted that the model surface elevation was based on an old digital elevation model (DEM), which may impact solute transport simulations in areas where the water table is close to the surface. This is because evapotranspiration (ET) in the model is set with an extinction depth of 2 m; hence, ET (and associated salinity increase) does not occur in any areas in the model where the water table is 2 m below the model grid surface. Consequently, Aquaterra recommended that the surface elevation for the model should be updated with Lidar based digital elevation data should such data become available.

3.2 Model update (Padmod4)

As part of the Padthaway WAP review, the Padthaway groundwater model has been updated so that further management scenarios could be run. The update largely involved extending the run time from 2007 to 2018 and incorporating metered extraction data. A comprehensive re-calibration of the groundwater flow and solute transport model was not scoped as part of this study, and model updates largely focused on the recommendations made by Wohling (2008) and Aquaterra (2009). However, some refinements were made to hydraulic parameters using the pilot point method in PEST (Doherty 2010). Recharge from 2007 to 2018 was also varied to account for rainfall variability through this period. As the most recent version of the model was labelled Padmod3 (Aquaterra 2009; RPS Aquaterra 2014), the updated model will herein be referred to as Padmod4. The following sections describe the updates made to the Padthaway model as part of this project.

3.2.1 Domain

The model domain was extended 3.8 km to the north to cover the entire Padthaway PWA, using the same cell size (100 m x 100 m). The northern boundary of the model now lies 1.8 km beyond the PWA (Figure 3.1). This involved extending the general head boundary along the western and north-western boundary of the model to suit the revised domain. Values assigned to the extended boundary cells were based on those in Padmod3, with the addition of head values in new cells based on the potentiometric surface.

3.2.2 Ground surface elevation

Updated surface elevation data was imported for layer 1 using a digital elevation model (DEM) based on airborne laser scanning data collected between October 2007 and May 2008. The DEM has a reported vertical accuracy root mean squared error of 0.5 m and gridded ground elevation points are given at a scale of 10 m x 10 m (Location SA

2017). For model cells (100 m x 100 m) a mean elevation from the DEM was applied (Figure 3.1) and hence the model surface elevation may still contain inaccuracies. Nevertheless, it is considered more accurate than that used in Padmod3.

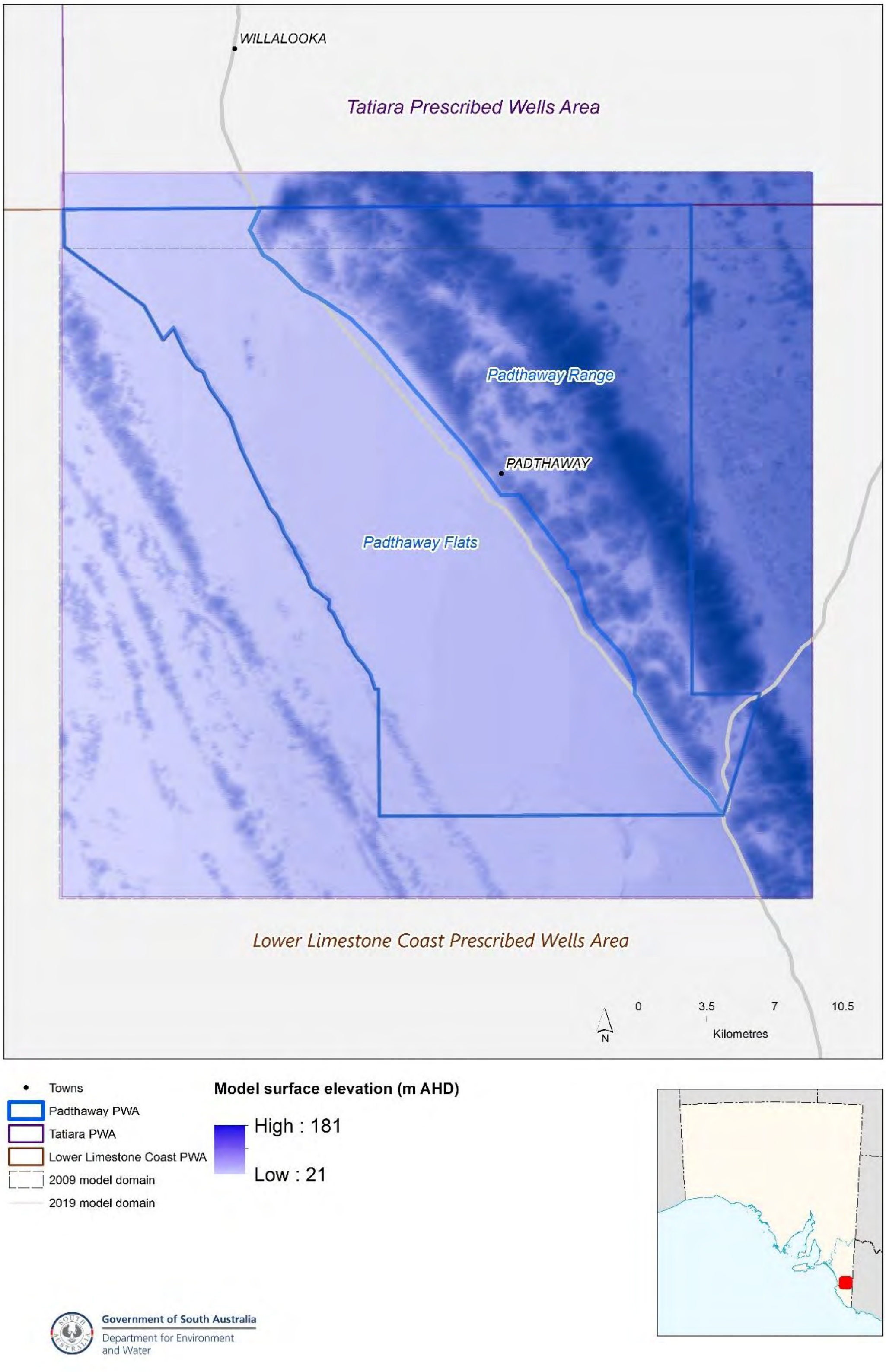


Figure 3.1. Revised model domain and surface elevation in Padmod4

3.2.3 Transient simulation extended to 2018

PadMod3 ran from January 1950 to December 2006, and scenarios were projected out from January 2007. As part of this project Padmod4 was updated to run to December 2018. Yearly stress periods were used given that annual extraction data was available from 2008 onwards, resulting in 23 stress periods in total. The stress period setup prior to 2007 has not been changed from that in Padmod3 (Table 3.1). As with Padmod3, stresses are applied at a constant rate during each stress period. That is to say, recharge and pumping are both applied 365 days of the year, in keeping with the setup applied in Padmod3. This is an acknowledged limitation of the model, where these stresses are likely to be seasonal. However, increasing the number of stress periods (e.g. to monthly, quarterly or seasonal) would require significant changes to the model which were considered beyond the scope of this study. Furthermore, increased stress periods would result in increased run times for the solute transport model.

Table 3.1. Transient stress periods in Padmod4 (where stress periods 1 to 11 are based on Padmod3)

Stress period	Time simulated	Stress period length (days)
1	1950–1960	3650
2	1960–1965	1826
3	1965–1970	1825
4	1970–1975	1826
5	1975–1980	1826
6	1980–1985	1825
7	1985–1992	2555
8	1992–1995	1095
9	1995–2000	1825
10	2000–2005	1825
11	2005–2006	730
12	2007	365
13	2008	366
14	2009	365
15	2010	365
16	2011	365
17	2012	366
18	2013	365
19	2014	365
20	2015	365
21	2016	366
22	2017	365
23	2018	365

3.2.4 Metered extraction data

In updating the model to run to 2018, groundwater pumping for 2008 to 2018 was based on metered extraction data, while pumping for 2007 was based on estimated use from annual water use reports. This data was sourced from the DEW database WILMA. In some cases, annual metered extraction volumes for the entire model domain, including the management areas surrounding Padthaway, were erroneously high. For example, the raw data showed pumping for 2014 to be 550 GL, whereas extraction is typically less than 50 GL/y. This was found to be due to erroneously high volumes reported for a small number of licences. In these cases, the high extraction values were replaced with average values for these licences from the remaining years. The annual extraction volumes determined in this way are reported in Table 3.2. Extraction rates prior to 2006 are unchanged from the rates applied in Padmod3 (Figure 3.2).

Table 3.2. Extraction volumes 2007–2018 in the Padthaway PWA and in the entire model domain

Year	Model domain (ML)	Padthaway PWA (ML)
2007	44,196	43,962
2008	56,974	56,193
2009	38,519	37,257
2010	32,657	31,587
2011	24,901	23,797
2012	34,149	32,181
2013	41,955	38,617
2014	41,340	38,615
2015	50,284	45,350
2016	42,007	39,585
2017	20,560	19,024
2018	32,229	30,552

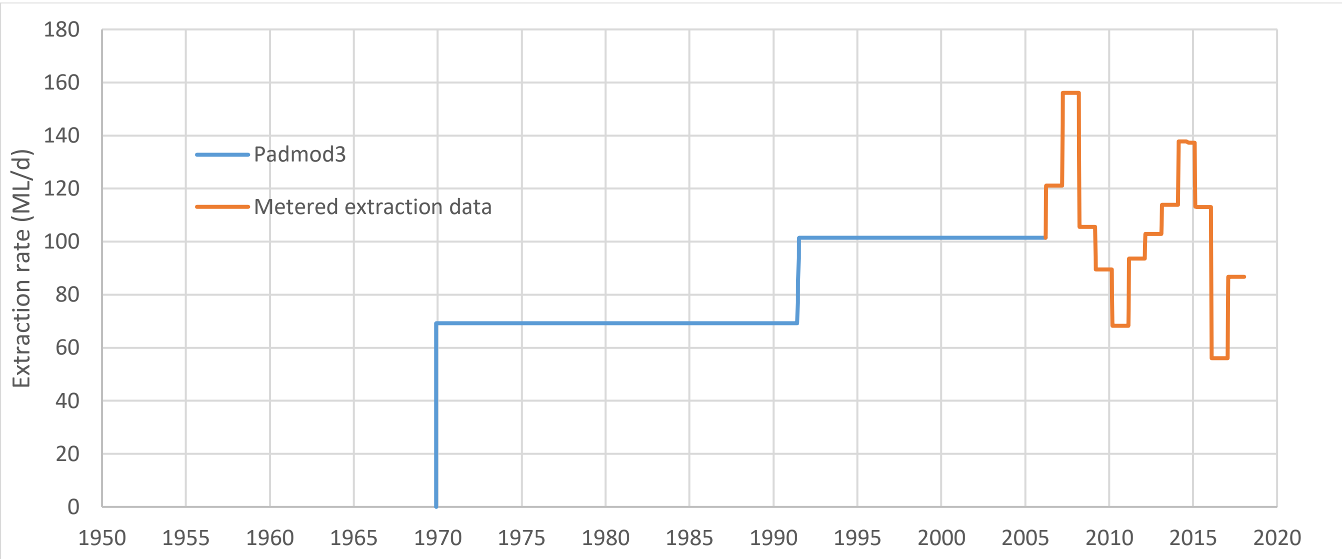


Figure 3.2. Groundwater extraction rates applied in Padmod4 (where rates up to 2007 are from Padmod3)

3.2.5 Recharge

Recharge on the Plains from 2007 to 2018 was initially based on recharge from the last stress period in Padmod3 (Year 2006). Recharge in the ranges from 2007 to 2009 was likewise based on Padmod3, which was based on the Salt Accessions Study. However, from 2010 onwards, recharge in the ranges was based on the rates presented by Wohling et al (2006) based on updated modelling of the increased recharge following land clearance for different soil types (Figure 3.3). Recharge on the Plains is most likely to have varied since 2006 based on variability in rainfall (Figure 2.1); hence annual recharge rates for each year from 2007 to 2018 were varied using recharge multipliers in PEST. This resulted in recharge varying from 22 ML/d in low rainfall years to 288 ML/d in higher rainfall years (Figure 3.4). This year to year variability in recharge follows the rainfall trend throughout this period (Figure 3.4).

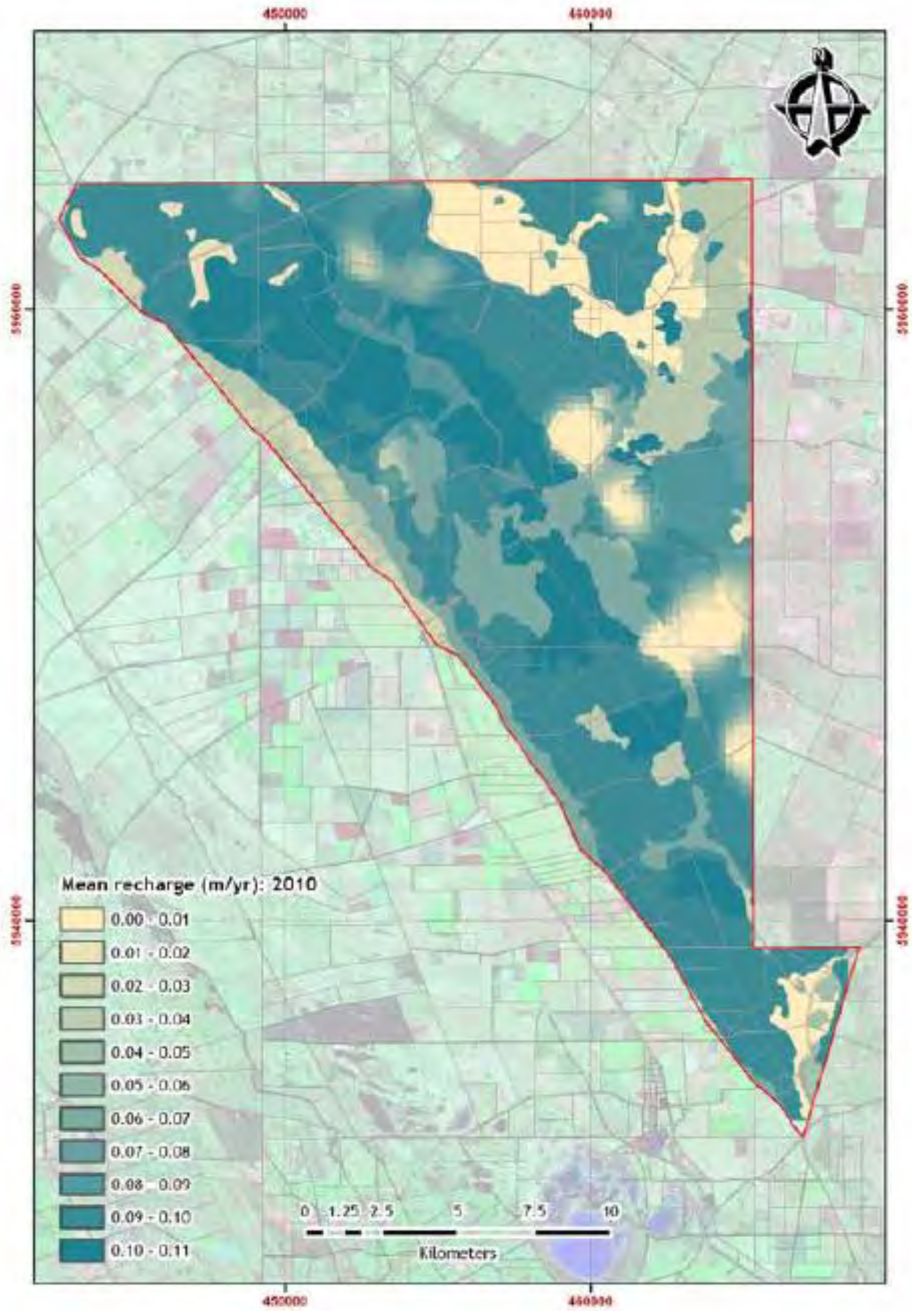


Figure 3.3. Groundwater recharge on the Padthaway Range at 2010 (Wohling et al, 2006)

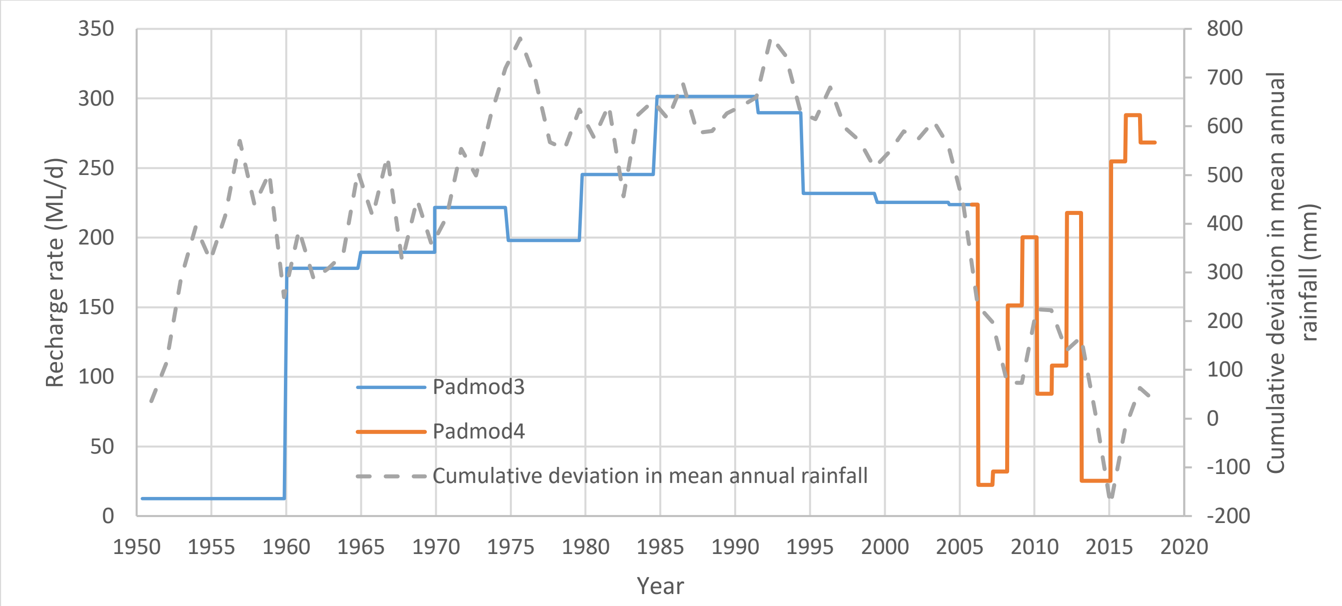


Figure 3.4. Modelled recharge rates and rainfall trend in Padmod4 (where rates up to 2007 are from Padmod3)

3.2.6 Aquifer parameters

Aquifer parameters in Padmod3 were zoned based broadly on geological zones in the area (Figure 3.5). In updating the model, it was decided to revise the zones using more detailed geological mapping (Figure 3.6). Cells in which the Marcollat Granite are present were converted to inactive cells, as granite outcrops are conceptualised to be a barrier to groundwater flow (Harris 1972). The pilot point method in PEST was used to refine hydraulic conductivity in the main aquifer layers 1 and 3. Initial model calibration runs showed that model results were insensitive to changes in layer 2, which is relatively thin (Figure 3.6) and contains no calibration targets.

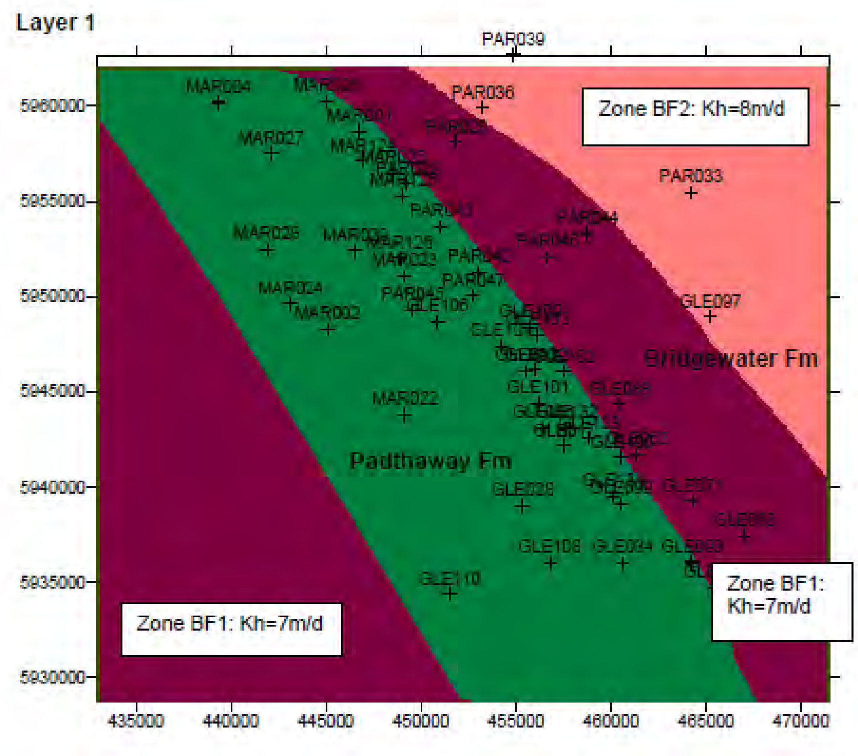


Figure 3.5. Layer 1 hydraulic conductivity values in Padmod3 (Aquaterra 2008)

Pilot points were assigned at locations of pump-test-derived hydraulic conductivity (Figure 3.7 and 3.8, Table 3.3). Pilot points were also assigned throughout the domain using a grid-based approach (Figure 3.7 and 3.8). In layer 1, pilot points were assigned upper and lower bounds based on values derived for the Padthaway Formation and the Bridgewater Formation (Table 3.4), using a zoned approach, with values assigned to zones shown in Figure 3.6. In layer 3, pilot points were assigned values derived for the Bridgewater Formation (Table 3.4). In total 555 pilot points were used, and parameters varied to fit 17,805 head measurements across the domain (Figure 3.9).

Table 3.3. Pump test derived hydraulic parameters and lower/upper bounds used in pilot point calibration

Name	Easting	Northing	Hydraulic conductivity (m/d)	Lower bound (m/d)	Upper bound (m/d)
Kt1	444998	5948109	143	136	150
Kt2	450799	5948323	287	273	301
Kt3	446586	5958462	498	473	522
Kt4	453621	5960855	16	15	17
Kt5	453518	5960817	20	19	21
Kt6	456466	5951793	16	15	16
Kt7	455387	5950425	13	13	14
Kt8	460222	5944854	62	59	65
Kt9	467049	5937392	2	1	3
Kt10	465408	5934852	107	102	112
Kt11	462074	5935011	112	106	118
Kt12	453621	5960855	16	15	17
Kt13	453518	5960817	20	19	21
Kt14	456466	5951793	16	15	16
Kt15	455387	5950425	13	13	14
Kt16	460222	5944854	62	59	65
Kt17	465408	5934852	107	102	112

Table 3.4. Initial values and lower/upper bounds assigned to grid-based pilot points

Area	Initial value (m/d)	Lower bound (m/d)	Upper bound (m/d)
Layer 1 Flats (Padthaway Formation)	200	2	498
Layer 1 Flats and Ranges (Bridgewater Formation)	10	5	107
Layer 3 (Bridgewater Formation)	10	5	107

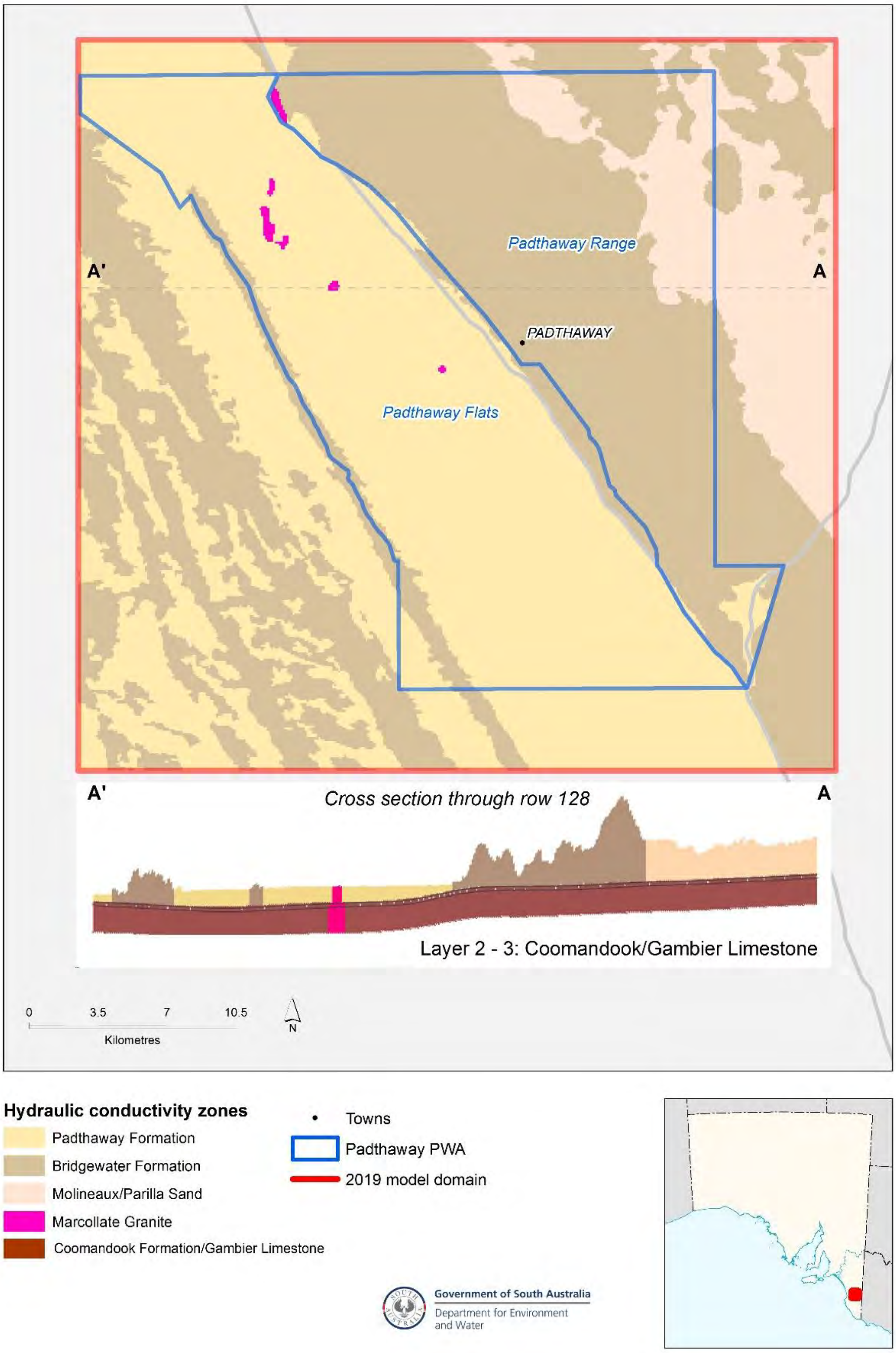


Figure 3.6. Hydrogeological zones used for aquifer parameterisation in Padmod4

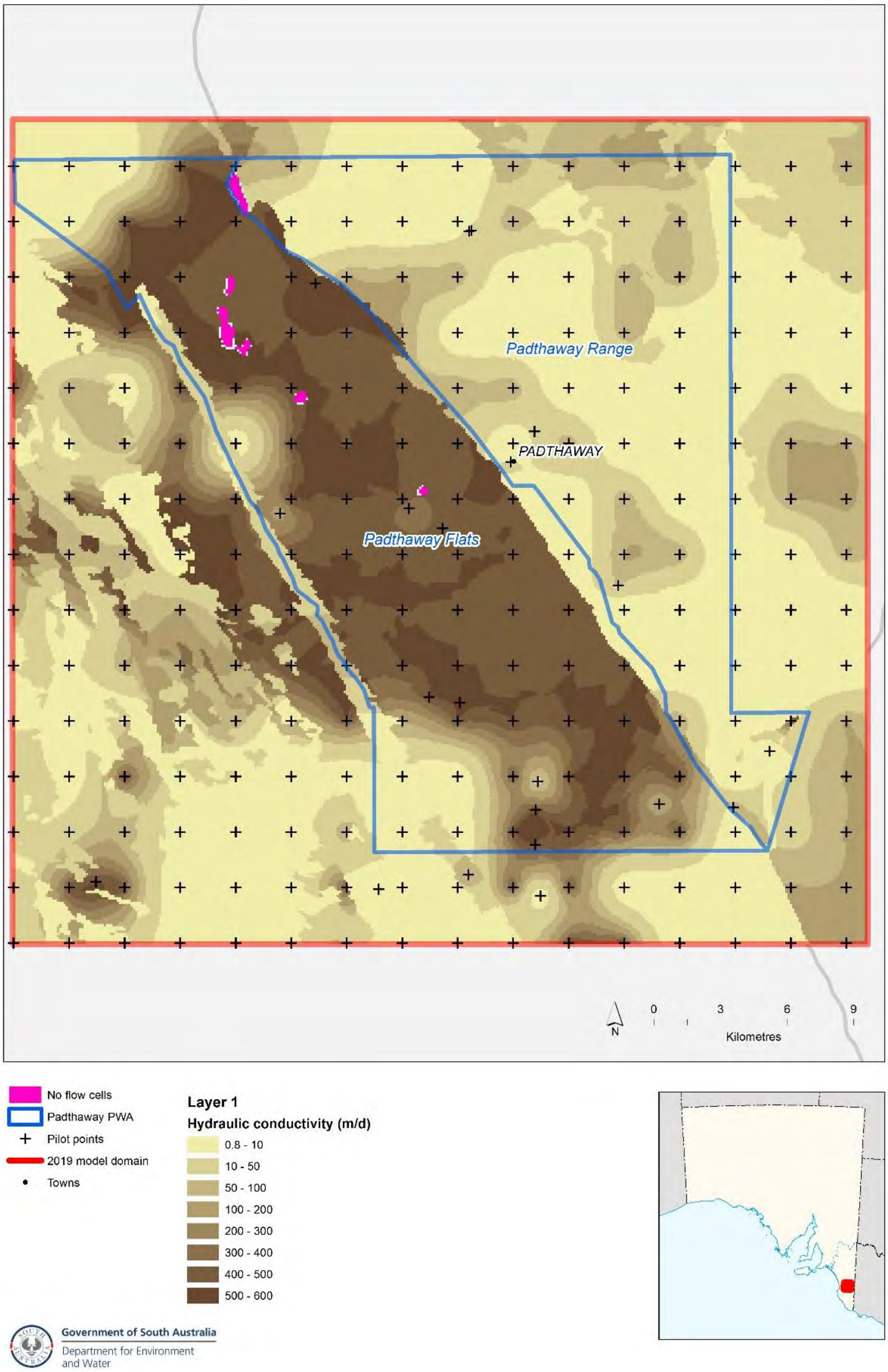


Figure 3.7. Layer 1 hydraulic conductivity values in Padmod4

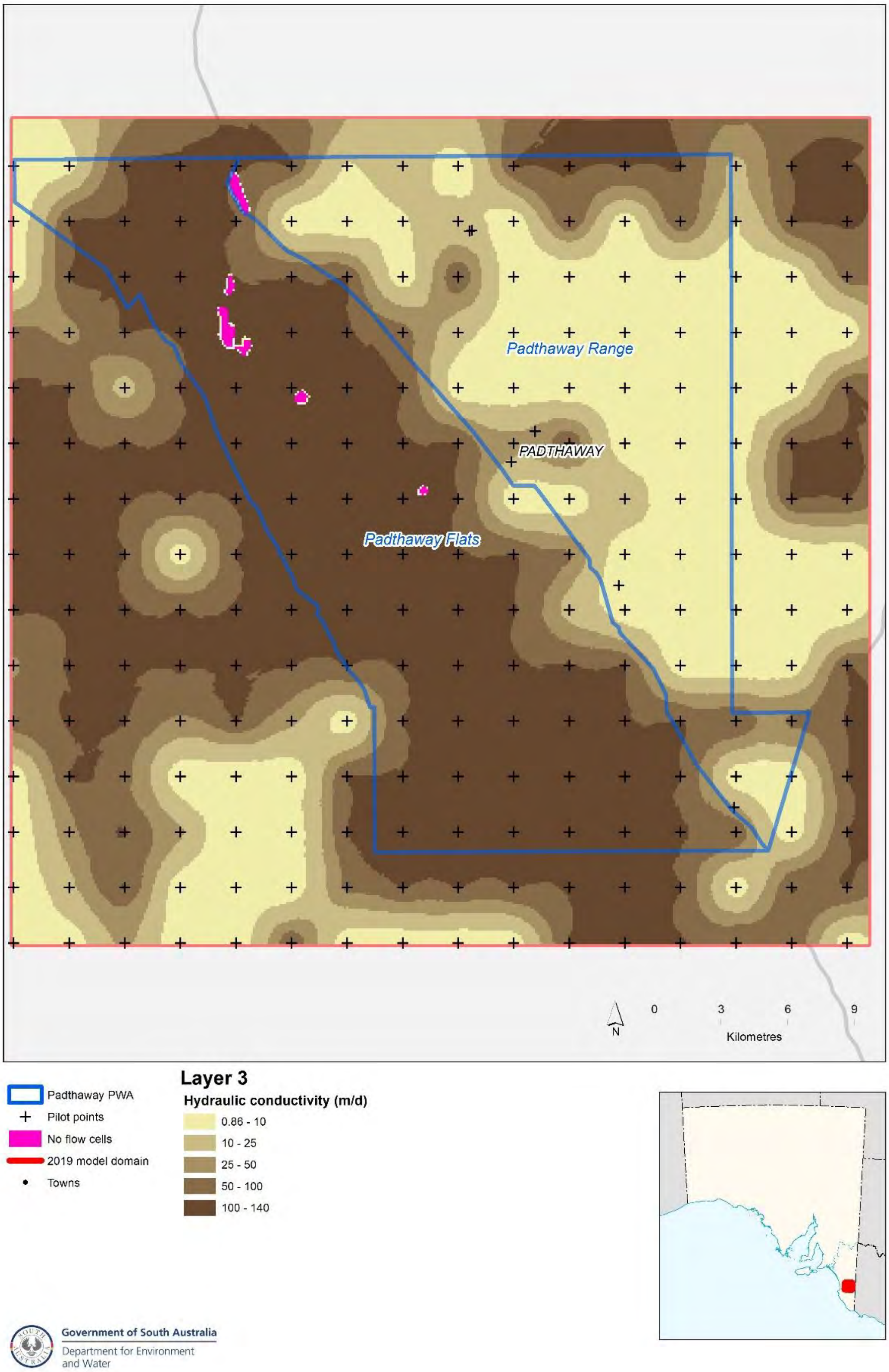


Figure 3.8. Layer 3 hydraulic conductivity values in Padmod4

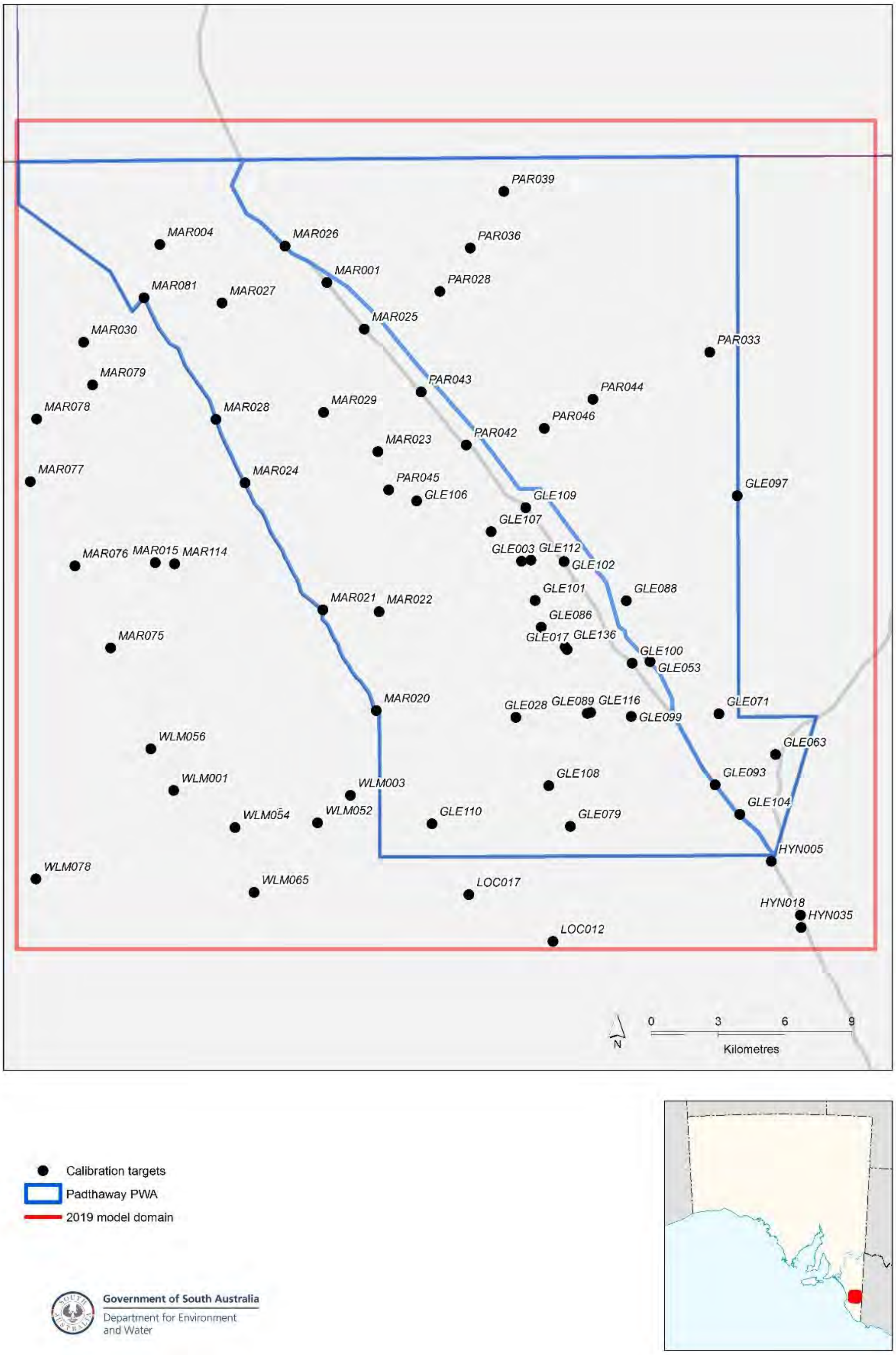


Figure 3.9. Observation well locations in Padmod4

4 Model calibration

4.1 Groundwater level

In updating and extending the Padthaway model, hydraulic parameters were revised and calibrated using the pilot point method in PEST (Section 3.2.6). Quantitative model error values are reported as root mean squared error (RMS) and scaled root mean squared error (SRMS), consistent with statistics often used in groundwater model studies (Barnett et al. 2012). The calibration approach applied here in updating the model resulted in a RMS error of 0.75 m and SRMS error of 1.9% (Figure 4.1).

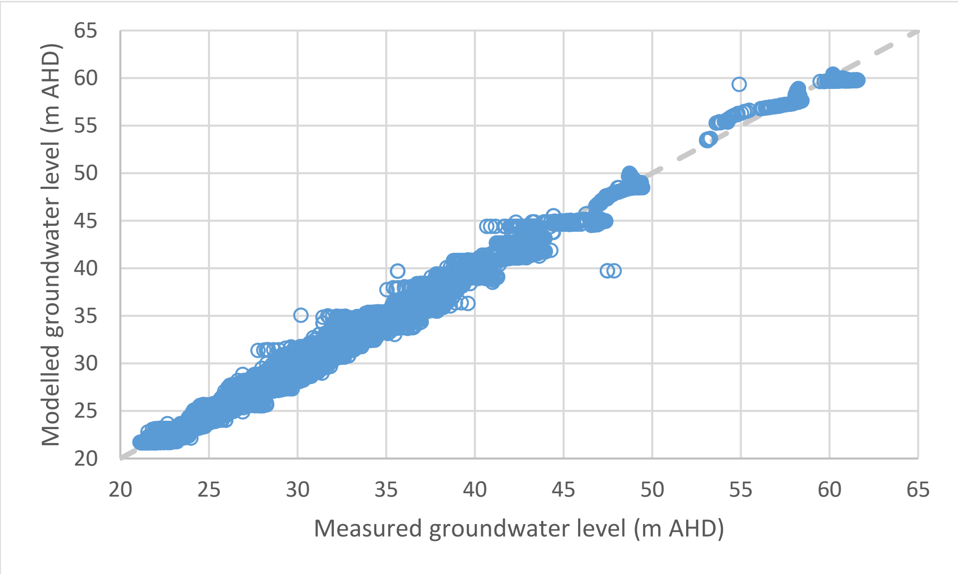


Figure 4.1. Measured and modelled groundwater levels in Padmod4 (RMS = 0.75m, SRMS = 1.9%)

The model fit is generally consistent with Padmod3 for the period 1970 to 2006 on the Padthaway Flats, and hydrographs fit well from 2007 to 2018 when stress periods become annual with the advent of metered extraction data (Figure 4.2). Seasonal fluctuations in groundwater level are not matched as Padmod4 has annual to multi-year stress periods (Table 3.1). An improvement in fit to groundwater levels in the Padthaway Ranges is also observed in Padmod4 (Figure 4.3). Note in Figures 4.2 and 4.3 comparisons are made with plots from Aquaterra (2009) which project groundwater levels to 2100. Plots from Aquaterra (2009) are used as they represent the most recent version of the model prior to the updates described in this report. Measured and modelled groundwater levels for all observation wells are in Appendix D. The updated model also gives a good approximate match to the potentiometric surface (Figure 4.4.). However note in Figure 4.4 the measured potentiometric surface is based on spring 2018 readings where groundwater levels are typically at their highest following winter rainfall. The model surface is based on average annual conditions, and seasonal fluctuations are not captured, hence only an approximate match can be expected.

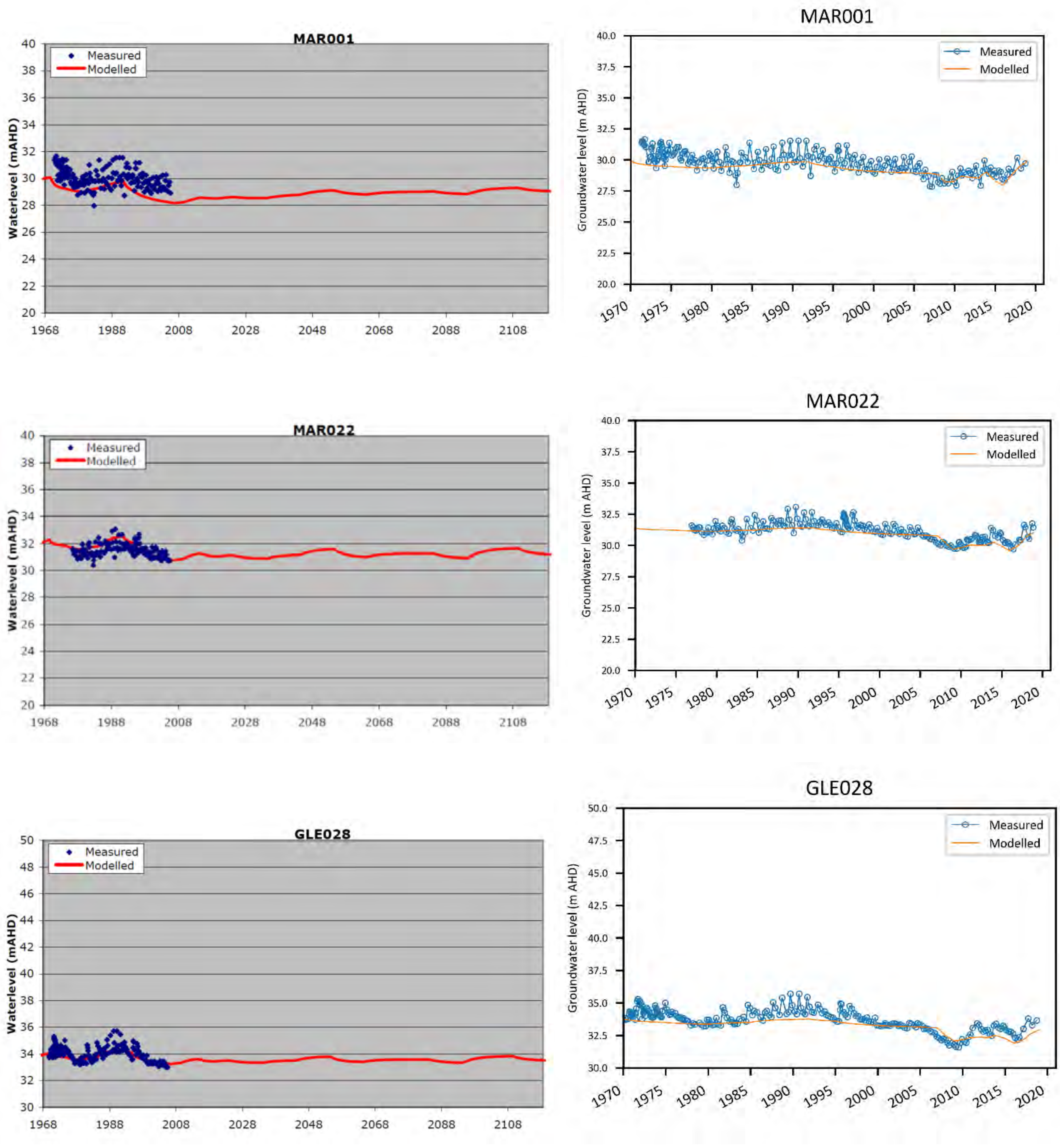


Figure 4.2. Measured and modelled groundwater levels in the Padthaway Flats in Padmod3 (left, Aquaterra 2009) and Padmod4 (right)

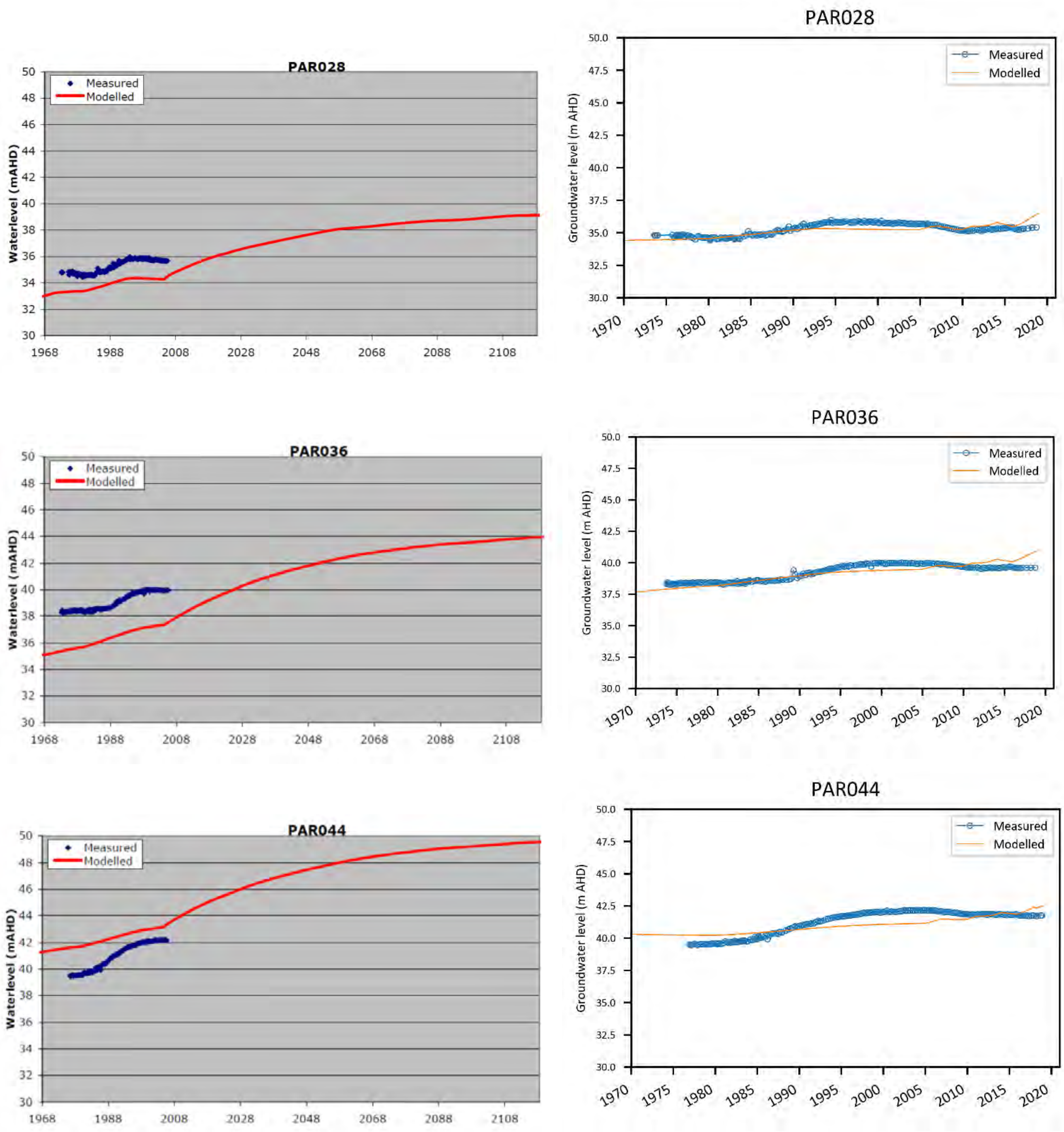


Figure 4.3. Measured and modelled groundwater levels in the Padthaway Ranges in Padmod3 (left, Aquaterra 2009) and Padmod4 (right)

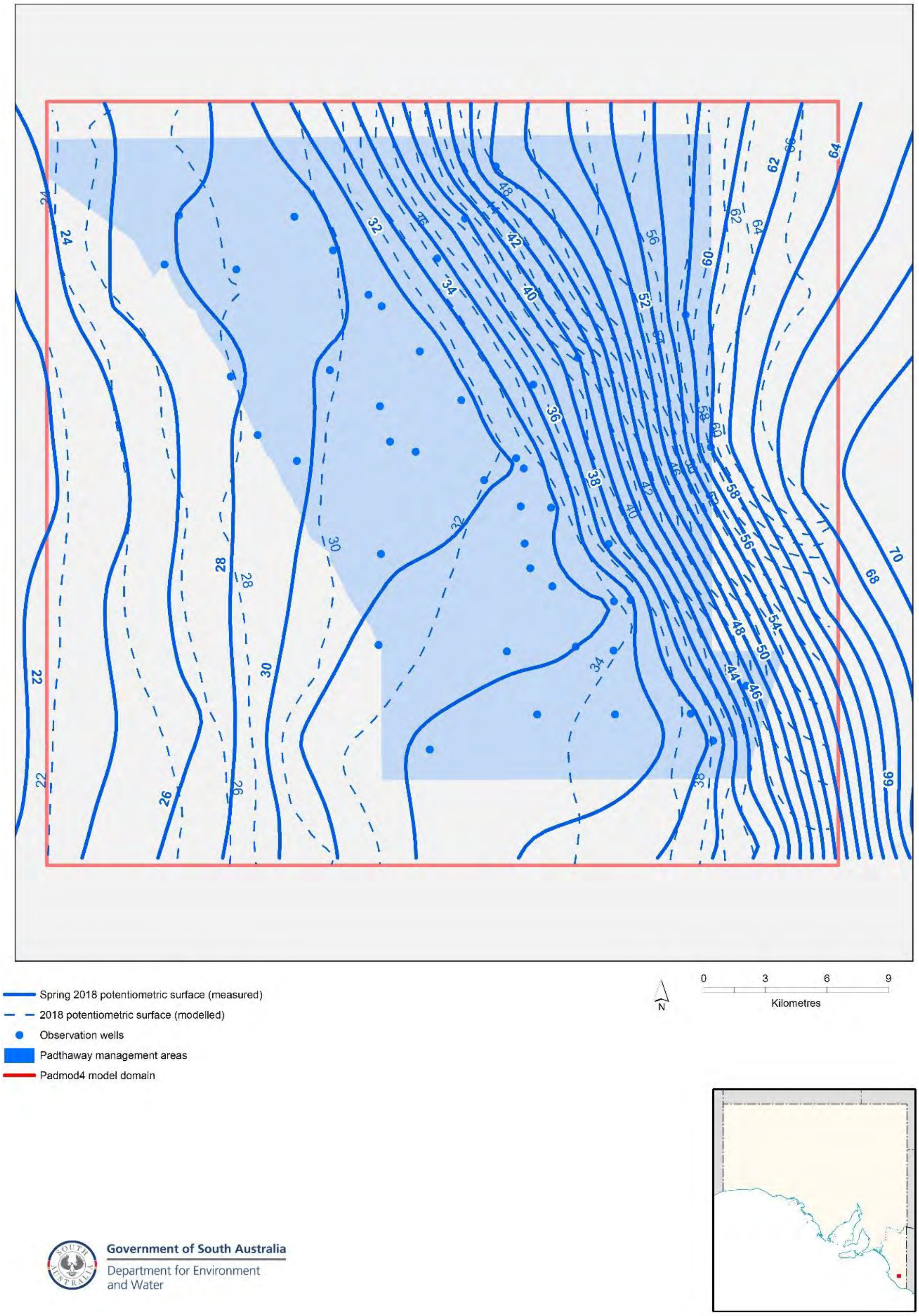


Figure 4.4. Measured and modelled potentiometric surface

4.2 Groundwater salinity

It should be noted that Padmod4 has not been calibrated for salinity. Rather, changes to the model have been made following previous recommendations, such as revising the surface elevation with improved data (Section 3.2.2). The model was calibrated by varying hydraulic parameters and recharge rates from 2007 to 2018 to improve the fit between measured and modelled groundwater level. These changes have resulted in changes to the solute transport simulation. In some cases, this has resulted in improvements to the fit between measured and modelled groundwater salinity, while in other instances there has not been any improvement.

Improvements in the fit between measured and modelled salinity can be seen for wells GLE028, GLE104 and MAR026 in Figure 4.5. Results are compared with those given in Aquaterra (2009), which project groundwater salinity to 2100. As discussed in relation to groundwater level results, plots from Aquaterra (2009) are used as they represent the most recent version of the model prior to the updates described in this report.

However, also shown in Figure 4.5 is the measured and modelled salinity at MAR022 where there has been no improvement, and possibly a less suitable fit between measured and modelled salinity. In Padmod3, groundwater salinity was overestimated by the model at MAR022. This is because the modelled groundwater level was above the modelled ground surface (Figure 4.6), due to an inaccurate DEM in Padmod1 (Aquaterra 2008), resulting in high rates of modelled evaporation and increased salinity. In Padmod4 the modelled groundwater level is now more accurate and below the ground surface (Figure 4.6), consistent with observations of the groundwater level being 1.5 to 3 m below ground level since 2000. Consequently, there is not as much modelled evaporation, and the salinity does not increase significantly. Given that the modelled water level in Padmod4 is consistent with observations in being 1.5 to 3m below ground level, this suggests the increasing salinity in MAR022 may be the result of a process other than evaporation. Such processes could include drainage of irrigation water, which has been subjected to evaporation, as MAR022 is located west of flood irrigation (Figure 2.2).

While the model simulates higher recharge with increased concentration under flood irrigation, a uniform recharge rate and salinity is used for all flood irrigation areas across the domain. These assumptions are based on the Padthaway Salt Accession studies and are consistent with Padmod3. Updating the model with spatially variable recharge rates and salinity for irrigation across the domain may improve the fit in locations such as MAR022. However, it would be a significant piece of work which is considered beyond the scope of this study. Furthermore, it would require significantly more data on both soil water and irrigation water salinity, which is not currently available. Measured and modelled groundwater salinity for all observation wells can be found in Appendix E.

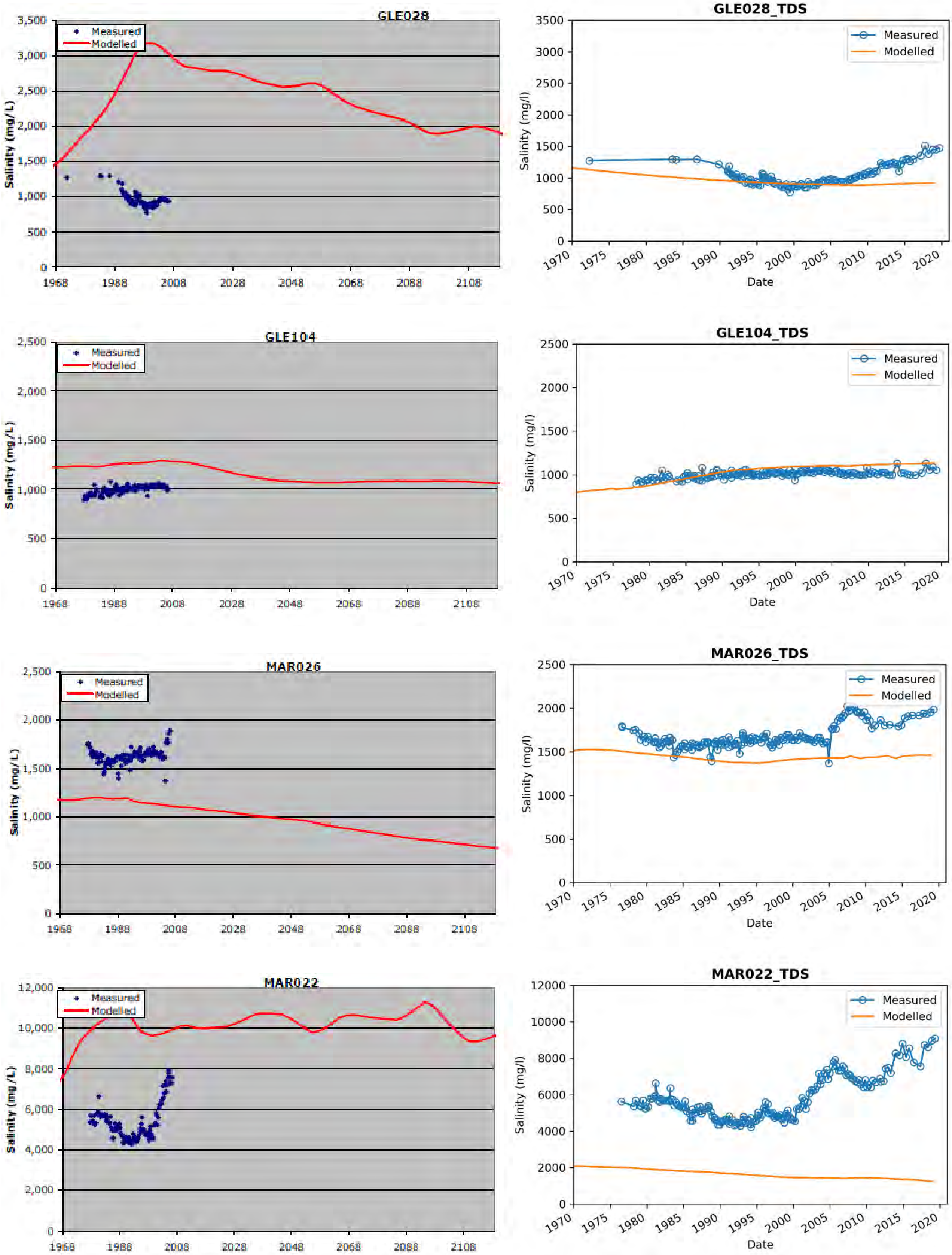


Figure 4.5. Measured and modelled groundwater salinity in the Padthaway Flats in Padmod3 (left, Aquaterra 2009) and Padmod4 (right)

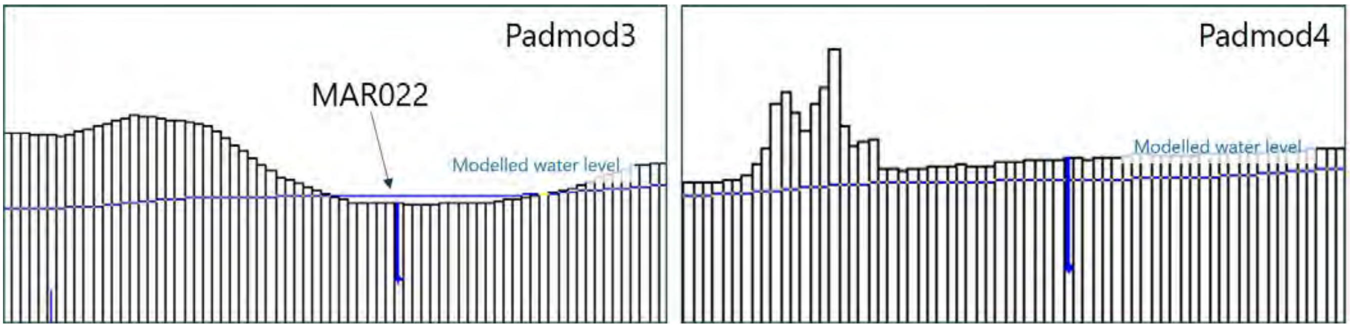


Figure 4.6. Location of well MAR022 in relation to modelled groundwater level in Padmod3 and Padmod4

5 Model scenarios

5.1 Overview

Model scenarios were developed in consultation with Natural Resources South East and the Padthaway WAP review Stakeholder Advisory Group. Two extraction scenarios were proposed to consider the potential impact of continued extraction at average current levels and increased extraction to full allocation. It was considered appropriate to model both scenarios assuming rainfall repeats the trend observed over the last 10 years, as well as factoring in potential rainfall reductions based on climate change projections. However, for the Padthaway Ranges, recharge data sets described by Wohling et al. (2006) are used for future recharge. Following the running of these scenarios, a third extraction scenario was setup to test the impact of reducing pumping from full allocation to the acceptable extraction limit of 48,000 ML/y, once resource condition limits are breached. The acceptable extraction limit was based on modelling originally done in support of the 2009 WAP (SENRMB, 2011). All model scenarios are run to 2040, and Table 5.1 provides a summary.

Table 5.1. Model scenarios

Scenario	Pumping	Recharge
1A	Groundwater extraction in Padthaway based on average metered use (2008-–2018) of 35,705 ML/y	Recharge on flats from calibration period 2008–2018 repeated on cycle, recharge in ranges based on Wohling et al. (2006)
1B	Groundwater extraction in Padthaway based on average metered use (2008–2018) of 35,705 ML/y	Recharge based on projected climate change impacts
2A	Groundwater extraction in Padthaway based on full allocation of 55,096 ML/y being used	Recharge on flats from calibration period 2008–2018 repeated on cycle, recharge in ranges based on Wohling et al. (2006)
2B	Groundwater extraction in Padthaway based on full allocation of 55,096 ML/y being used	Recharge based on projected climate change impacts
3A	Groundwater extraction in Padthaway based on full allocation of 55,096 ML/y being used until RCLs are breached, then extraction is reduced to 48,000 ML/y in 2033	Recharge on flats from calibration period 2008–2018 repeated on cycle, recharge in ranges based on Wohling et al. (2006)
3B	Groundwater extraction in Padthaway based on full allocation of 55,096 ML/y being used until RCLs are breached, then extraction is reduced to 48,000 ML/y in 2026	Recharge based on projected climate change impacts

5.2 Climate change impacts on groundwater recharge

Climate change impacts on recharge are based on rainfall projections provided by Charles and Fu (2015). Charles and Fu developed climate projections based on downscaled climate modelling using 15 global climate models (GCMs). These climate models were calibrated to observed rainfall at 24 weather stations across the South East, including the station at Padthaway (BoM station #26017). The models were used to simulate climate projections based on two Representative Concentration Pathways (RCP) for future greenhouse gas and aerosol concentrations, including an intermediate emission scenario (RCP 4.5) and a high emission scenario (RCP 8.5). Projections are given relative to the 20 year 'baseline' period from 1986 to 2005.

Results of projected changes in mean annual rainfall for station 26017 at Padthaway show rainfall reductions of 7.1 to 10.9% by 2040 (Figure 5.1). For Padthaway, the RCP4.5 scenario results in a greater reduction in rainfall by 2040 than RCP8.5. While this may seem counterintuitive, it could be attributed to several factors such as: (1) similarity in pathways 4.5 and 8.5 up to 2040; (2) the result of projections, which are stochastically generated from the RCPs and contain randomly generated wet/dry years; (3) the result of using 15 different GCMs, some of which may simulate greater rainfall reduction under RCP4.5 for this time period at this rainfall station. The similarity in projections up to 2040 can be seen in the year to year variability in projected rainfall (Figure 5.2); however, projections become more negative under RCP8.5 after 2050. Given the similarity in projections up to 2040, it was decided to use the projected rainfall reduction of 10.9% as a worst-case scenario.

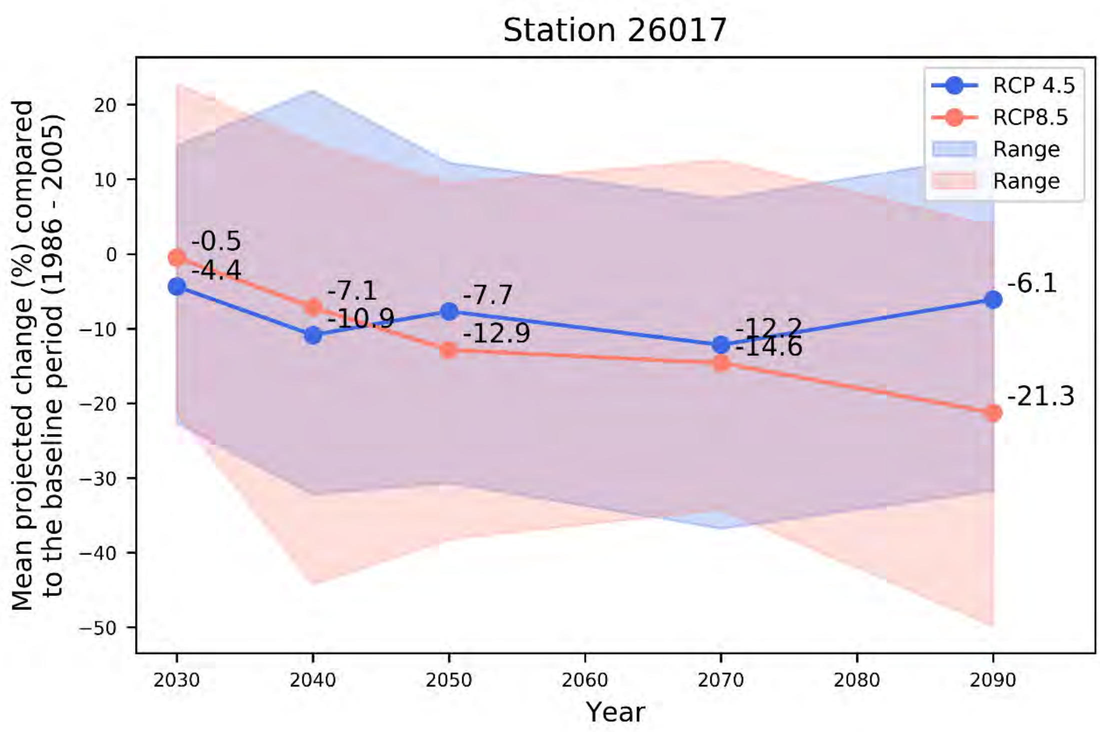


Figure 5.1. Projected changes in mean annual rainfall for the Padthaway (rainfall station 26017), based on RCP 4.5 and RCP 8.5

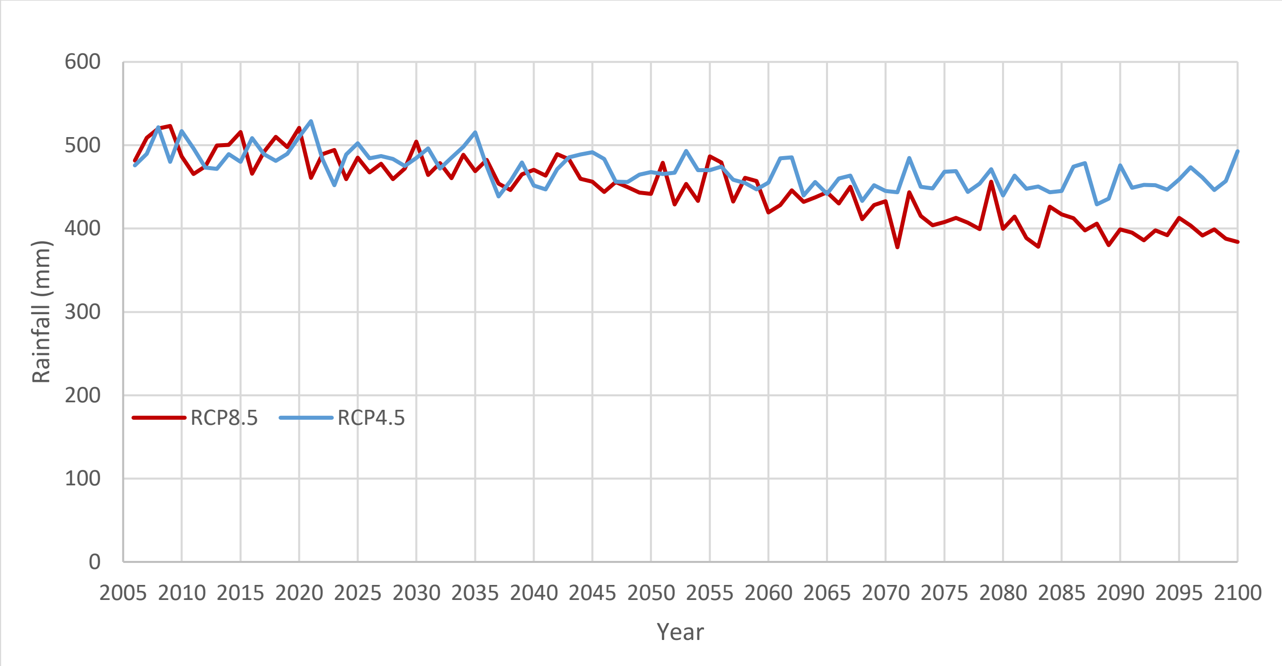


Figure 5.2. Year to year variability in projected changes in mean annual rainfall for the Padthaway (rainfall station 26017), based on RCP 4.5 and RCP 8.5

Projected changes in rainfall are applied to recharge using a scaling factor of 3—that is, a 10.9% reduction in rainfall by 2040 translates to a 32.7% change in recharge by 2040. The scaling factor approach is based on work by Green, Gibbs and Wood (2011) and Green et al. (2012), who used unsaturated zone models to simulate the potential changes in recharge for various downscaled climate change scenarios in the Eyre Peninsula and Northern and Yorke regions of South Australia. The authors reported scaling factors of 4.3 for the Northern and Yorke (Green, Gibbs and Wood (2011) and 3.2 for the Eyre Peninsula (Green et al. 2012). This approach has previously been adopted in groundwater modelling by Li and Cranswick (2016), who used a scaling factor of 3 for the Barossa Valley and Wood and Li (2020) who used a scaling factor of 3.2 for the Eyre Peninsula.

5.3 Resource condition limits

The 2009 Padthaway WAP set resource condition limits (RCLs) for groundwater levels in June 2004 as a management target (i.e. to maintain groundwater levels above the RCL). June 2004 water levels were chosen based on reported low well yields in flood irrigation wells as groundwater levels declined in 2004 (SENRMB, 2011). However, no management actions were taken as a result of water levels declining below the RCL specified in the 2009 WAP.

As part of the review of the Padthaway WAP, a stakeholder advisory group was consulted on groundwater resource condition since the 2009 WAP. As has been discussed in Chapter 2, groundwater levels have declined below the June 2004 levels in many parts of the Padthaway Flats since 2009. However, in most cases levels have recovered again due to above average rainfall and reduced extraction. In consultation with the stakeholders, a new draft RCL based on winter 2009 groundwater levels has been proposed. This new draft RCL represents the minimum level most observation wells on the flats have reached in the past. The reason for setting a new RCL lower than the existing RCL is because groundwater levels have been observed to recover from below the June 2004 RCL with no management intervention. However, the new RCL based on 2009 groundwater levels is meant to act as a level which may trigger management response.

To test the impact of a potential management response, scenarios 3A and 3B were setup. Based on the results of scenarios 2A and 2B, the point in time at which 25% of currently monitored wells exceed the draft RCL (groundwater levels below those in 2009) was determined, and pumping was reduced from full allocation to the acceptable extraction limit of 48,000 ML/y, where the acceptable extraction limit was determined through the original

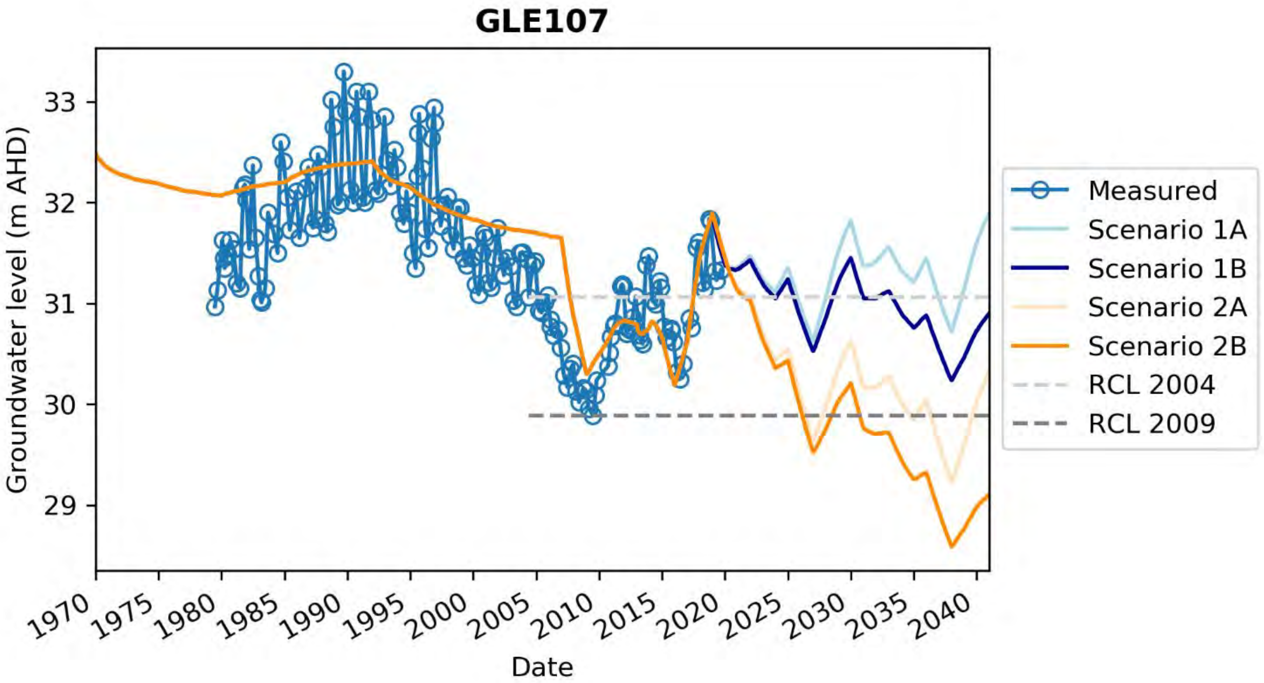
Padthaway modelling work (SENRMB, 2011). The reduction in pumping occurs three years after the RCL is exceeded, to allow for potential recovery following high rainfall. These draft RCL settings and management response arrangements were determined in consultation with Limestone Coast Landscape Board and the stakeholder advisory group.

5.4 Scenario results – groundwater level

5.4.1 Padthaway Flats

Groundwater levels under scenario 1A generally stay above the 2004 and 2009 RCLs on the flats. In this scenario groundwater extraction is constant at the average metered use (2008–2018) and recharge repeats modelled recharge from 2008–2018 on a cycle. Groundwater levels do decline below the 2004 RCL; however, as has been observed in the past 10 years, they recover following periods of higher rainfall recharge. Assuming the same pumping regime but reduced rainfall recharge (scenario 1B), groundwater levels generally decline below the 2004 RCL; however, they stay above historic minimums and the 2009 RCL (Figure 5.3).

In Scenario 2A extraction is at the full allocation volume (55,096 ML/y) and groundwater levels generally decline below the 2004 and 2009 RCLs. Though there is some recovery in some years assuming above average rainfall, this recovery does not sustain levels above the 2009 RCL. In scenario 2B which assumes the same pumping but reduced rainfall recharge, groundwater levels show a long-term declining trend. There is some fluctuation following rainfall and recharge, but the overall trend is declining (Figure 5.3). In scenario 2A, 25% of monitoring wells on the flats show exceedance of the 2009 RCL by 2030, while in scenario 2B, 25% of wells exceed the RCL much earlier in 2023, due reduced recharge in scenario 2B. Thus, for the purposes of scenario 3A and 3B, pumping is reduced from full allocation to 48,000 ML/y in 2033 and 2026 in scenarios 3A and 3B respectively, three years after the RCL is exceeded in 25% of wells (Table 5.1).



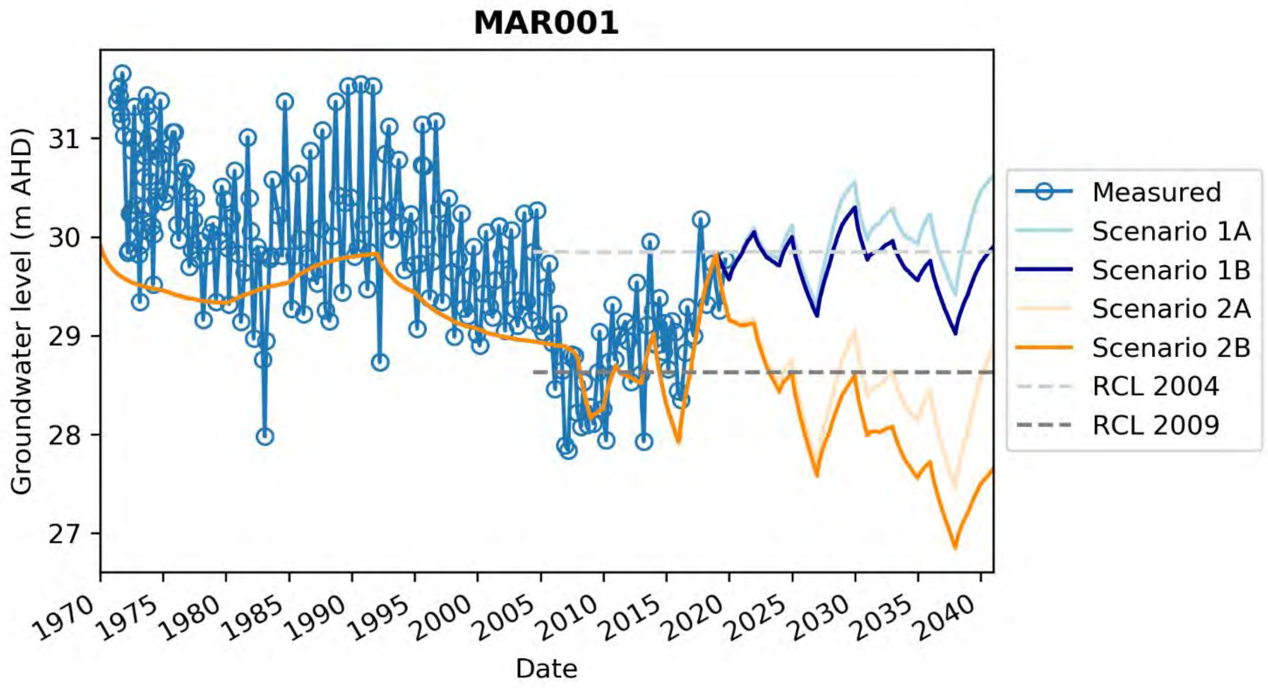
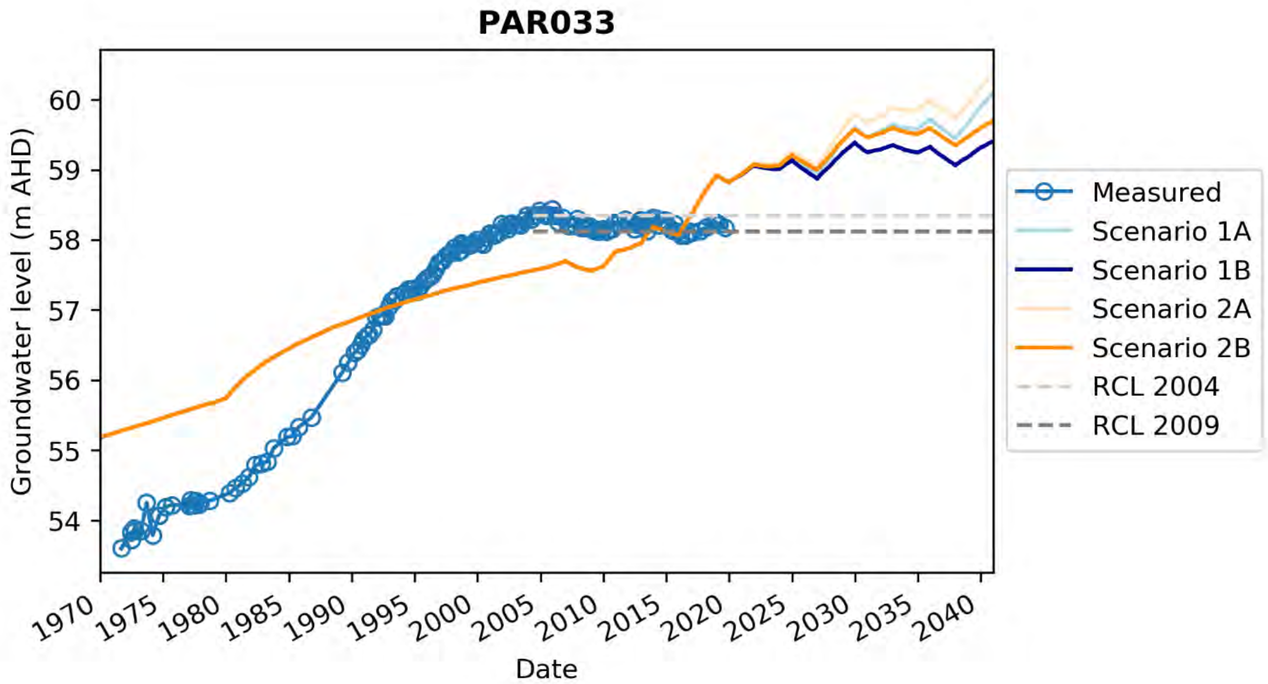


Figure 5.3. Measured and modelled groundwater levels for all scenarios at representative wells in the Padthaway Flats

5.4.2 Padthaway Ranges

Model scenarios generally show that groundwater levels continue to rise in the Padthaway Ranges. This is most likely due to recharge assumptions applied in the ranges, based on modelling described in Wohling et al. (2006). That is, recharge is assumed to still be adjusting to changes in land use, with long term increases based on drainage through the unsaturated zone, which varies spatially and temporally based on soil type. At some observation wells, groundwater levels appear to have plateaued since 2009 (Figure 5.4) and hence, recharge assumptions for the ranges may need to be revisited in the future, and factored into future scenario work.



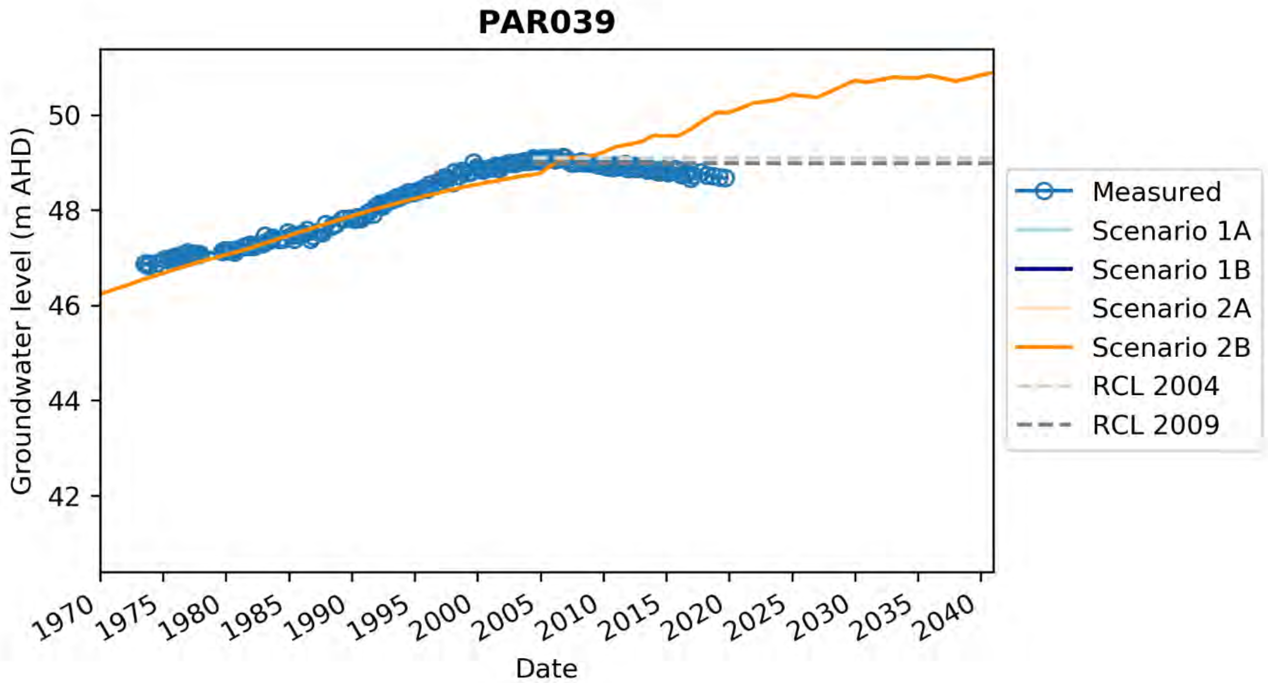


Figure 5.4. Measured and modelled groundwater levels for all scenarios at representative wells in the Padthaway Ranges

5.4.3 Modelled drawdown

Figures 5.5 and 5.6 plot the spatial extent of modelled drawdown in scenarios 2A and 2B at 2040. For scenario 2A (Figure 5.5) the drawdown extent reaches the edge of the PWA, however the drawdown is only 0.2–0.4 m at Cockatoo Lake. As discussed in section 4.1, the model does not simulate seasonal fluctuations in groundwater level, therefore it is difficult to determine whether this level of drawdown would impact upon Cockatoo Lake. However in scenario 2B the drawdown near Cockatoo Lake is 0.8–1 m (Figure 5.6). Again, it is difficult to determine what impact this would have on Cockatoo Lake based on model results alone, as the model does not simulate seasonal maximum/minimum groundwater levels. However groundwater extraction does have the potential to cause drawdown in groundwater levels of up to 1 m in the vicinity of Cockatoo Lake, which may change its likelihood of receiving groundwater discharge.

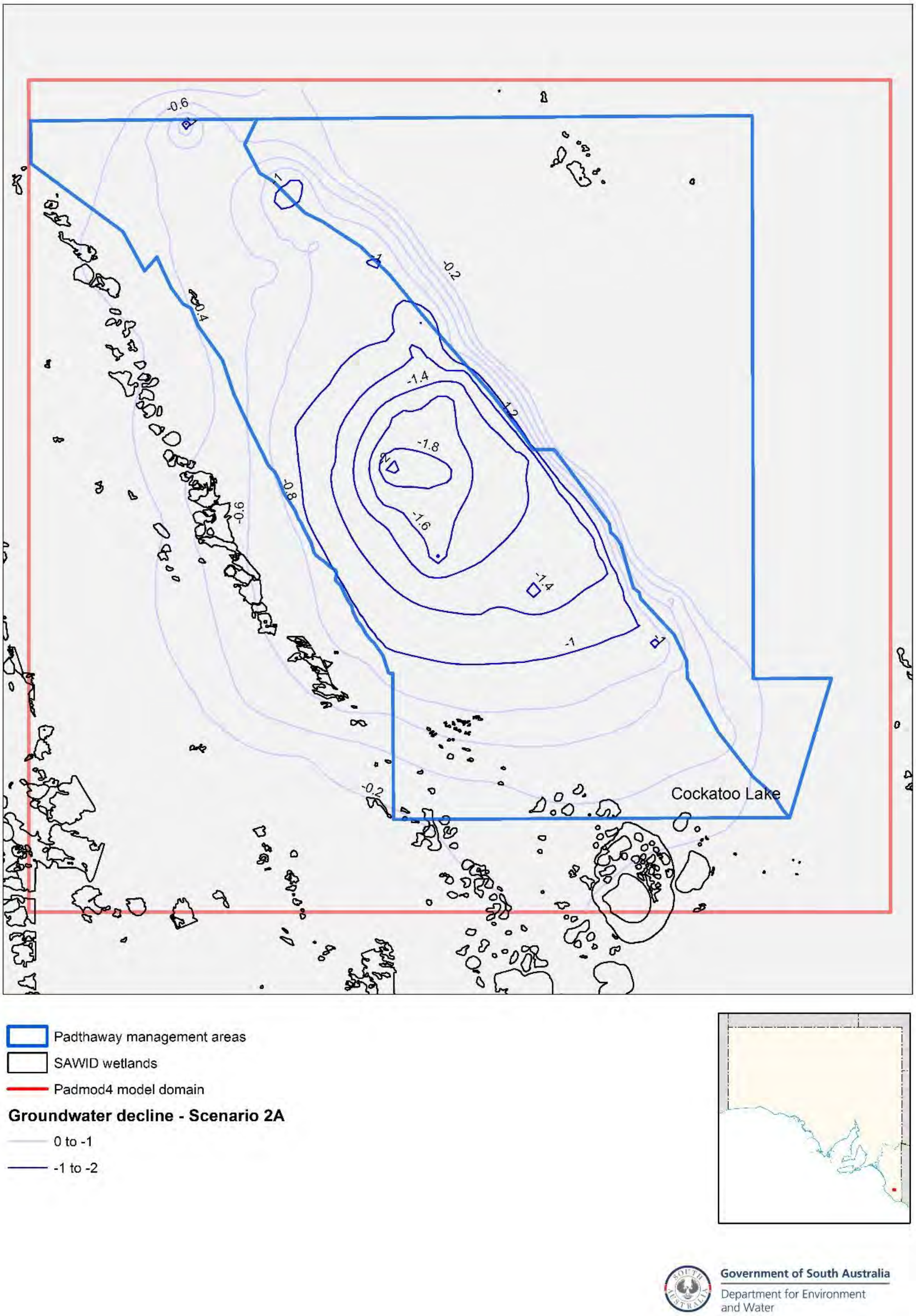


Figure 5.5. Drawdown contours at 2040 for scenario 2A

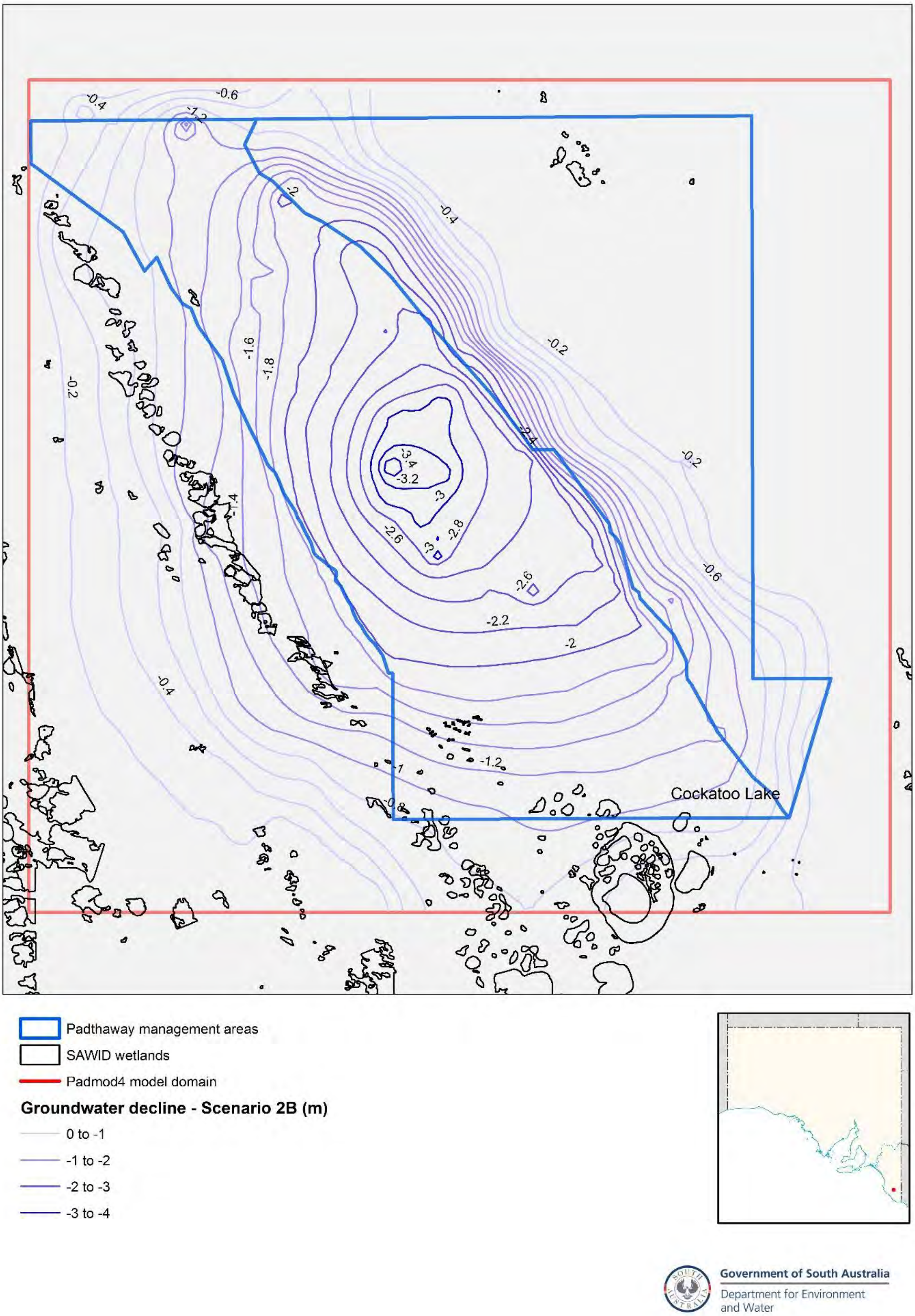


Figure 5.6. Drawdown contours at 2040 for Scenario 2B

5.5 Scenario results – salinity

Salinity results are generally similar for all model scenarios at key observations wells. The biggest difference between scenarios is in shallow water table areas (Figure 5.7). In scenarios 1A and 1B the water table generally remains closer to the ground surface, hence increases in salinity associated with evapotranspiration are observed. In scenarios 2A and 2B, groundwater levels decline further below the ground surface, hence the salinity is not observed to increase as much (Figure 5.6). Spatially there is little noticeable difference in salinity for the four scenarios (Figure 5.7).

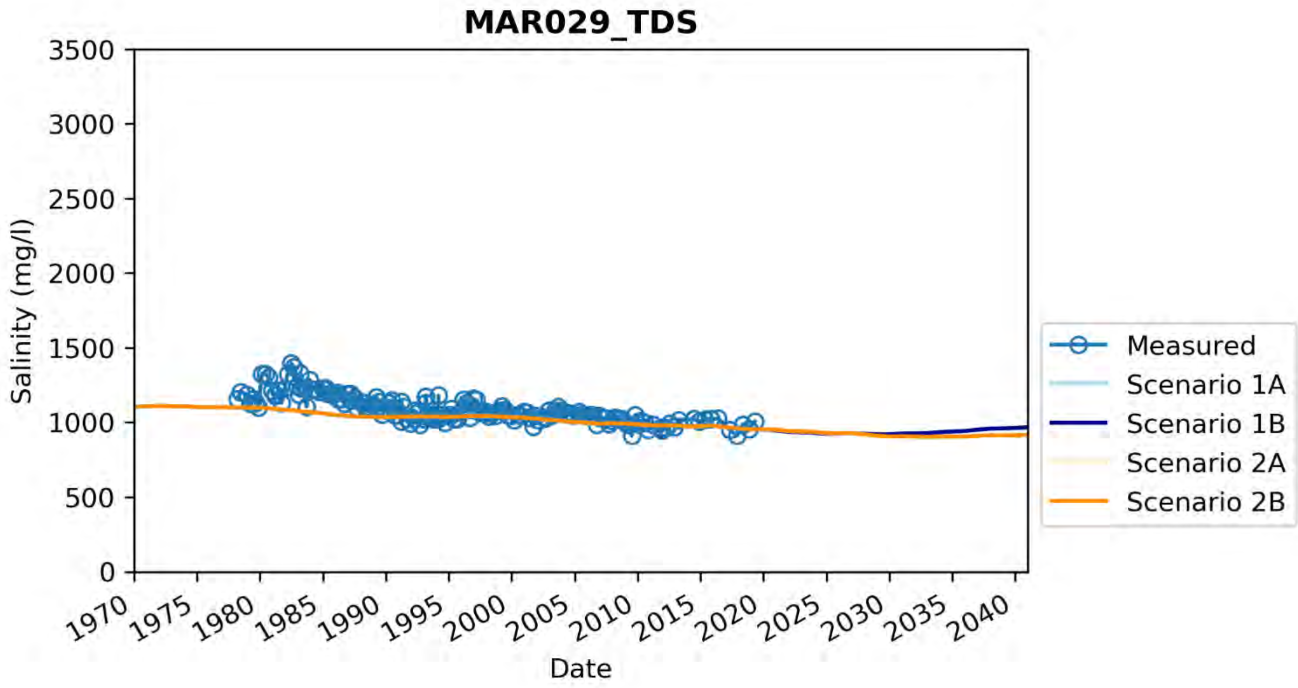


Figure 5.7. Measured and modelled groundwater salinity for all scenarios MAR029

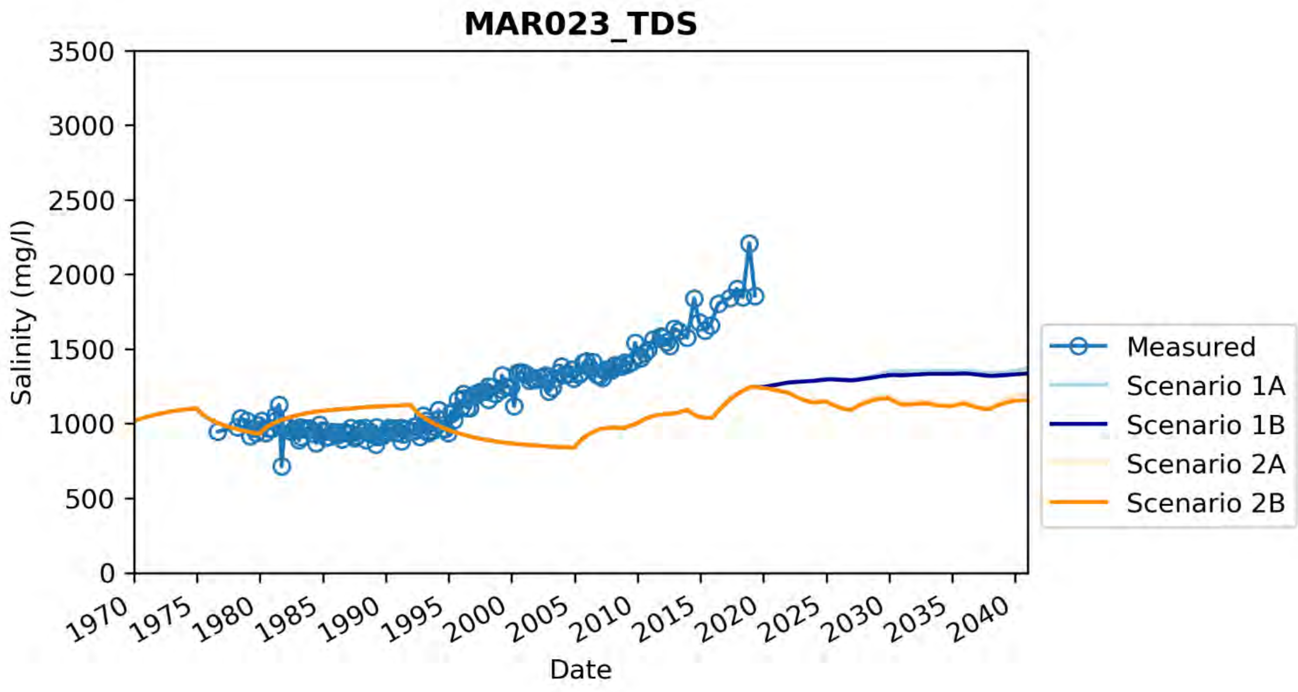


Figure 5.8. Measured and modelled groundwater salinity for all scenarios MAR023

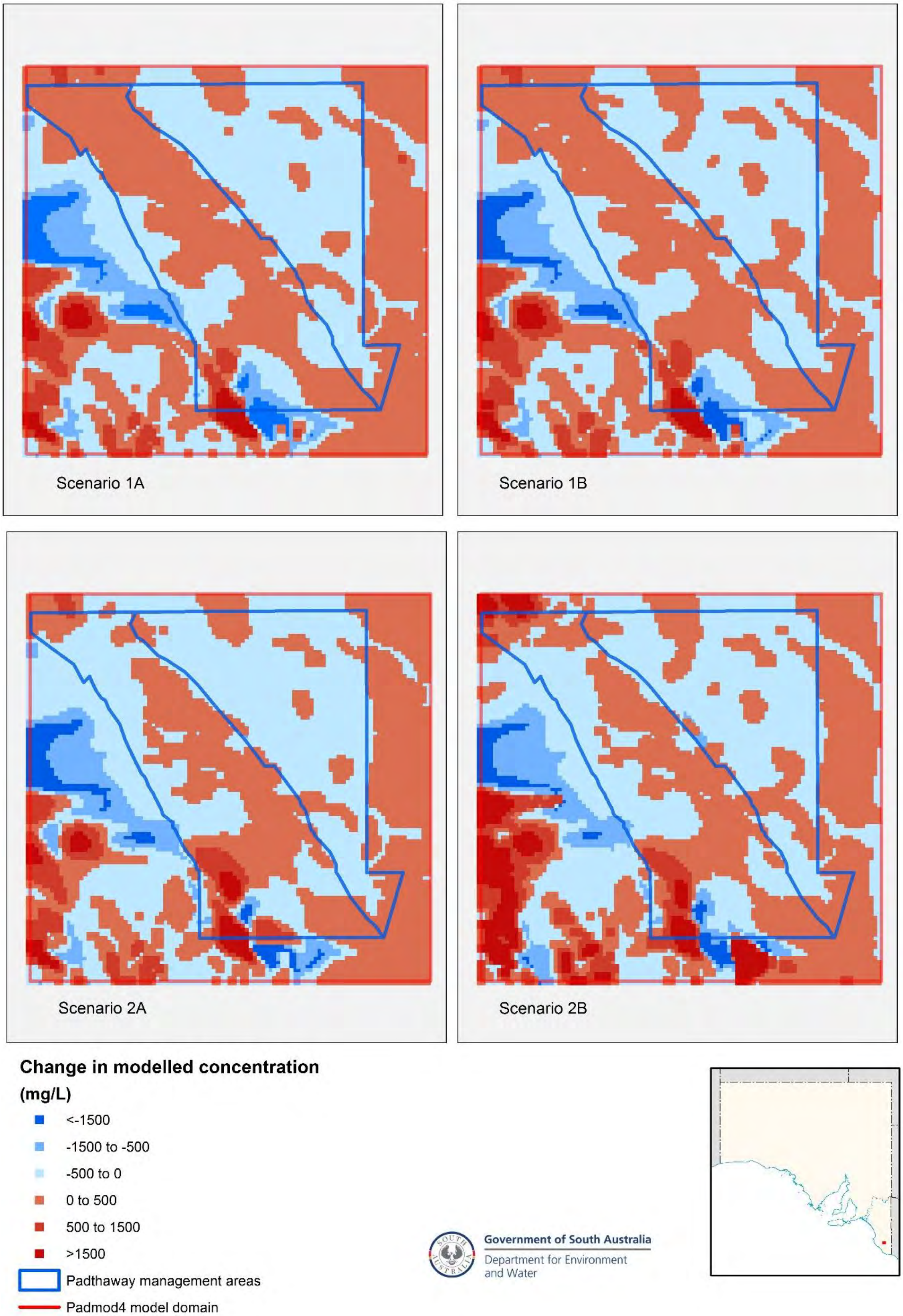


Figure 5.9. Changes in groundwater salinity at 2040 for all scenarios

5.6 Scenario results – lateral through-flow

A key management principle in the 2009 Padthaway WAP is to maintain '*lateral through-flow of underground water, in order to prevent recycling of irrigation water which can lead to increases in salinity, and to ensure salts are flushed from the region*' (SENRMB, 2009). This was a key outcome from the Padthaway salt accession studies, which outlined the need to maintain flow from Naracoorte Ranges onto the Padthaway Flats (Harrington, van den Akker & Brown 2006).

Mass balance results from the model show that under all scenarios, the rate of flow from the ranges to the flats generally increases with time, with year to year variability related to year to year groundwater level fluctuation on the flats (Figure 5.10). The simulated increases in groundwater levels in the ranges (Figure 5.4) increase the hydraulic gradient, which results in an increase in flow from the ranges to the flats. In general, the rate of flow from the ranges to the flats is 10 ML/d greater under scenarios 2A and 2B. This is because the groundwater extraction rate is higher on the flats in scenarios 2A and 2B (Figure 5.3), which results in greater water level decline on the flats than scenarios 1A and 1B, and hence a larger gradient for flow from the ranges to the flats.

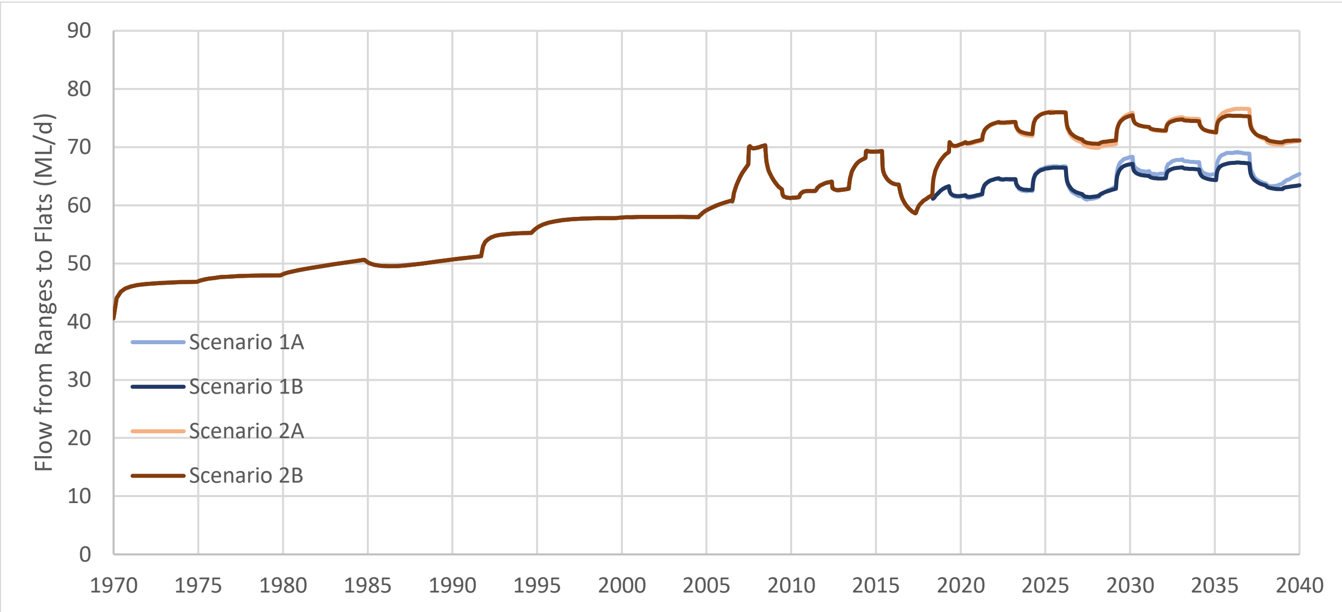


Figure 5.10. Simulated flow from the ranges to the flats under all scenarios

This suggests that all scenarios are beneficial in terms of maintaining groundwater flow from the ranges to the flats. However, mass balance results show that the greater water level decline on the flats under scenarios 2A and 2B leads to a significant reduction in the flow of groundwater out of the flats (Figure 5.11). In other words, under scenarios where full allocation is extracted, lateral flow out of the flats is significantly reduced. As discussed in Section 4.2, the model does not simulate increased salinity from irrigation recycling; rather, the salinity of irrigation water is kept constant. However, if groundwater flow out of the flats were to significantly reduce, there would be a risk of groundwater salinity increasing in the flats as a result of irrigation recycling. Consequently, scenarios 2A and 2B may result in undesirable impacts on groundwater salinity not simulated by the model.

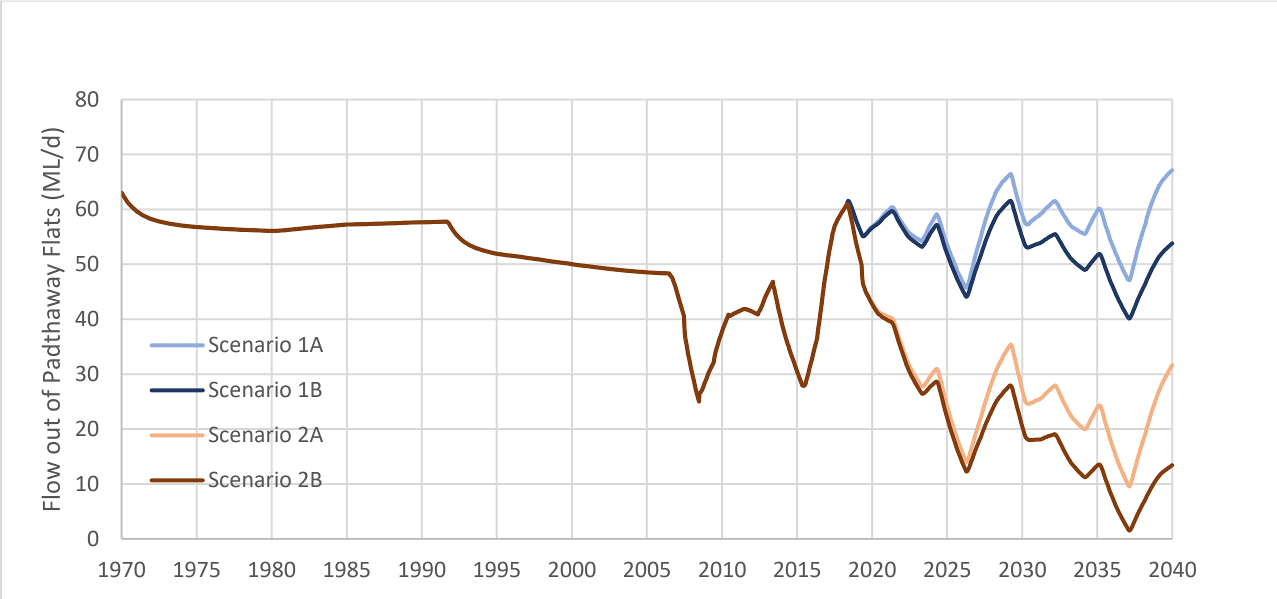


Figure 5.11. Simulated flow out of the Padthaway Flats (to the west of the PWA)

5.6.1 Management response

Scenarios 3A and 3B were used to test the impact of the potential management response of reducing pumping from full allocation (scenarios 2A and 2B) to the acceptable extraction limit of 48,000 ML/y, after RCLs are breached. Scenario 3A follows scenario 2A, in which the draft 2009 groundwater level RCL is breached in 25% of monitoring wells by 2030, meaning extraction is lowered to 48,000 ML/y in 2033. Results show some recovery of water levels compared to full allocation extraction, however groundwater levels in some cases are only returned above the RCL following high recharge towards the end of the simulation (Figure 5.12).

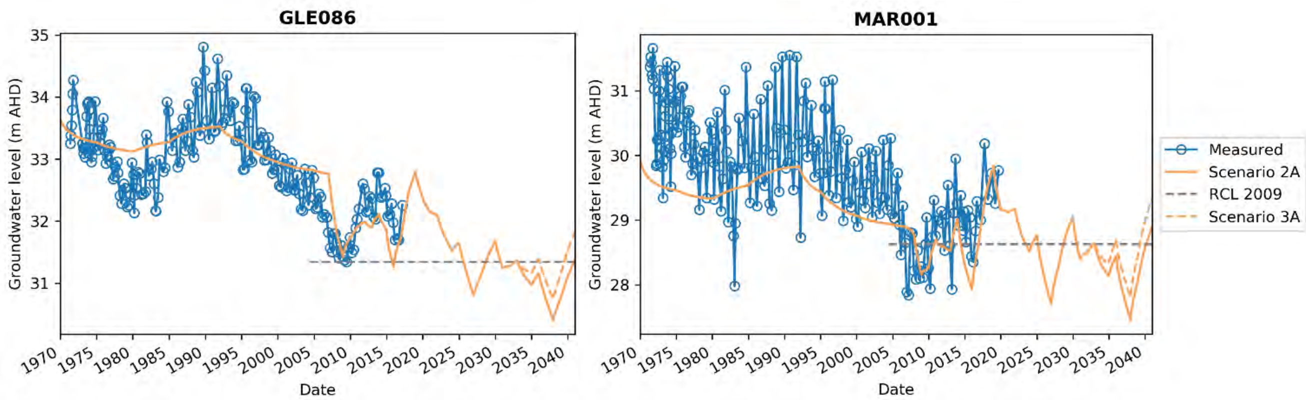


Figure 5.12. Modelled groundwater levels for scenarios 2A and 3A

Scenario 3B follows scenario 2B, in which the draft RCL is breached in 2023, with extraction lowered to 48,000 ML/y in 2026. Results show some recovery in water levels which becomes greater over time, however groundwater levels do not necessarily return above the RCL. In this scenario recharge is decreasing with time as well based on climate change projections (Figure 5.13). In both scenario 3A and 3B, the spatial extent of drawdown is less at 2040 than in scenarios 2A and 2B (Figure 5.14). This demonstrates that although the reduction in pumping may not lead to immediate recovery above the RCL in all wells, there is an overall improvement in groundwater level across the PWA. Note in Figure 5.14, drawdown is the difference between groundwater levels in 2018 and 2040.

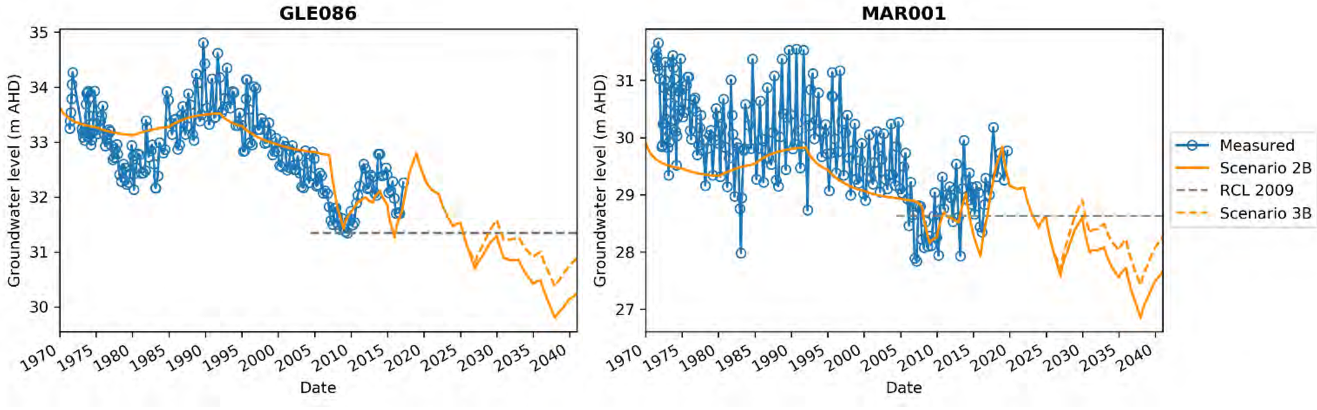


Figure 5.13. Modelled groundwater levels in scenarios 3A and 3B

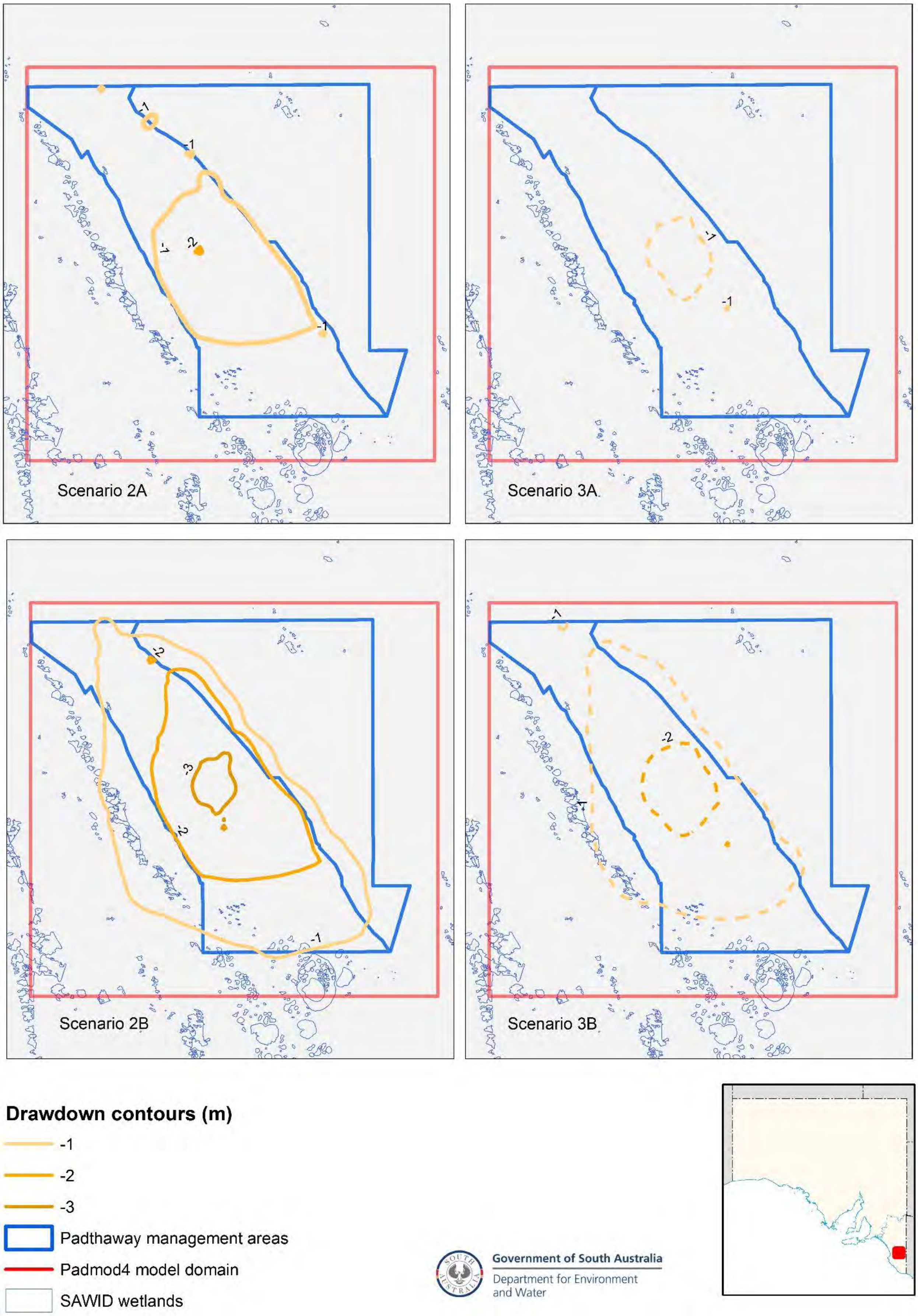


Figure 5.14. Modelled drawdown (m) for full extraction (2A, 2B) and recovery scenarios (3A, 3B)

5.7 Scenario results – management implications

The model scenarios assume extraction is constant at either average rates (scenario 1A and 1B) or full allocation rates (scenario 2A and 2B). However, as shown in Figure 2.8, groundwater extraction is likely to fluctuate from year to year in response to rainfall. As has been observed over the past 10 years (2008–2018) this may result in years where extraction approaches full allocation and groundwater levels decline. However, if above average rainfall and lower extraction occurs, groundwater levels are likely to recover above the resource condition limit, as has been observed.

Thus, the allocation limit at 55 GL/y provides for increased extraction in low rainfall periods, and may be a suitable extraction upper limit to maintain. However, if extraction at full allocation is sustained for several years, it may have adverse impacts on the groundwater resource. It is recommended that rates of extraction and groundwater levels are monitored and reported on annually, so that impacts on the resource can be understood and management options assessed. This could be performed through the Department for Environment and Water status reports (DEW, 2018).

A potential management response of lowering extraction to the acceptable limit of 48 GL/y (48,000 ML/y) three years after new RCLs are breached was tested with the model. For scenario 3A it showed recovery of groundwater levels above the RCL in some wells, however recovery appears strongly related to recharge in addition to the change in extraction. In scenario 3B where recharge declines with time there is some recovery following the reduction in pumping, however recovery above the RCL is not observed in all wells. Hence reductions in pumping may help maintain groundwater within the RCL, but the magnitude of the response will be dependent upon recharge as well as a change in extraction. As stated above, extraction is not expected to occur at rates of full allocation of 55 GL every year, based on measured extractions over the past 10 years, and maintaining the current allocation limit provides for increased extraction in dry years. However, reduction in pumping to the acceptable extraction limit of 48 GL/y defined in the 2009 WAP may help improve groundwater level recovery if successive dry years and declining groundwater levels are observed.

The model may be suitable for assessing longer-term salinity trends in parts of the PWA; however, in some areas the model is not suitable for simulating longer-term salinity trends, due to data limitations and resulting model assumptions (i.e. lack of knowledge on the spatial variability in unsaturated zone salinity). Furthermore, salinity increases may continue to occur in parts of the PWA due to ongoing flushing of unsaturated zone salt and movement through the aquifer, irrespective of management strategies. However, groundwater level declines associated with sustained extraction at full allocation of 55 GL/y are predicted to reduce groundwater flow out of the PWA, which may potentially result in unwanted salinity changes. Therefore, as suggested above, groundwater level and extraction should be monitored and reported on annually. If declines associated with increased groundwater extraction are observed, it may be necessary to revisit the model to assess if declines are impacting groundwater flow, and whether management intervention would lead to improvement in groundwater resource condition.

6 Model capability and limitations

6.1 Model capability

The model described in this report is a revised version of the model described by Aquaterra (2008). It carries much of the same assumptions as the original model; however, some recommendations from the previous model reports have been addressed. In particular, the extension of the model from 2007 to 2018 includes the addition of metered groundwater extraction data, while prior to 2007, extraction is based on estimated use. The inclusion of this data, and the refined surface elevation, addresses previous recommendations reduces limitations in the model described by Aquaterra (2008).

Based on the model performance in simulating groundwater level and salinity, the model capabilities can be summarised as follows:

- The model is capable of simulating past groundwater level change in the Padthaway PWA, with a good match between measured and modelled groundwater levels. This includes periods where groundwater levels have declined in response to below-average rainfall and increased extraction, and periods of groundwater level recovery following above-average rainfall and reduced extraction. The inclusion of metered groundwater extraction data from 2007 to 2018 greatly improves confidence in the model results and simulated recharge.
- The model is capable of simulating future changes in groundwater level in response to assumed groundwater extraction and recharge scenarios.
- The model is capable of simulating past changes in groundwater salinity in some parts of the domain. However, the fit between measured and modelled groundwater salinity is not satisfactory at all locations where salinity observation data has been collected.
- Based on the models fit to measured salinity, the model is not currently capable of simulating future change in groundwater salinity for assumed extraction and recharge scenarios with a high level of confidence. The model may be suitable for providing broad indications of future salinity changes, within the assumptions applied in the solute transport model. Future improvements of model performance would rely upon further data acquisition and model sensitivity testing.

6.2 Model assumptions, limitations and uncertainty

While the model is capable of simulating groundwater levels quite well, the model still has limitations in terms of its abilities to simulate groundwater salinity. This largely relates to the assumptions applied to the solute transport model, and the data available to inform these assumptions. In particular, the model assumes constant salinity for recharge. The recharge salinity varies for different land use types based on the results of Harrington, van den Akker & Brown (2006). However, it is spatially constant. In other words, all areas of flood irrigation receive recharge of the same salinity based on field studies, as do all areas of pivot irrigation, vineyard (drip) irrigation, and areas of dryland agriculture.

The salinity of recharge however is likely to be influenced by recharge rate, unsaturated zone salinity and the salinity of any irrigation water applied. All of these factors are expected to show a large degree of spatial and temporal variability. While accounting for this variability may improve the solute transport model, the data required on unsaturated zone and irrigation water salinity is not available. Consequently, addressing these limitations is considered beyond the scope of this study. Further recommendations to address these limitations are given in Chapter 7.

A quantitative parameter uncertainty analysis has not been undertaken as part of this study. Uncertainty in parameter distributions (e.g. the distribution of hydraulic conductivity values in Figure 3.7) is likely to have some impact on model simulations. However, assessing the impact of such parameter uncertainty on model predictions is considered to be of less importance than improving understanding of the spatial distribution of salinity inputs to the aquifer. In other words, a quantitative parameter uncertainty analysis on hydraulic conductivity is not expected to reduce uncertainty in salinity predictions made by the model.

A more suitable approach may be to test sensitivity of model results to different recharge salinity concentration inputs, by running the model multiple times with varying recharge concentrations. This was considered beyond the scope of the current modelling exercise, and assumptions related to recharge concentration are consistent with those described in Aquaterra (2008). However, this type of sensitivity analysis may improve understanding of uncertainty in recharge concentrations and inform the scoping of a more detailed parameter uncertainty analysis.

7 Conclusion and recommendations

7.1 Conclusions and management implications

The Padthaway groundwater flow and solute transport model has been updated to provide technical support to the review of the Padthaway Water Allocation Plan. The updates follow previous recommendations and include:

- extending the model domain to cover the entire Prescribed Wells Area
- extending the simulation period to include the years 2007 to 2018, with metered groundwater extraction data used to simulate pumping from irrigation wells
- revising the ground surface elevation in the model using updated survey data
- re-calibrating the model by varying recharge rates from 2007 to 2018 and hydraulic parameters to fit groundwater levels.

The updated model has been used to run four scenarios to assess the impact of continued groundwater extraction at current average rates (35 GL/y) and increased groundwater extraction to full allocation (55 GL/y). Both scenarios have been run separately assuming average recharge rates and reduced recharge under climate change. The scenarios show that:

- continued extraction at current average rates generally results in stable groundwater levels, with some year to year variability related to recharge. Groundwater salinity may increase as a result of evapotranspiration in some shallow water table areas. However, lateral groundwater flow out of the PWA is maintained, which is a key management principle in Padthaway to mitigate salinity increases from irrigation recycling.
- Increased extraction to full allocation rates generally results in groundwater level declines in the Padthaway Flats. While this decline limits any potential salinity increases from evapotranspiration, it also results in a significant reduction in groundwater flow out of the PWA, with the potential to result in increased salinity from irrigation recycling. Groundwater level reduction (drawdown) associated with these scenarios may also impact on groundwater levels around Cockatoo Lake.
- Extraction is not expected to occur at rates of full allocation of 55 GL every year, based on measured extractions over the past 10 years, and maintaining the current allocation limit provides for increased extraction in dry years. However, reduction in pumping to the acceptable extraction limit of 48 GL/y defined in the 2009 WAP may help improve groundwater level recovery if successive dry years and declining groundwater levels are observed.

As discussed in Section 5.7, the most likely future scenario in Padthaway is one in which groundwater extraction fluctuates from year to year following variability in rainfall. As has been observed since 2007, significant increases in groundwater extraction, up to almost full allocation, can occur. However, provided they are not sustained, and periods of higher rainfall and lower extraction occur subsequently, the groundwater resource can generally be maintained within management principles. That is, groundwater levels are maintained or recover to acceptable levels, and groundwater flow through and out of the management area is maintained.

The model is not capable of simulating or predicting salinity trends with high confidence for reasons discussed in Chapter 6. It is likely that salinity will continue to increase in parts of the PWA in the future as a result of continued flushing of the salt in the unsaturated zone, and movement of this salt through the aquifer. These processes will continue to occur irrespective of groundwater management settings.

7.2 Recommendations

At the time of writing, the Padthaway WAP review process is underway and discussions with groundwater managers and stakeholders are ongoing. Nevertheless, the following general recommendations related to management of groundwater resources in Padthaway can be made:

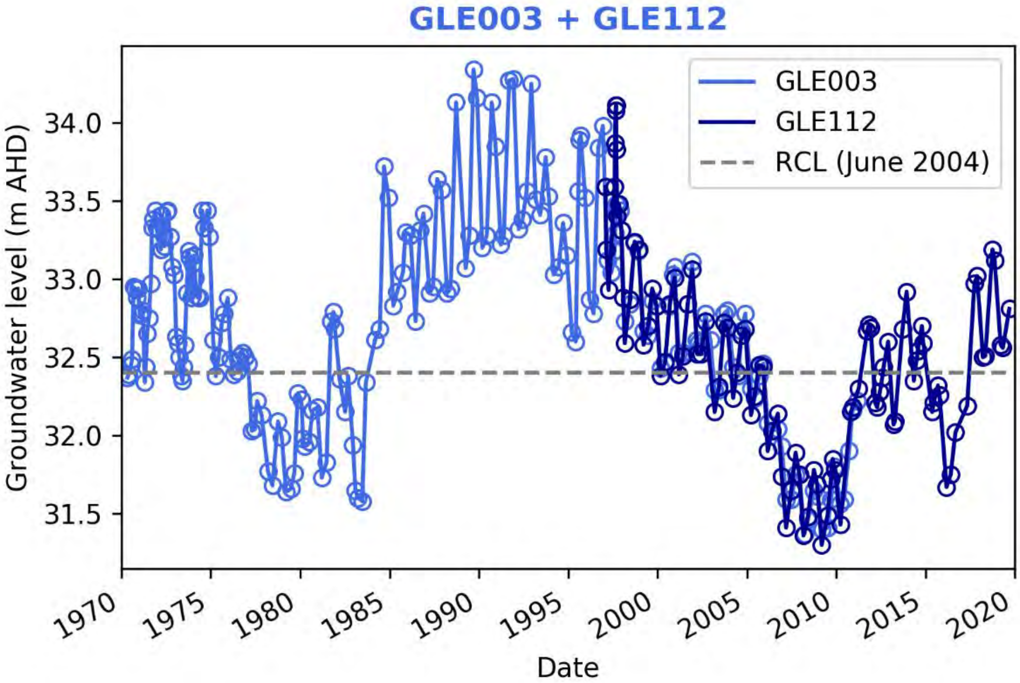
- The current level of full allocation (55 GL/y) should be considered an upper limit to groundwater extraction. The groundwater resource may be able to sustain such high levels of extraction for brief periods, and such allowances provide a buffer for irrigation practices in dry years. However, ongoing extraction of this volume is likely to lead to detrimental impacts on the resource, including declining groundwater levels and reduced flow volumes, which may impact salinity.
- Notwithstanding future management options adopted in the Padthaway Water Allocation Plan, it is recommended that both groundwater extraction rates and groundwater levels be reviewed annually. This is currently undertaken by DEW as part of the groundwater status report process. However, it may be necessary to tailor this report more to assess groundwater levels against resource condition limits.

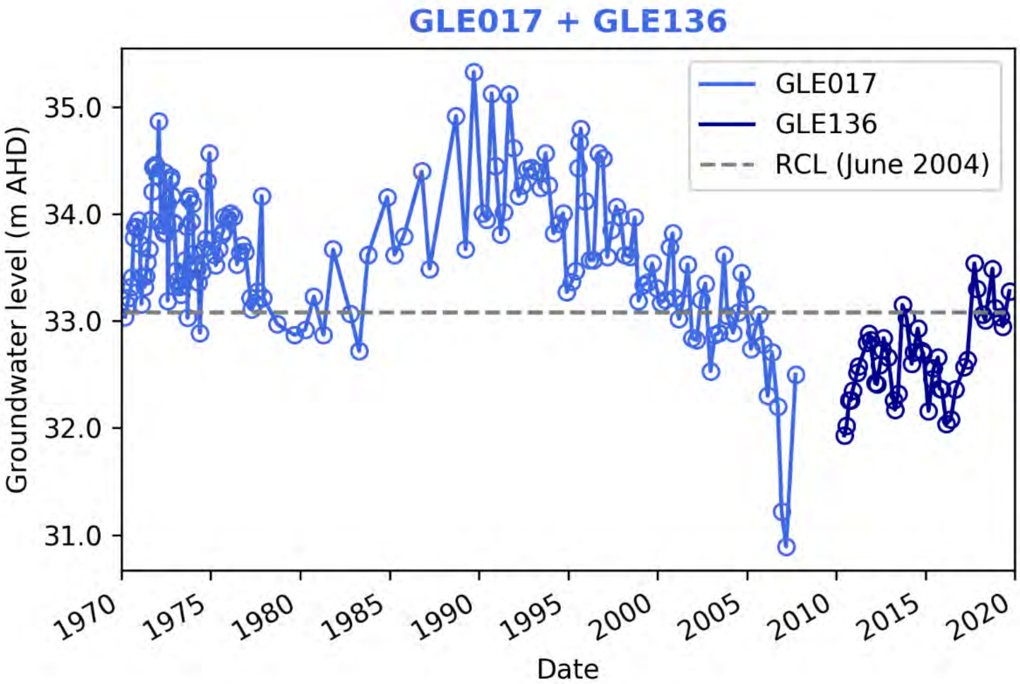
Recommendations for further refinement to the model include:

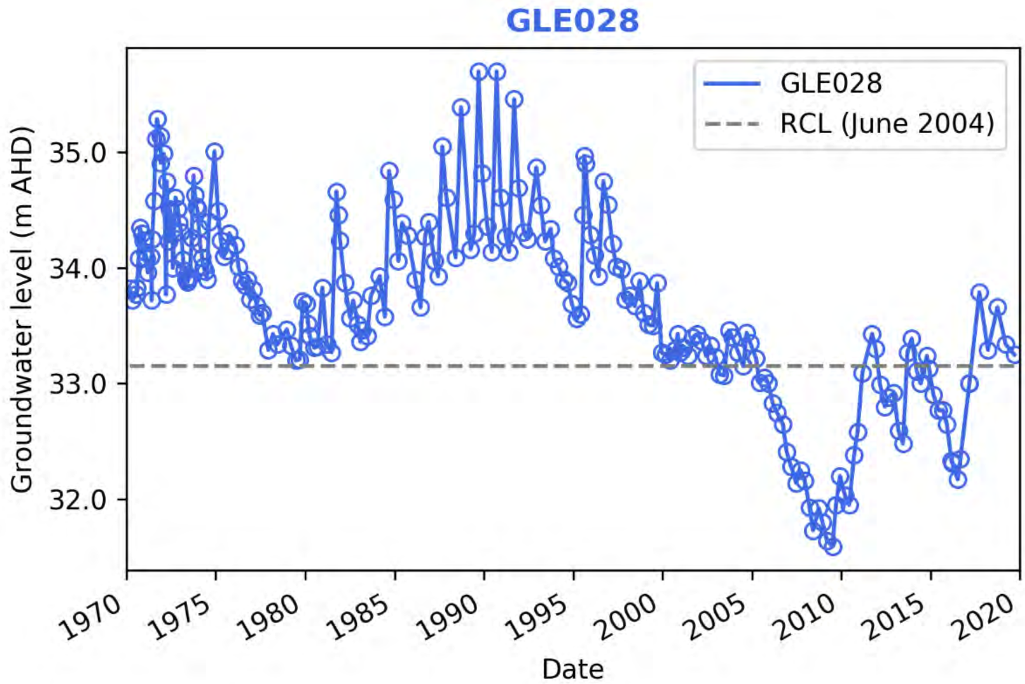
- Model stress periods prior to 2006 could be annual rather than five-yearly (see Table 3.1). Pumping rates can be kept the same as in the previous version of the model (Padmod3; Aquaterra 2009); however, recharge could be varied on an annual basis to improve the simulated match to observed groundwater levels. This may affect solute transport simulations.
- Further stress period refinement could be considered, making stress periods bi-annual to simulate seasonal maximum and minimum groundwater levels. This may help assess the potential impact of groundwater extraction scenarios on surface water-groundwater interactions at Cockatoo Lake. If this approach were taken, more calibration work considering spatial variability in specific yield using the pilot point approach may help further improve model fit.
- More spatial and temporal variability in recharge concentrations could be applied. While there may not be sufficient data on unsaturated zone and irrigation water salinity to do this, some more detailed model sensitivity testing could be undertaken. For example, if the salinity increases discussed in Section 4.2 cannot be simulated via modelled evapotranspiration, then several scenarios of varying recharge concentration could be tested to see if this improves model results. This may improve understanding of the impact of parameter (recharge concentration) uncertainty on model results, and help inform recommendations around further uncertainty analysis.
- The assumptions related to recharge on the ranges could be revisited, taking into account observations of stabilising and declining groundwater levels in the ranges since 2009. This may involve revisiting the modelling described in Wohling et al. (2006), or doing further sensitivity testing to recharge in the Padthaway ranges using this updated version of the model (Padmod4).

8 Appendices

A. Groundwater levels in the Padthaway Flats



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33.0
32.0
1970
1975
1980
1985
1990
1995
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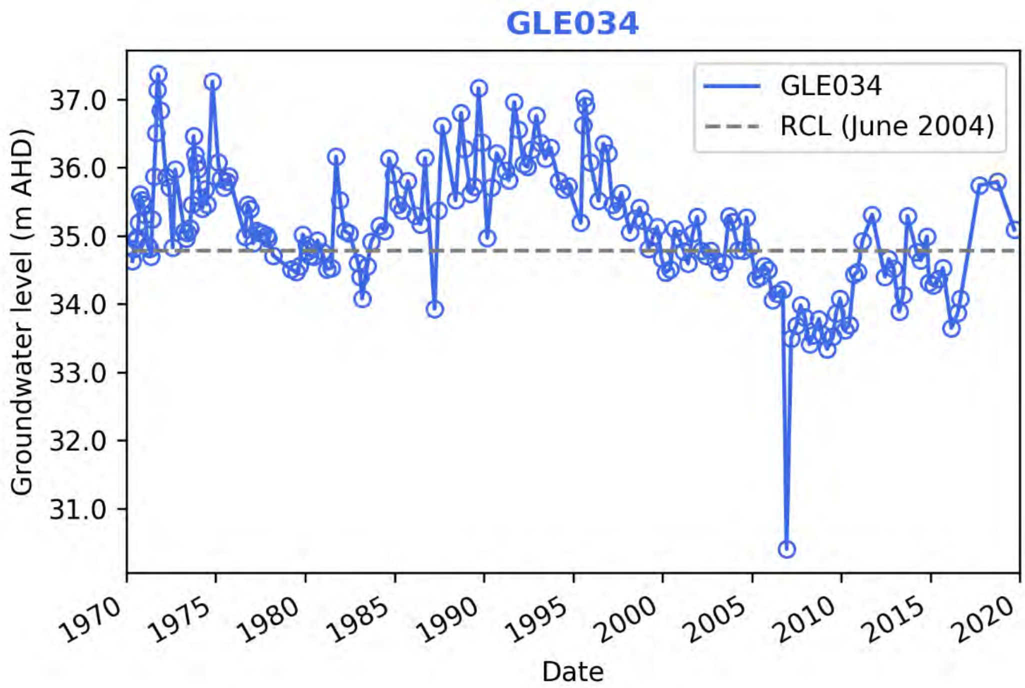
2005
2010
2015
2020
Date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36.0
35.0
34.0
33.0
32.0
31.0
1970
1975
1980
1985
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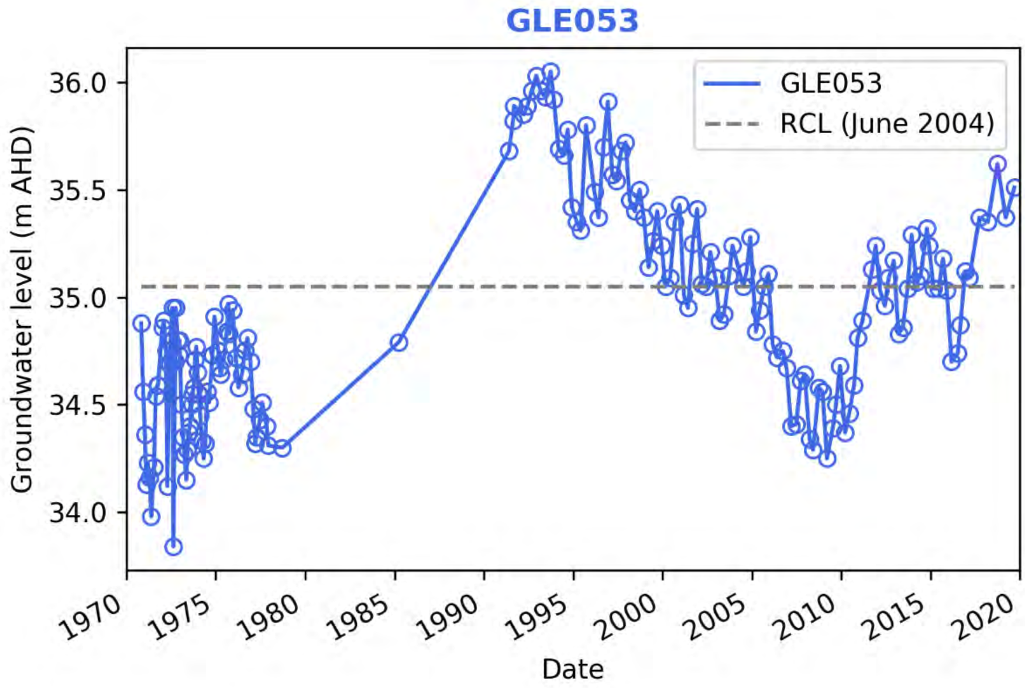
2020
Date



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GLE053
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34.5
34.0
1970
1975
1980
1985
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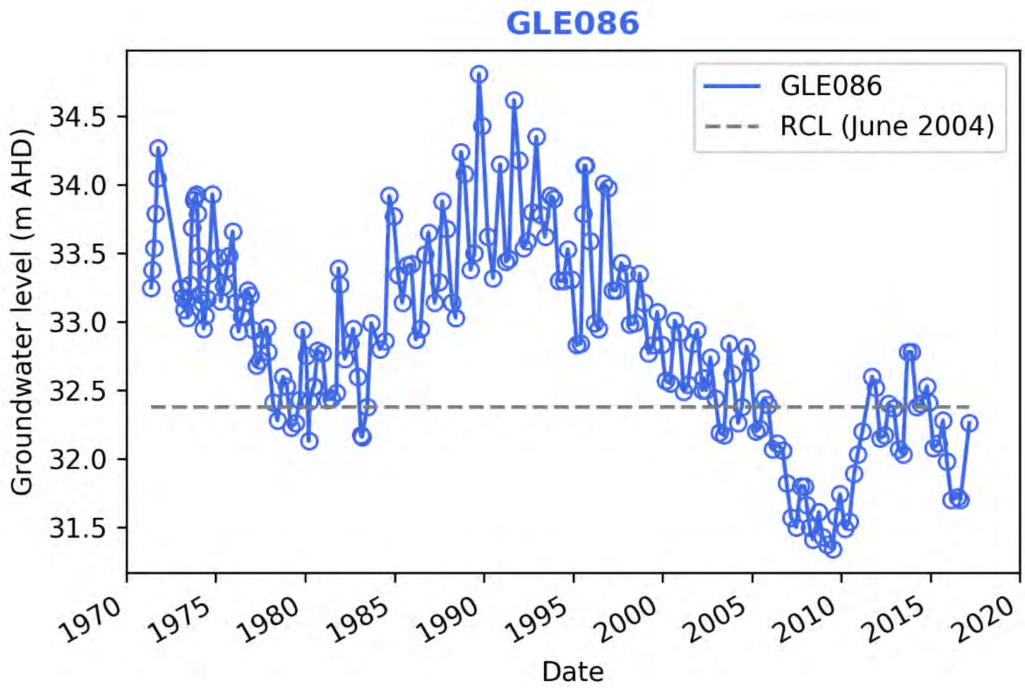
Date



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33.5
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32.5
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1970
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1980
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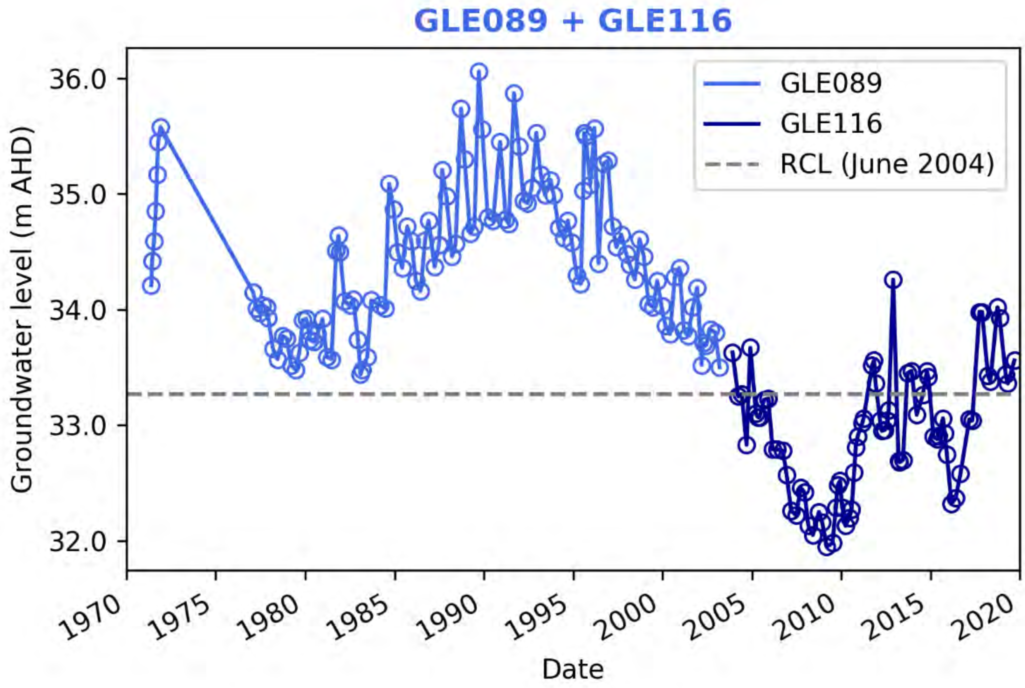
Date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GLE089
GLE116
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Groundwater level (m AHD)
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33.0
32.0
1970
1975
1980
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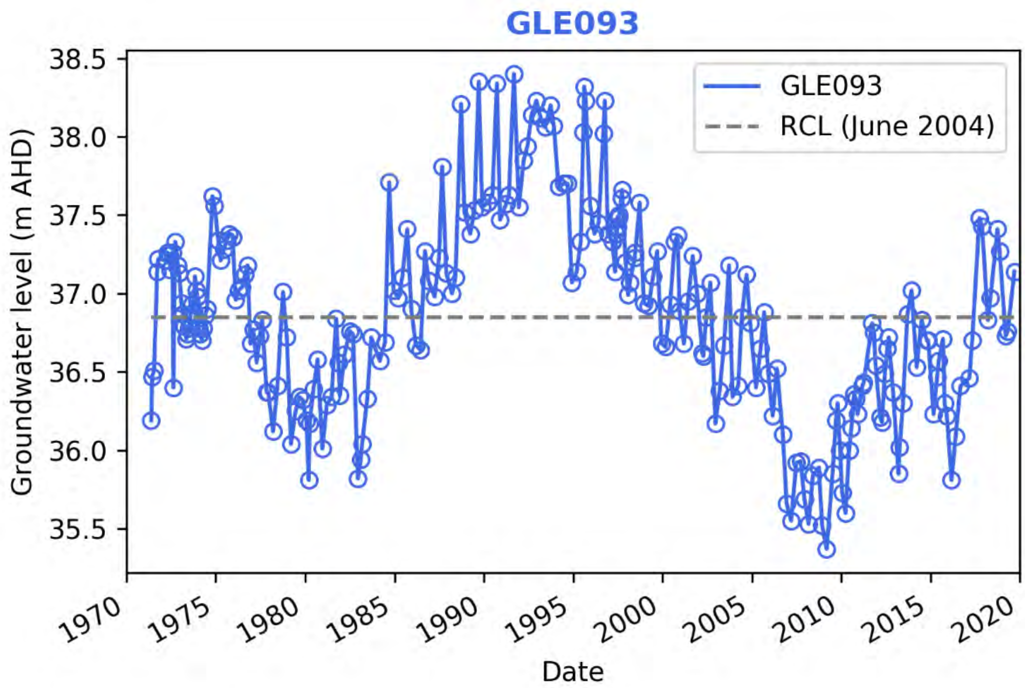
Date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36.0
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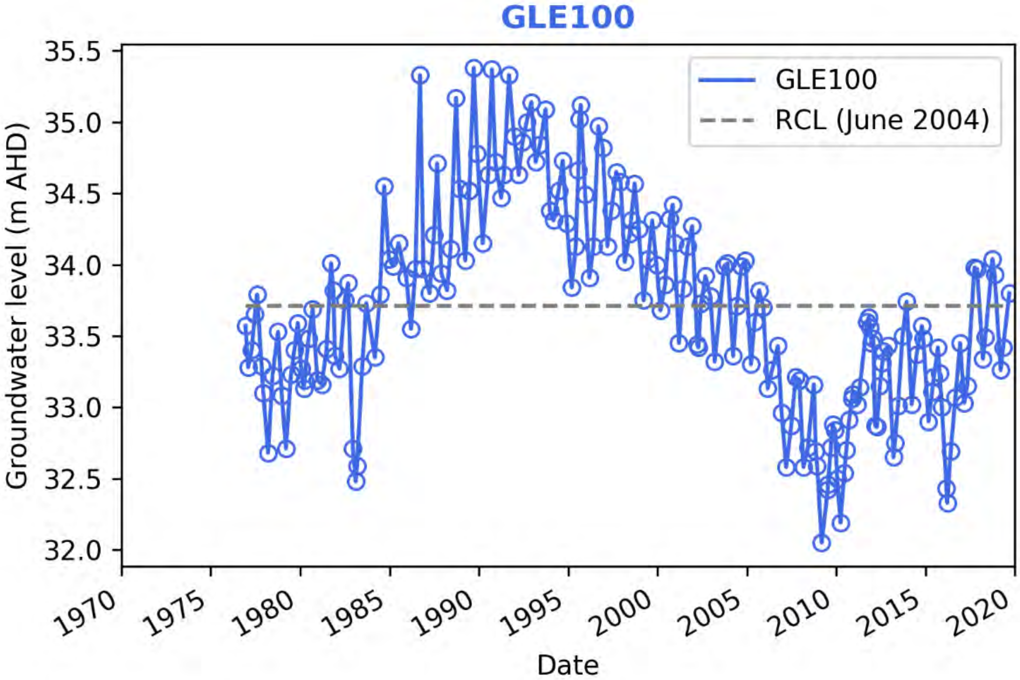
Date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32.0
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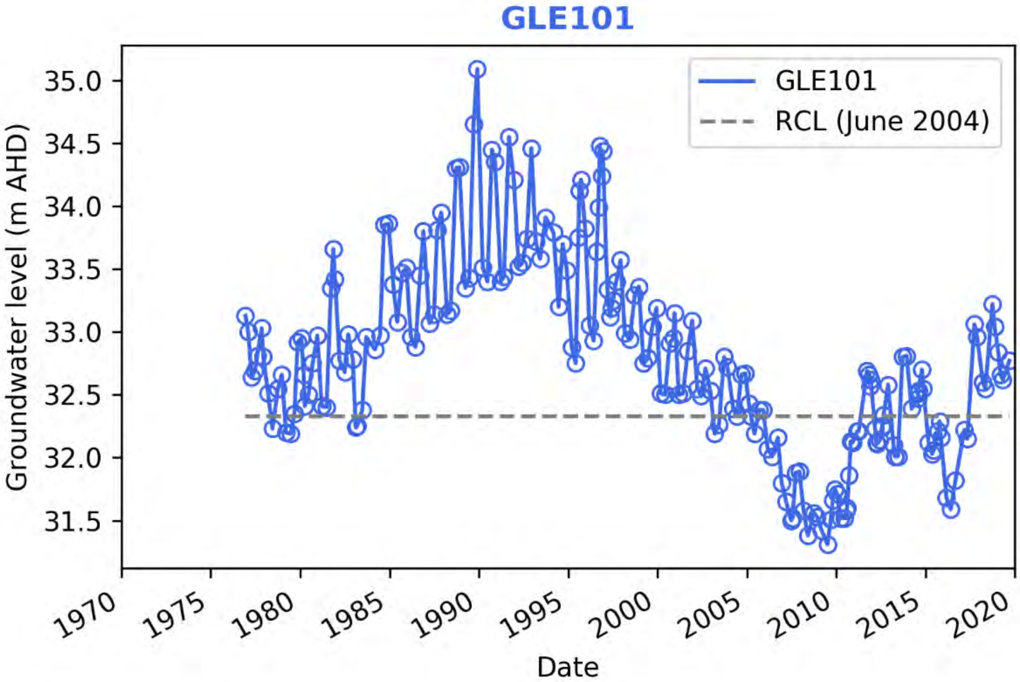
Date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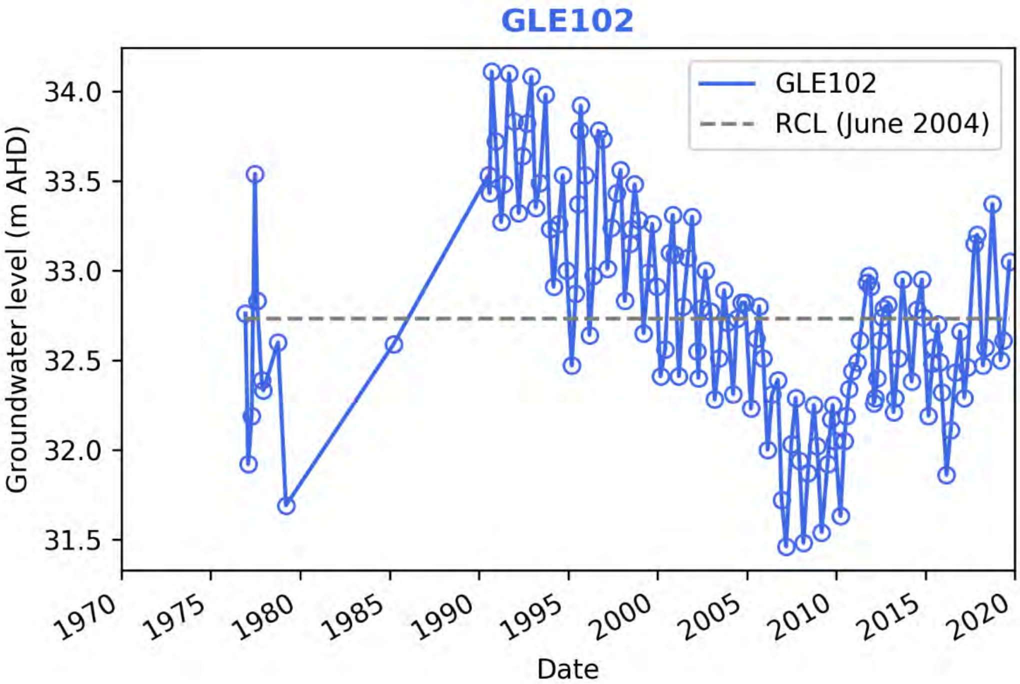
Date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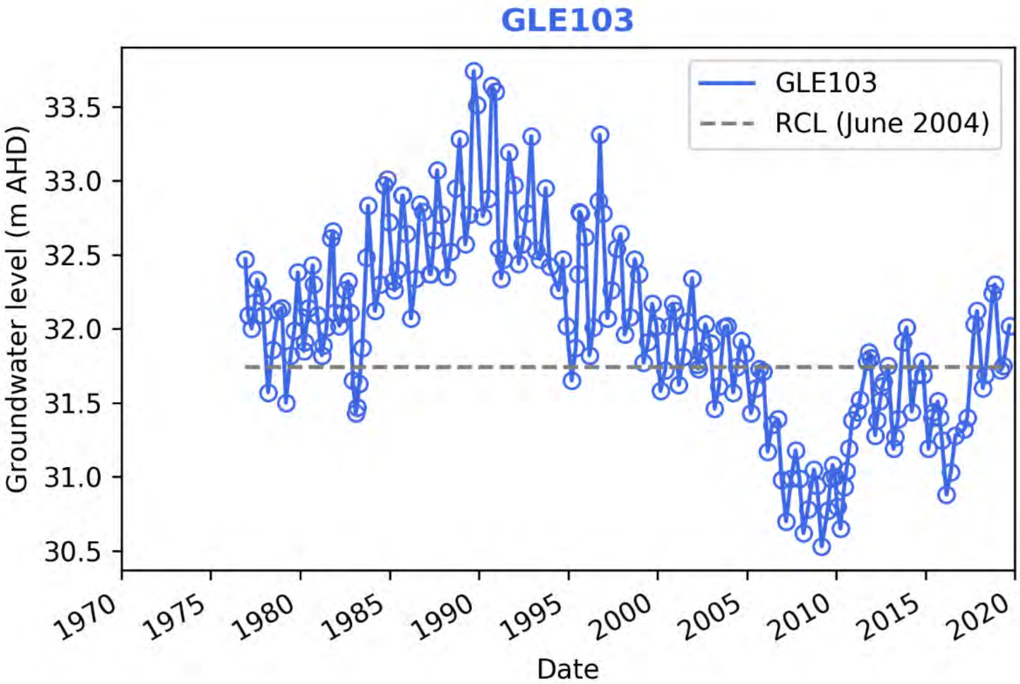
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2020
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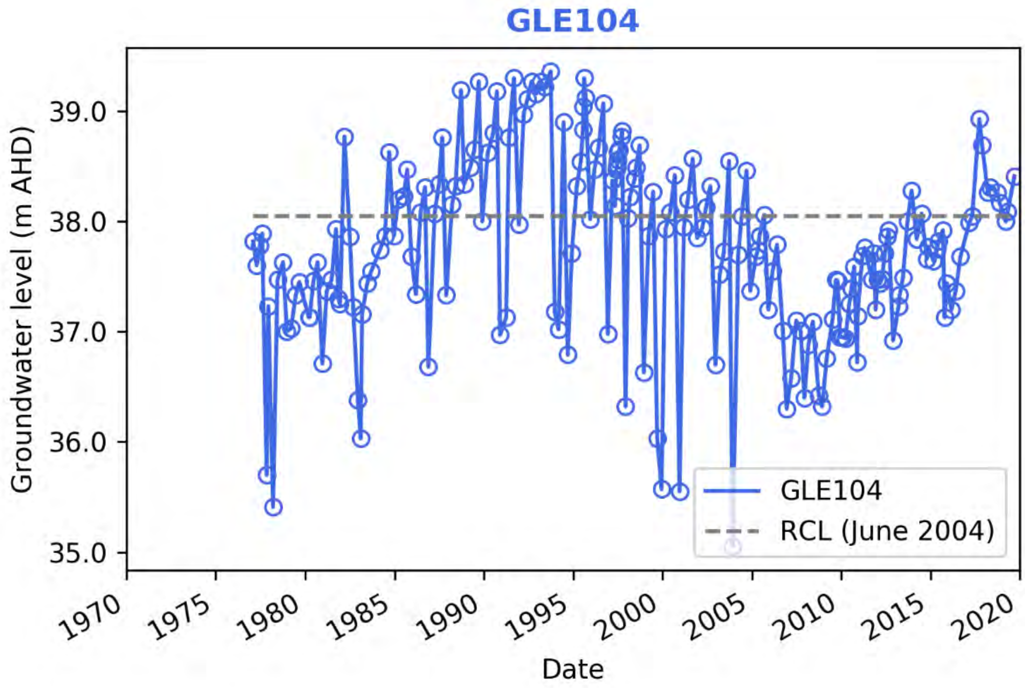

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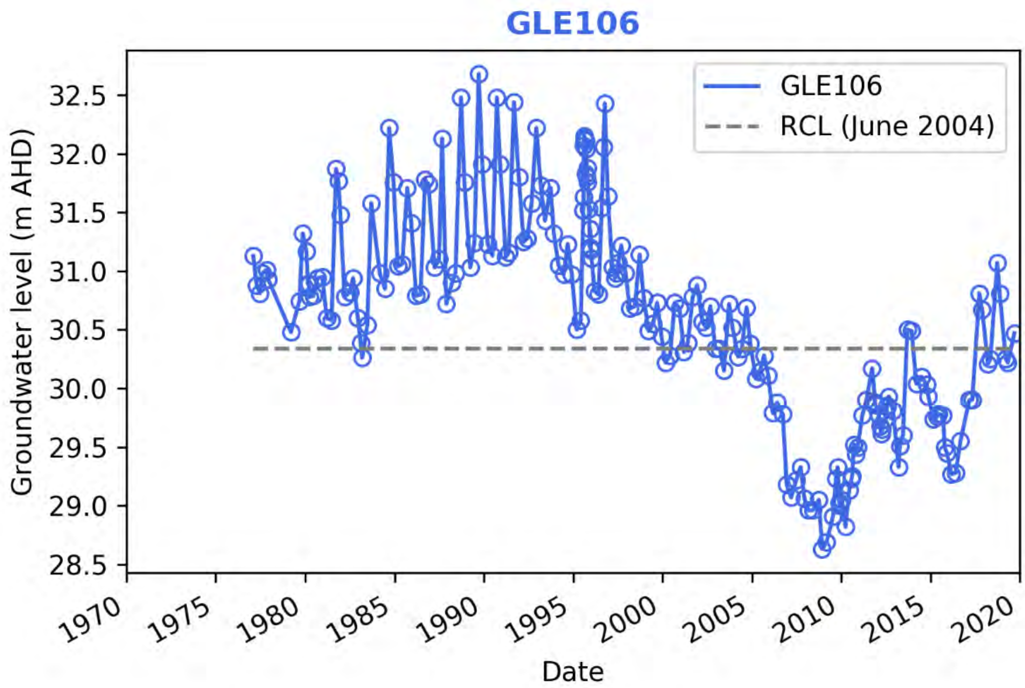
GLE104
RCL (June 2004)



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31.0
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28.5
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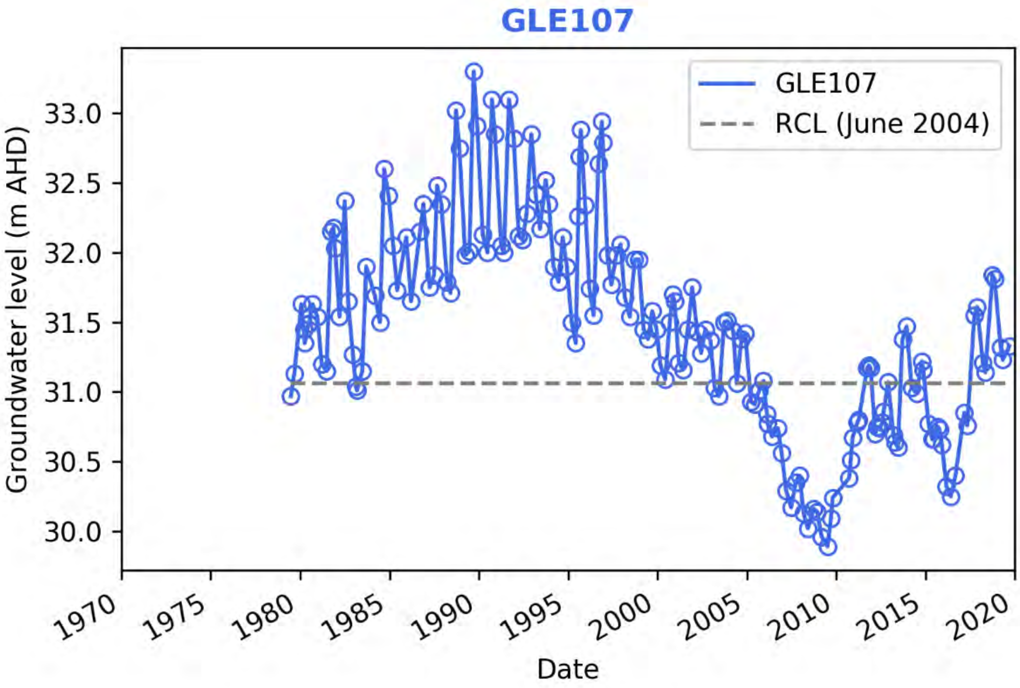
Date
GLE106
RCL (June 2004)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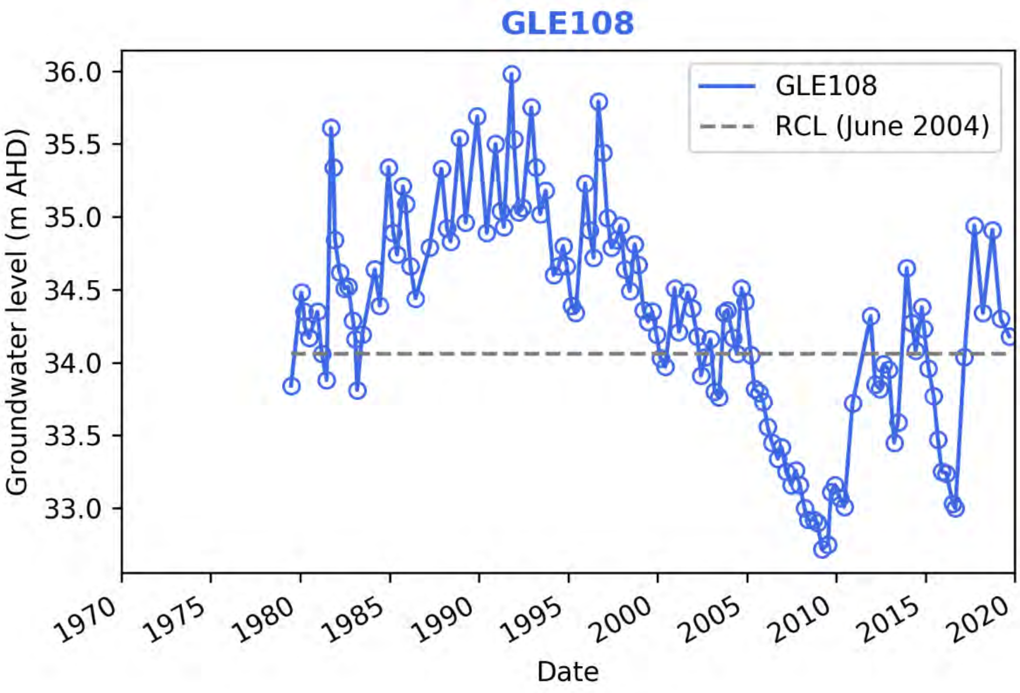
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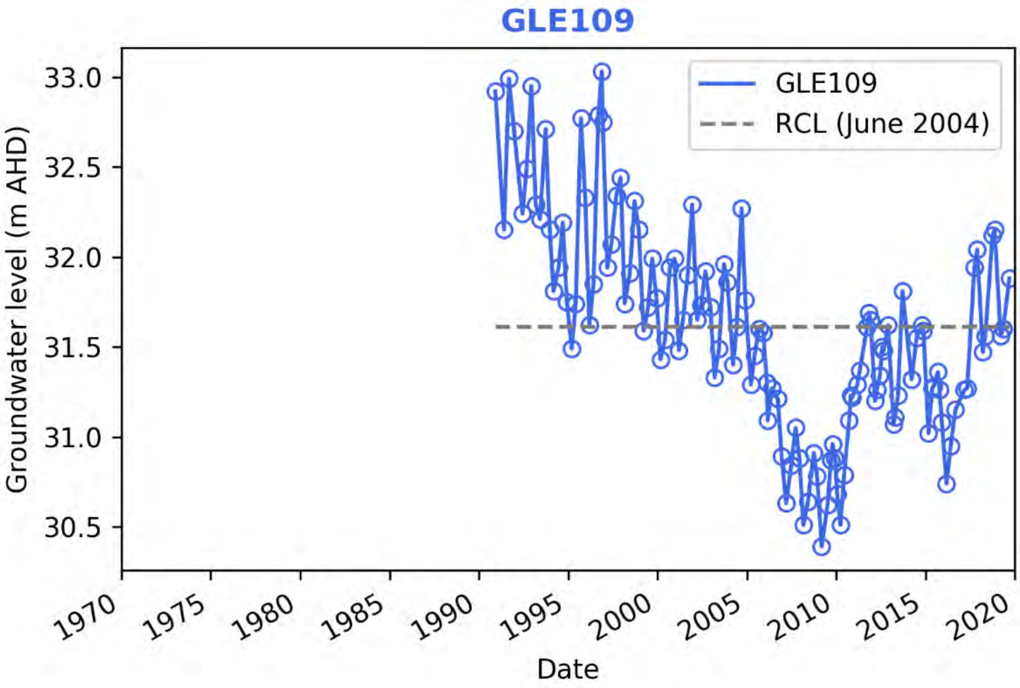
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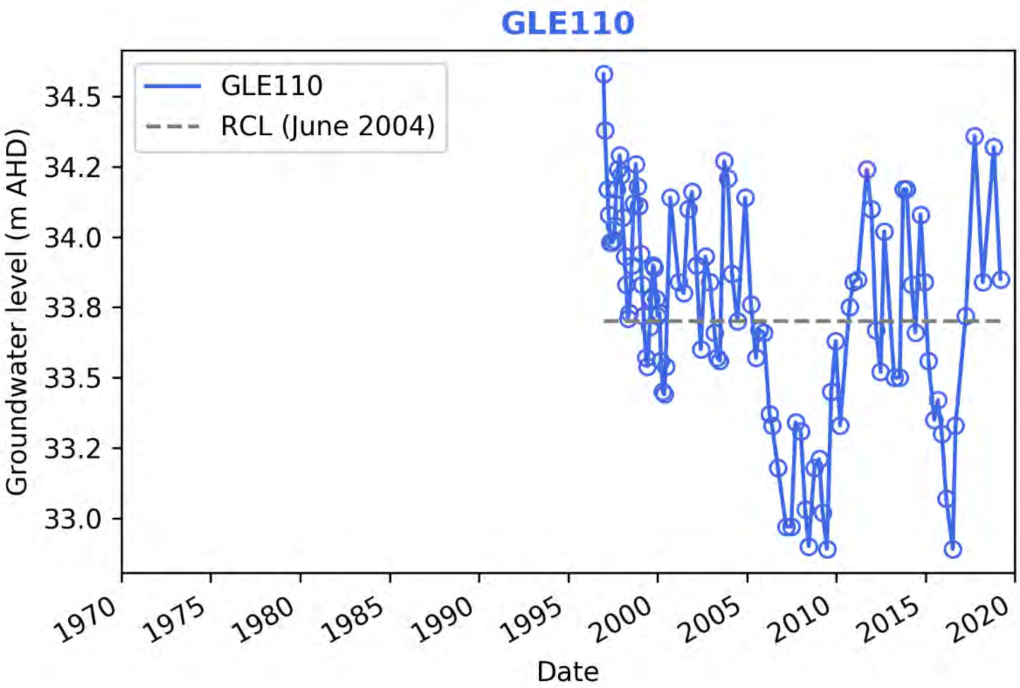
2020
Date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33.5
33.2
33.0
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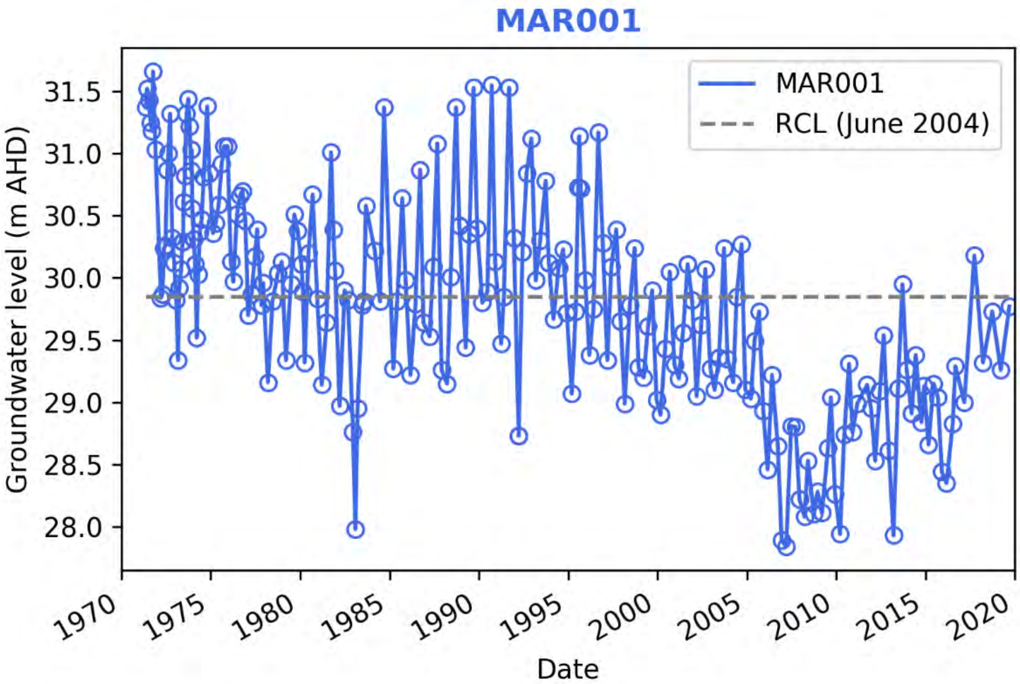
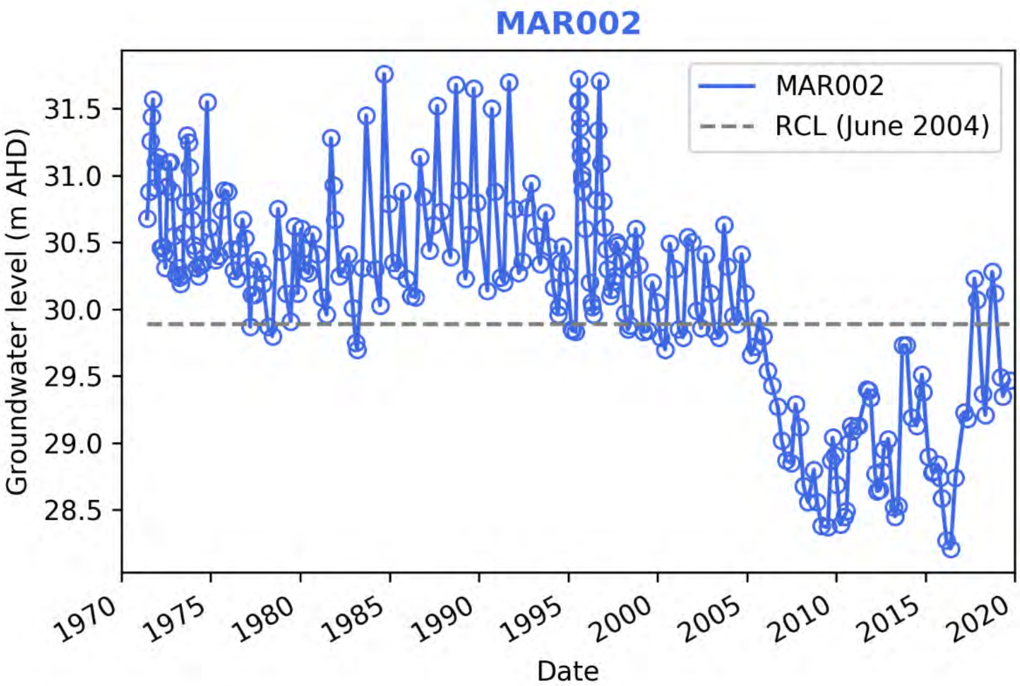
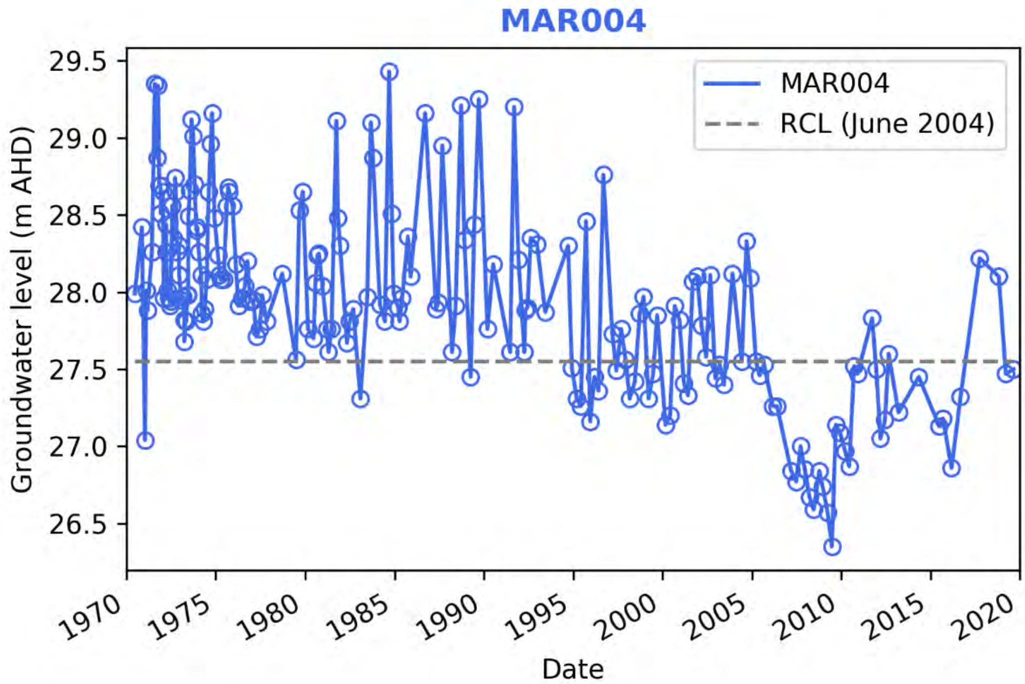
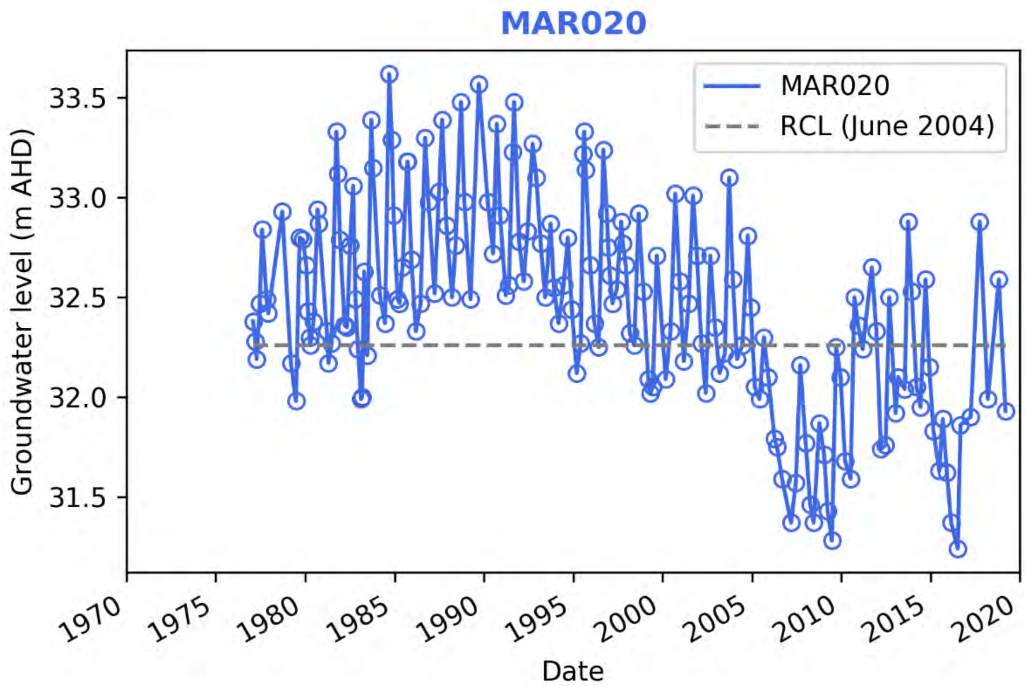
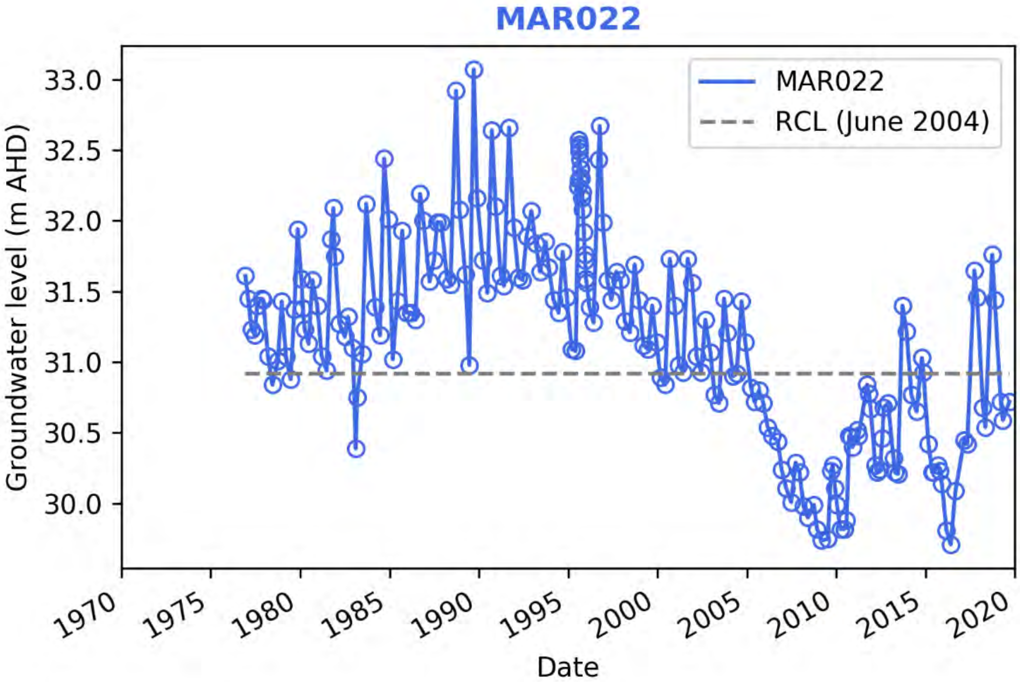
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

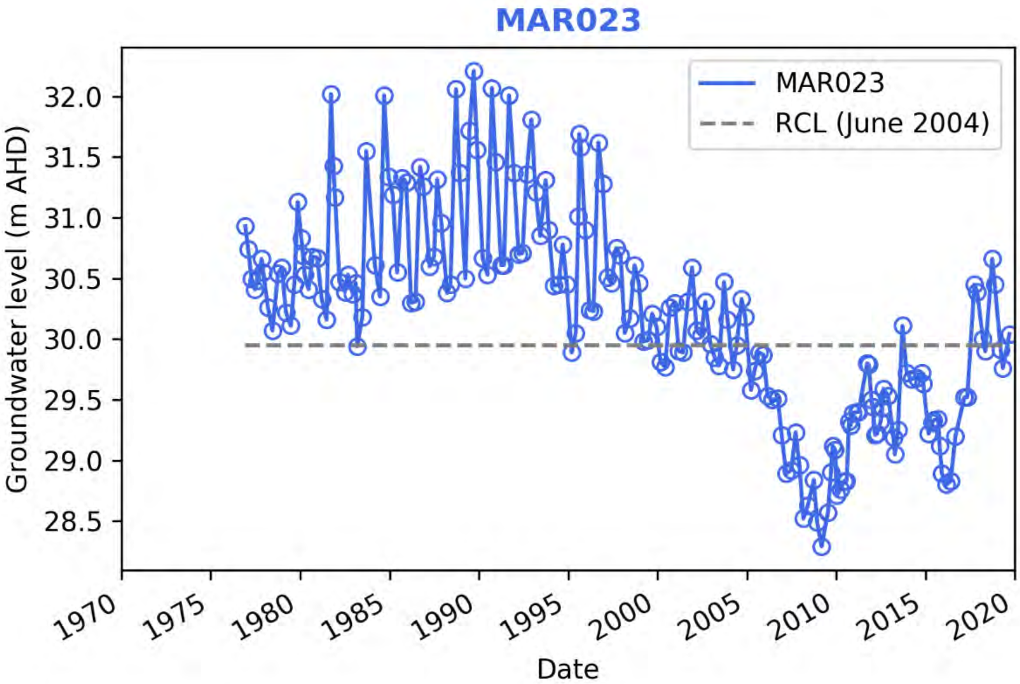

MAR001
MAR001
RCL (June 2004)
Groundwater level (m AHD)
31.5
31.0
30.5
30.0
29.5
29.0
28.5
28.0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

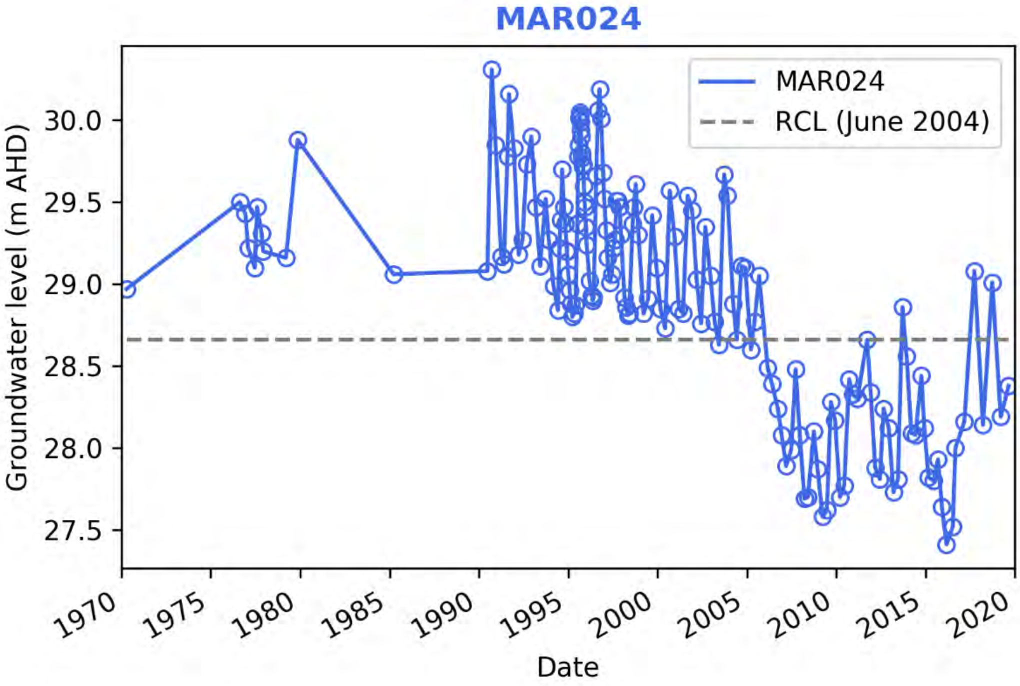

MAR002
MAR002
RCL (June 2004)
Groundwater level (m AHD)
31.5
31.0
30.5
30.0
29.5
29.0
28.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

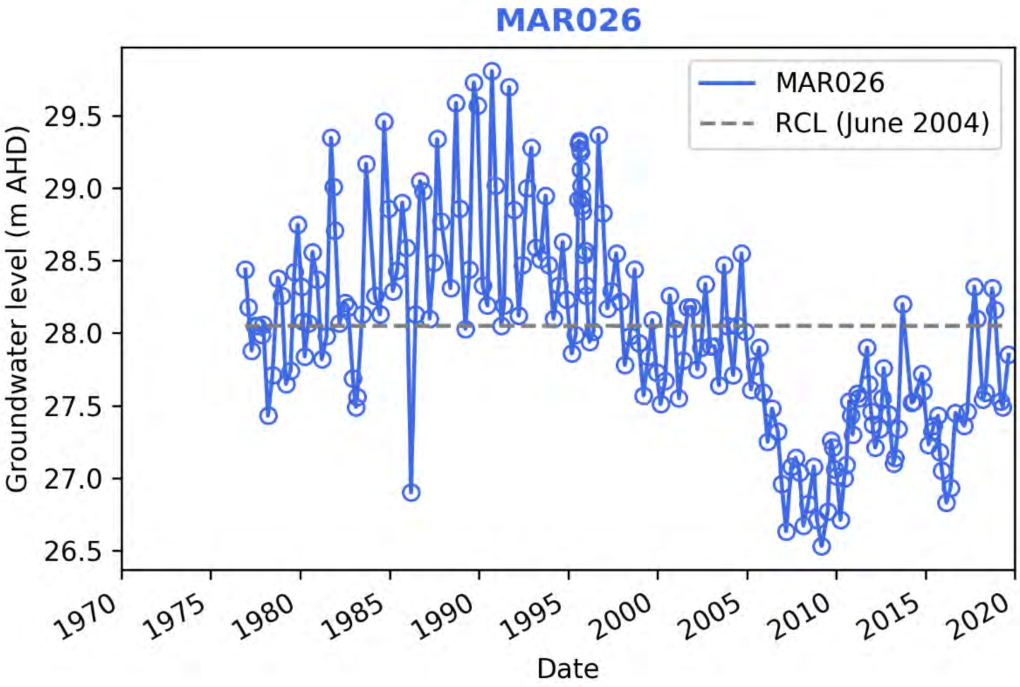

MAR004
MAR004
RCL (June 2004)
Groundwater level (m AHD)
29.5
29.0
28.5
28.0
27.5
27.0
26.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

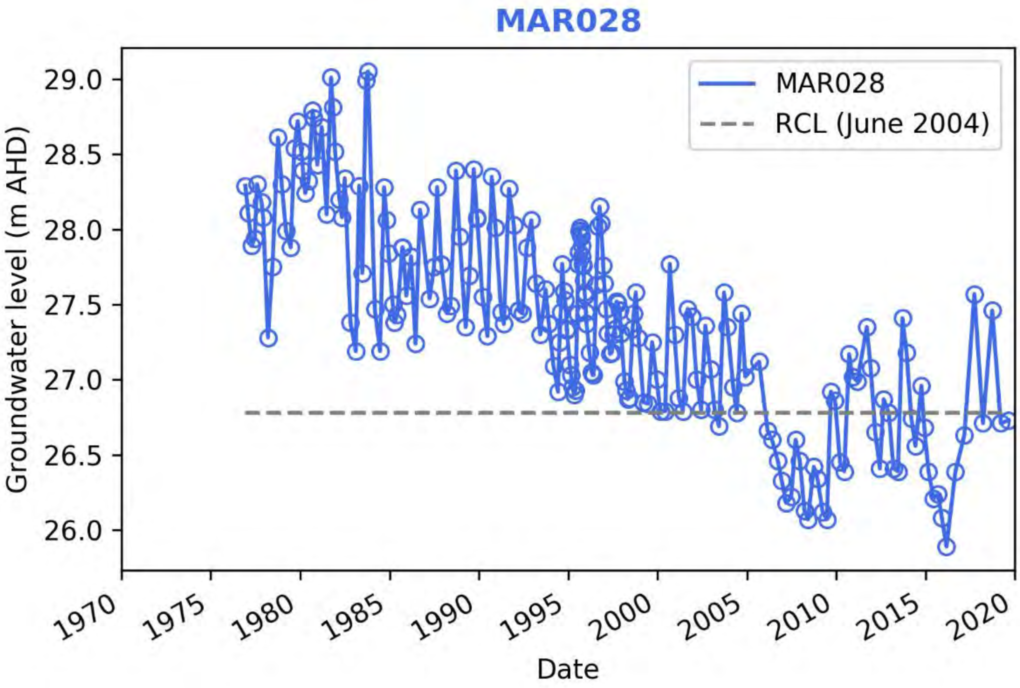

MAR020
MAR020
RCL (June 2004)
Groundwater level (m AHD)
33.5
33.0
32.5
32.0
31.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

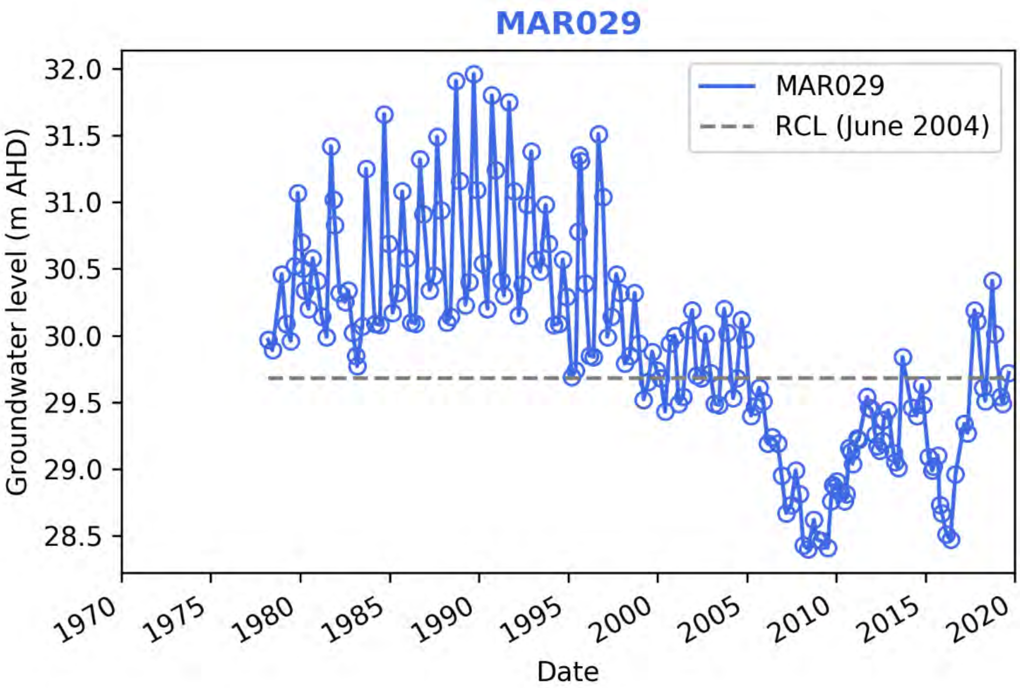

MAR022
MAR022
RCL (June 2004)
Groundwater level (m AHD)
33.0
32.5
32.0
31.5
31.0
30.5
30.0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

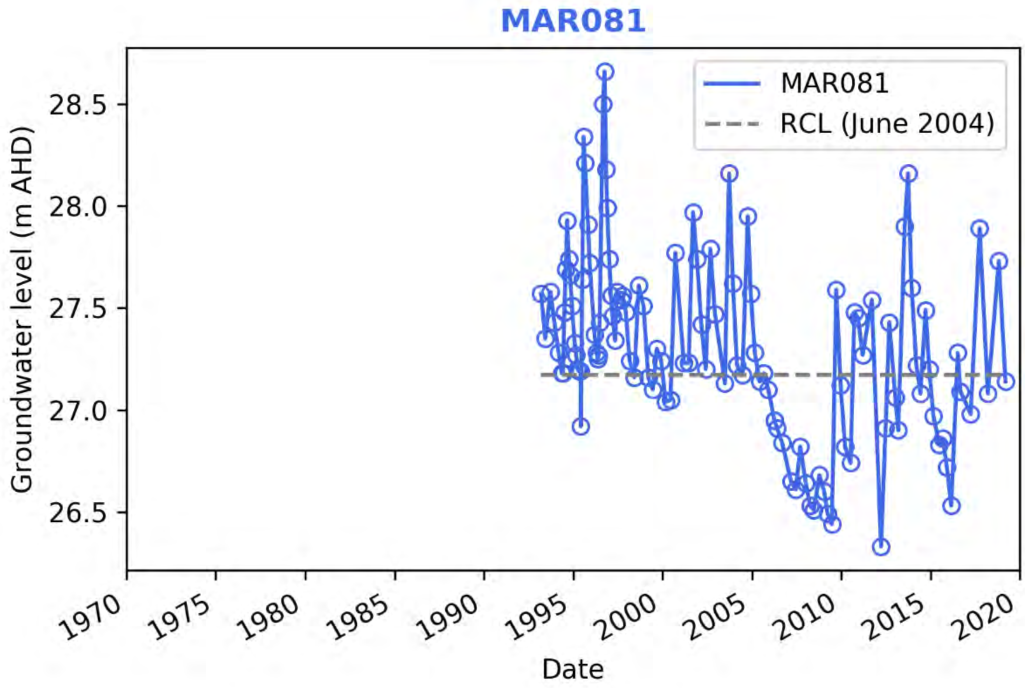

MAR023
MAR023
RCL (June 2004)
Groundwater level (m AHD)
32.0
31.5
31.0
30.5
30.0
29.5
29.0
28.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

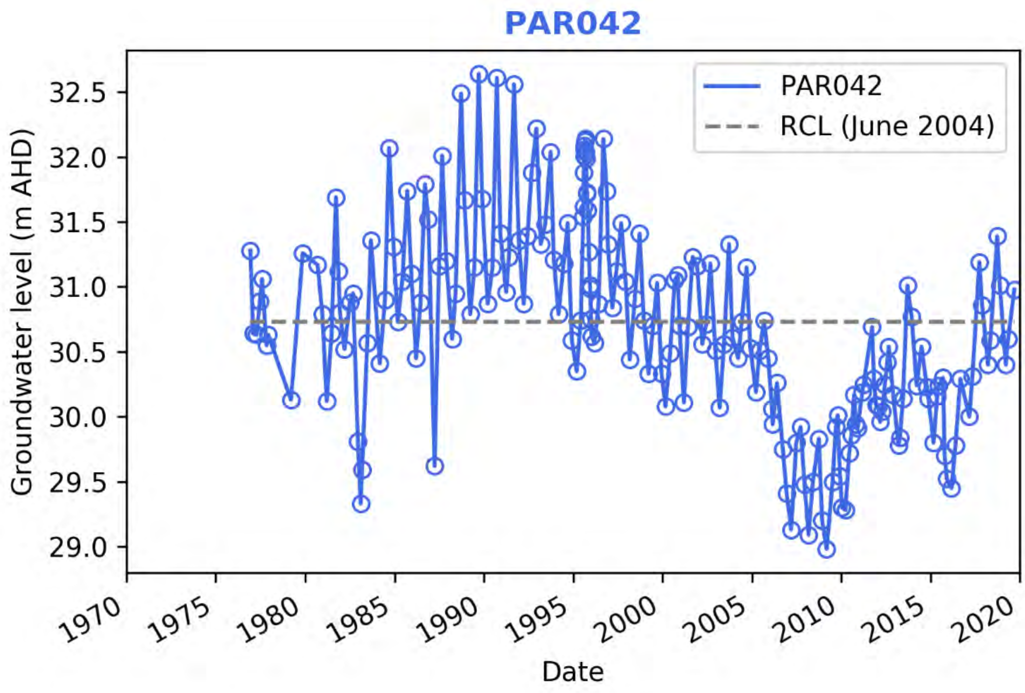

MAR024
MAR024
RCL (June 2004)
Groundwater level (m AHD)
30.0
29.5
29.0
28.5
28.0
27.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

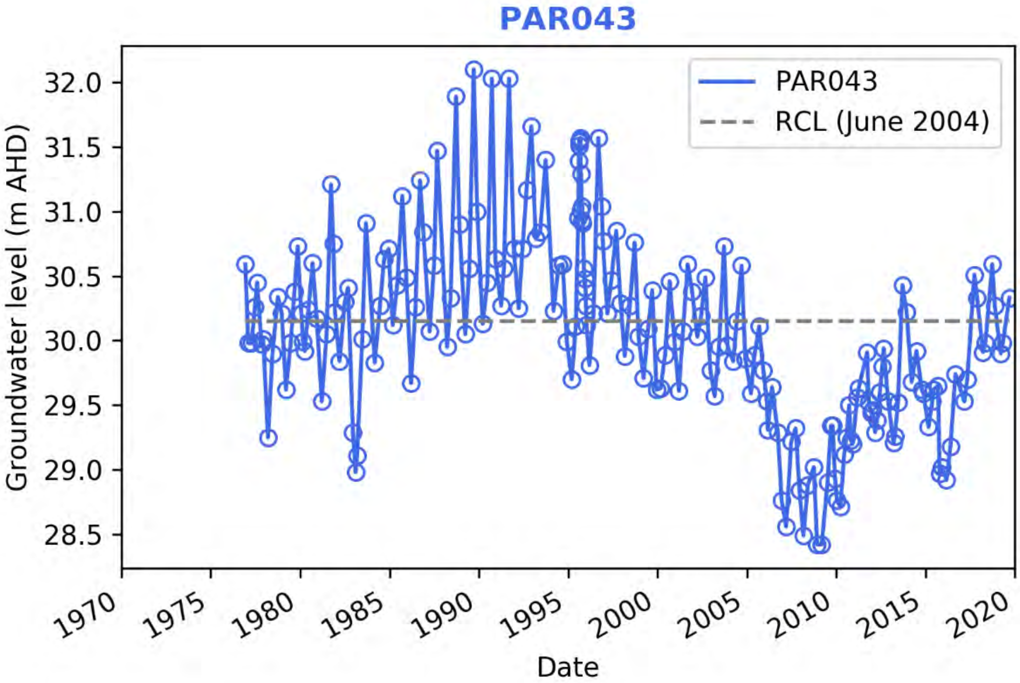

MAR026
MAR026
RCL (June 2004)
Groundwater level (m AHD)
29.5
29.0
28.5
28.0
27.5
27.0
26.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date


MAR028
MAR028
RCL (June 2004)
Groundwater level (m AHD)
29.0
28.5
28.0
27.5
27.0
26.5
26.0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

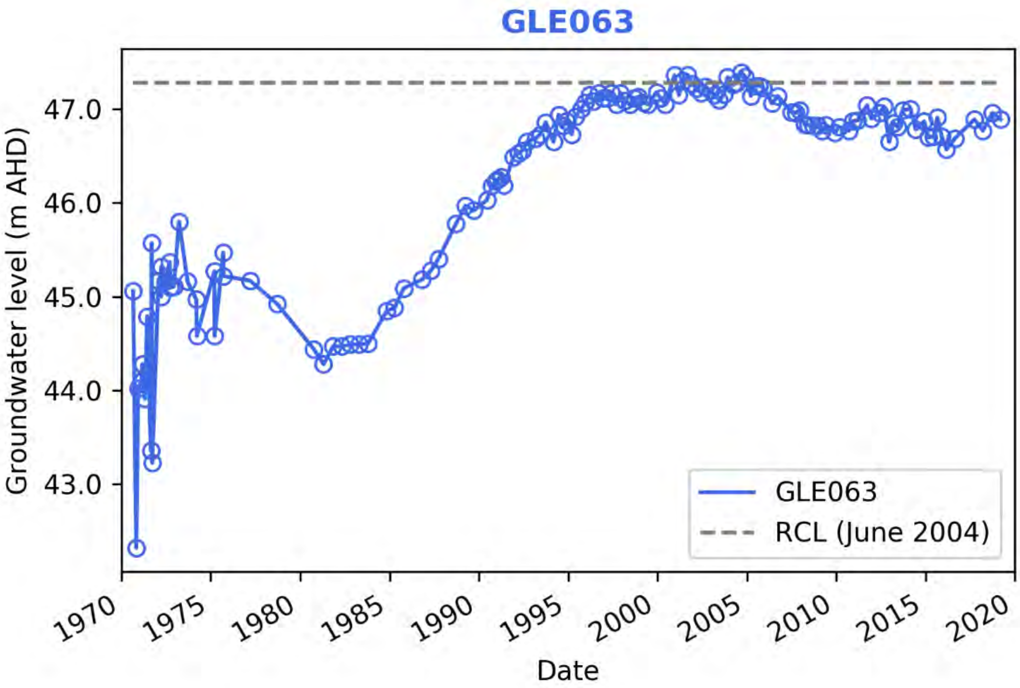

MAR029
MAR029
RCL (June 2004)
Groundwater level (m AHD)
32.0
31.5
31.0
30.5
30.0
29.5
29.0
28.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

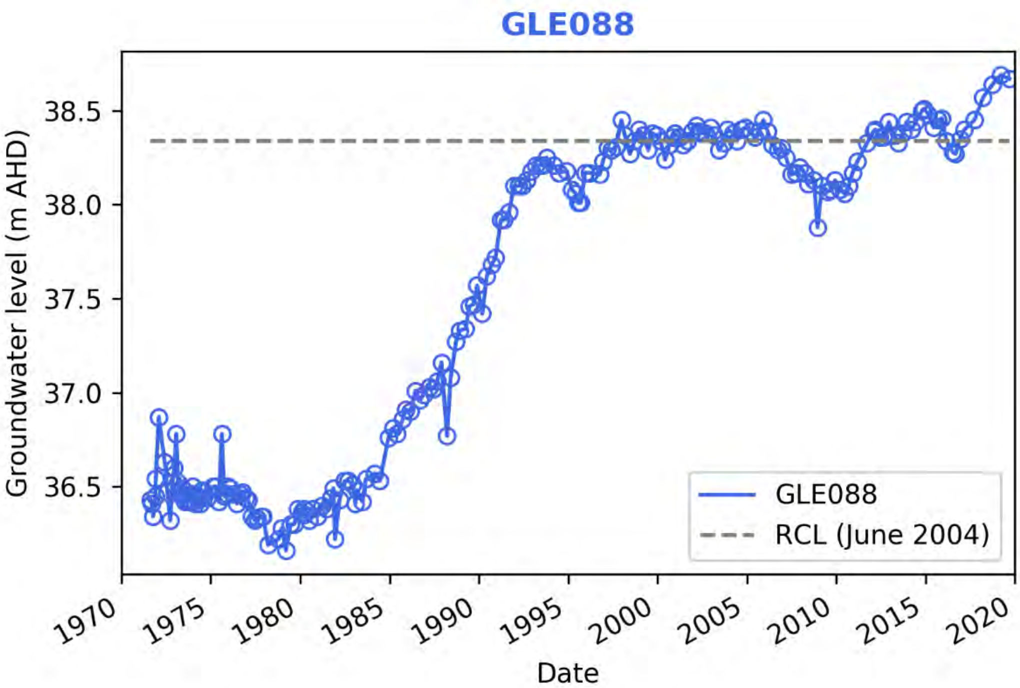

MAR081
MAR081
RCL (June 2004)
Groundwater level (m AHD)
28.5
28.0
27.5
27.0
26.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

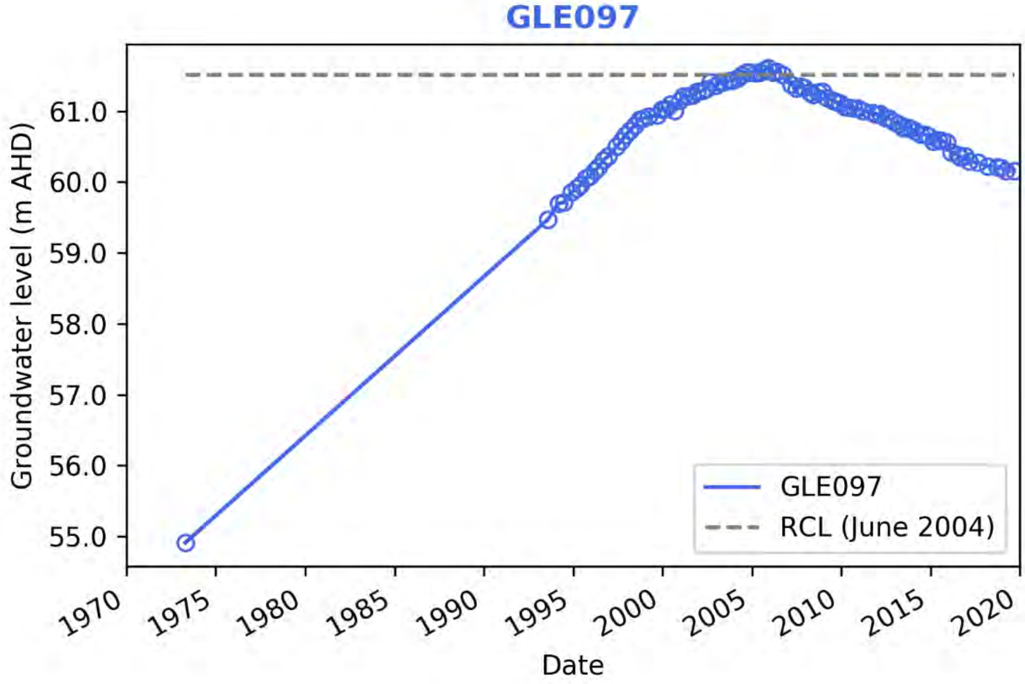

PAR042
PAR042
RCL (June 2004)
Groundwater level (m AHD)
32.5
32.0
31.5
31.0
30.5
30.0
29.5
29.0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

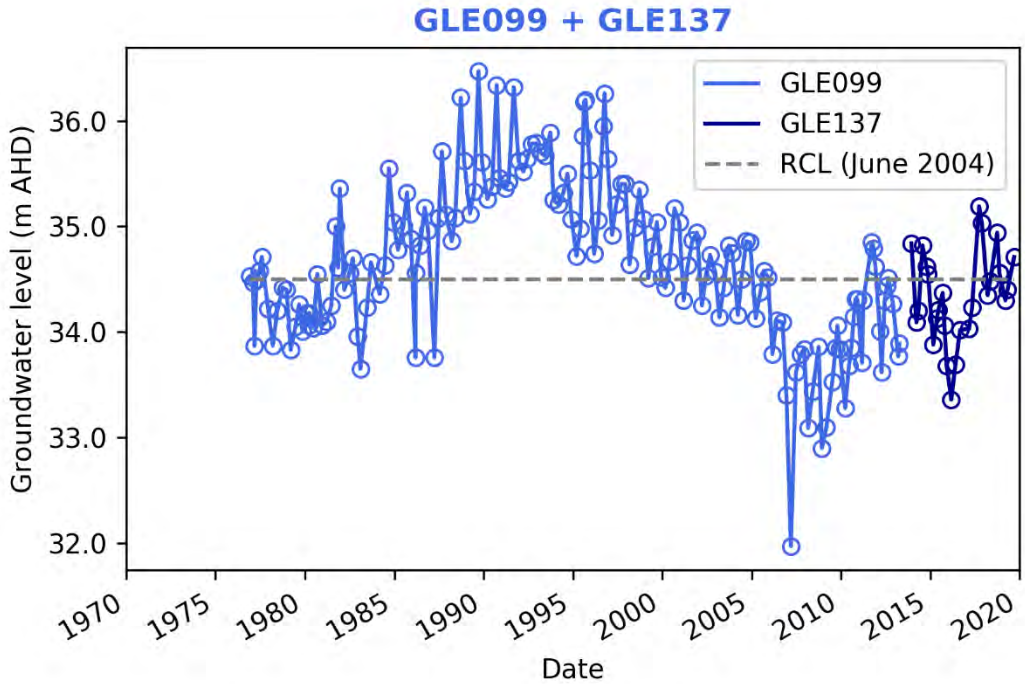

PAR043
PAR043
RCL (June 2004)
Groundwater level (m AHD)
32.0
31.5
31.0
30.5
30.0
29.5
29.0
28.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

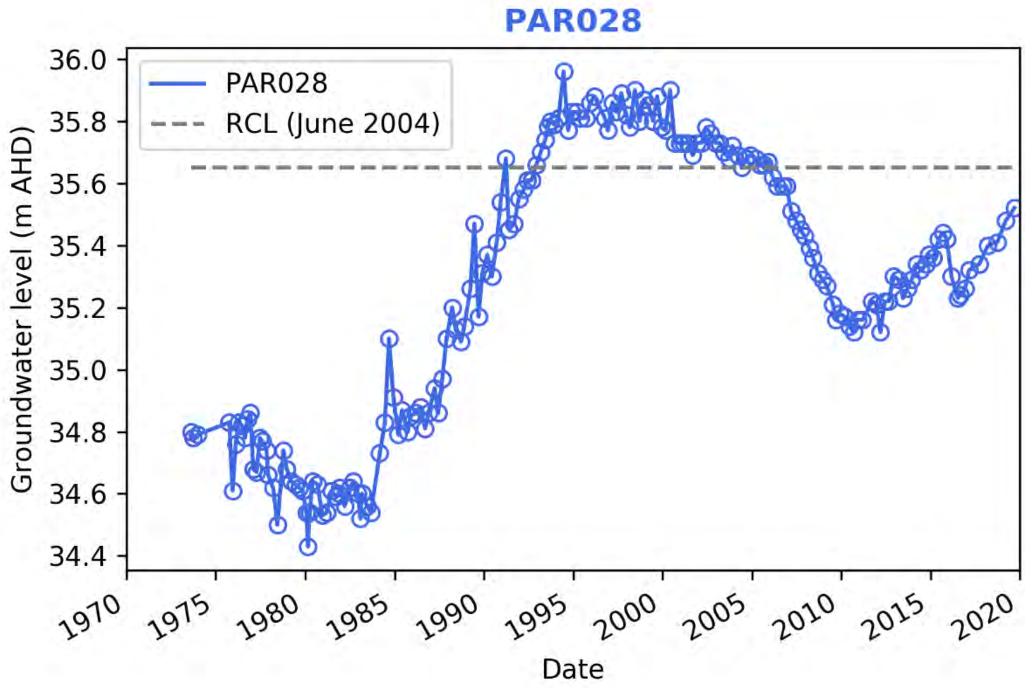
B. Groundwater levels in the Padthaway Ranges

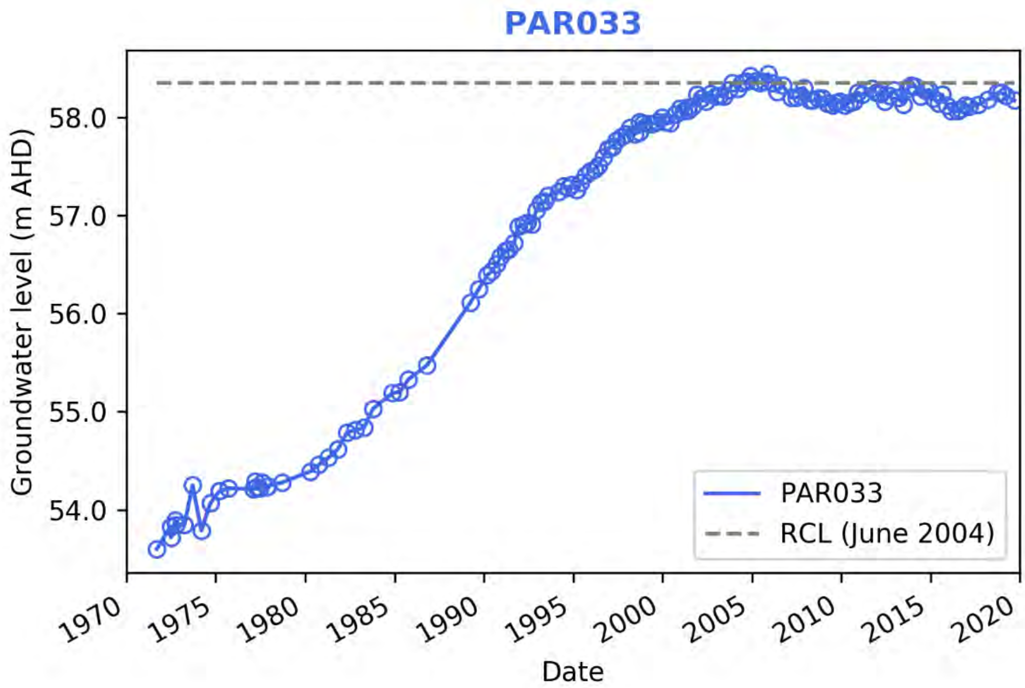


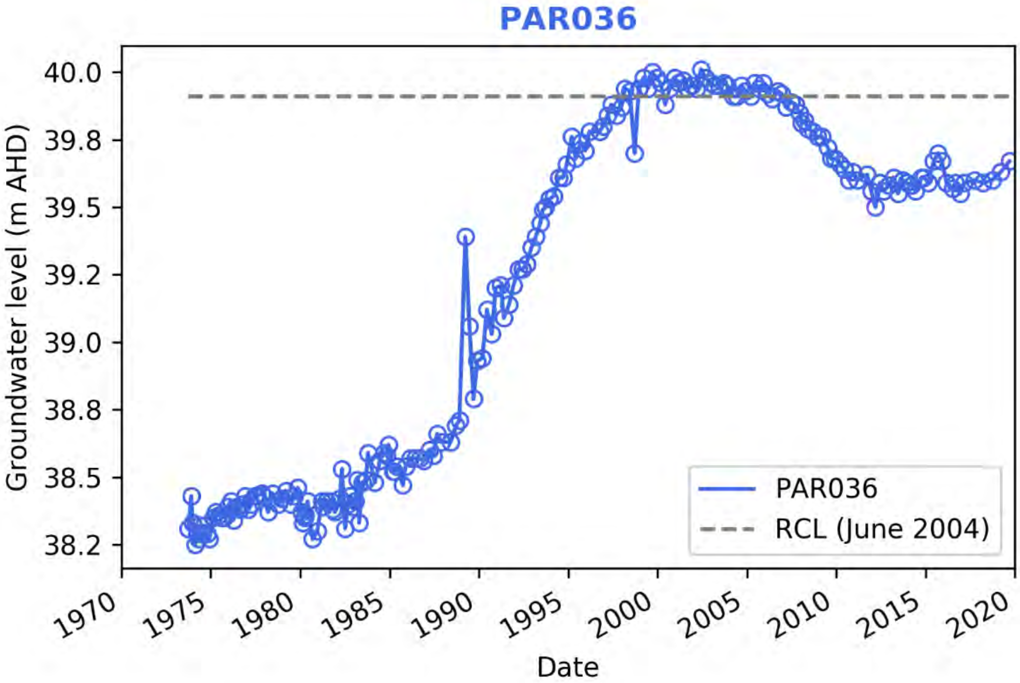


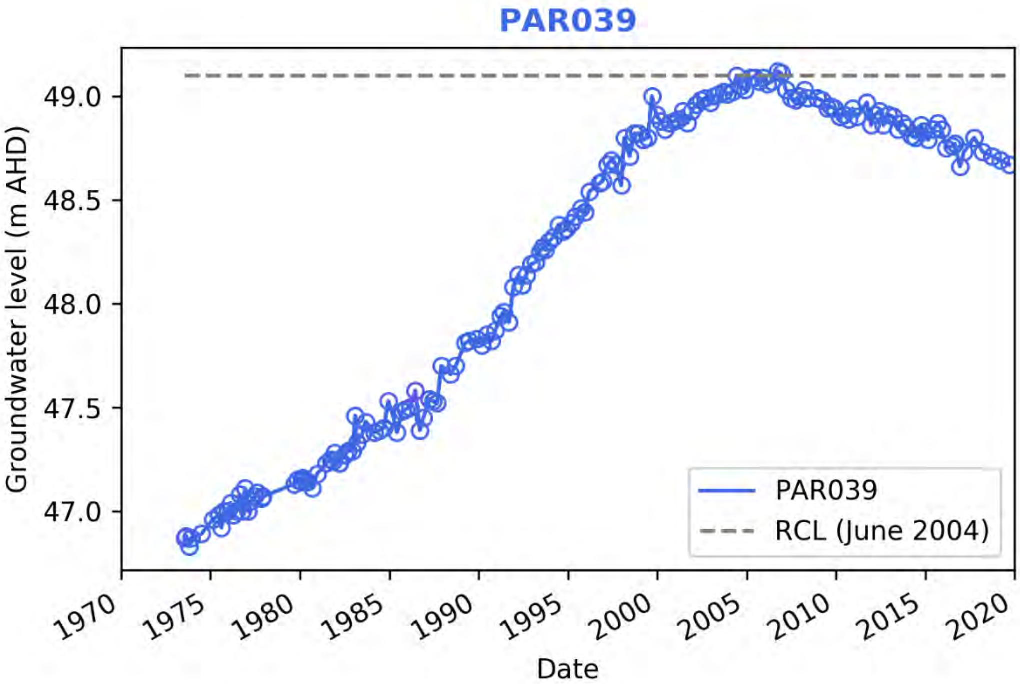

GLE097
Groundwater level (m AHD)
61.0
60.0
59.0
58.0
57.0
56.0
55.0
GLE097
RCL (June 2004)
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

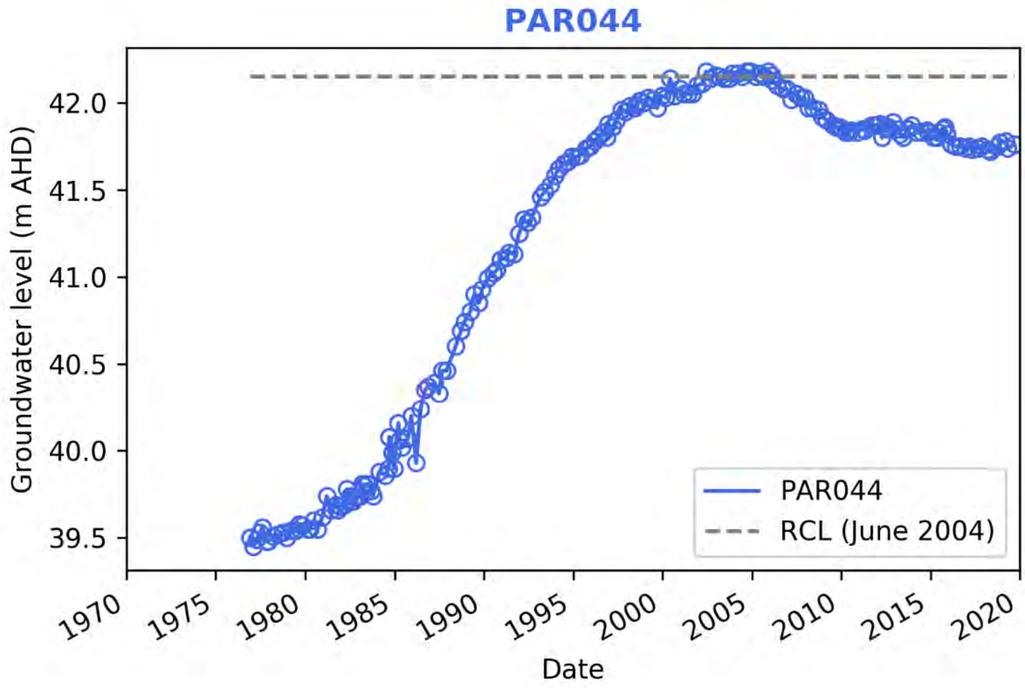

GLE099 + GLE137
Groundwater level (m AHD)
36.0
35.0
34.0
33.0
32.0
GLE099
GLE137
RCL (June 2004)
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date


PAR028
PAR028
RCL (June 2004)
36.0
35.8
35.6
35.4
35.2
35.0
34.8
34.6
34.4
Groundwater level (m AHD)
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

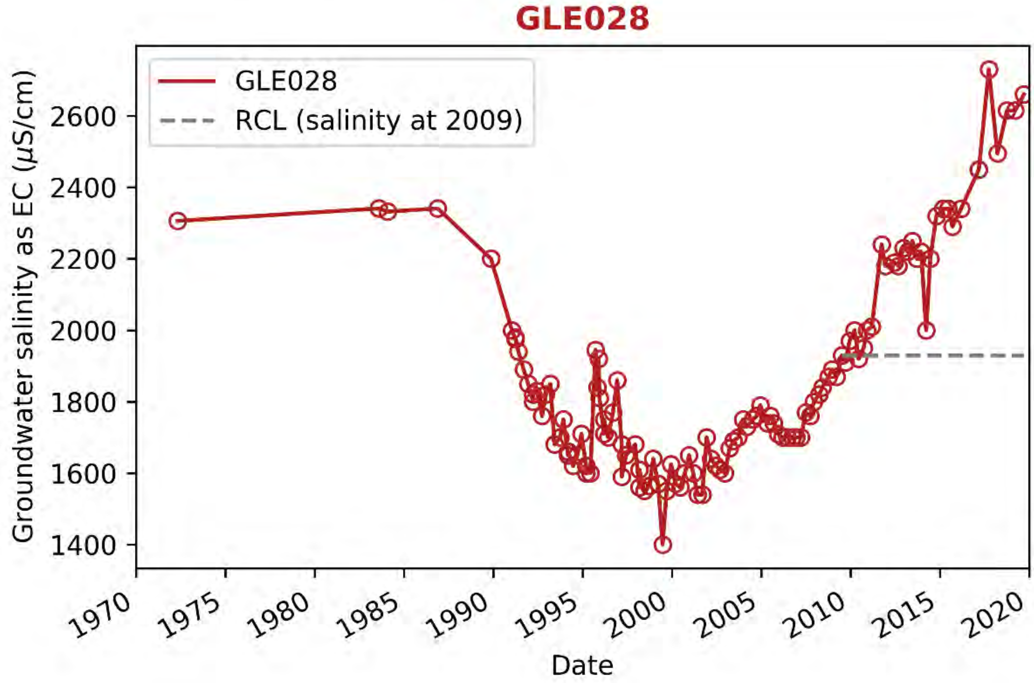

PAR033
PAR033
RCL (June 2004)
58.0
57.0
56.0
55.0
54.0
Groundwater level (m AHD)
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

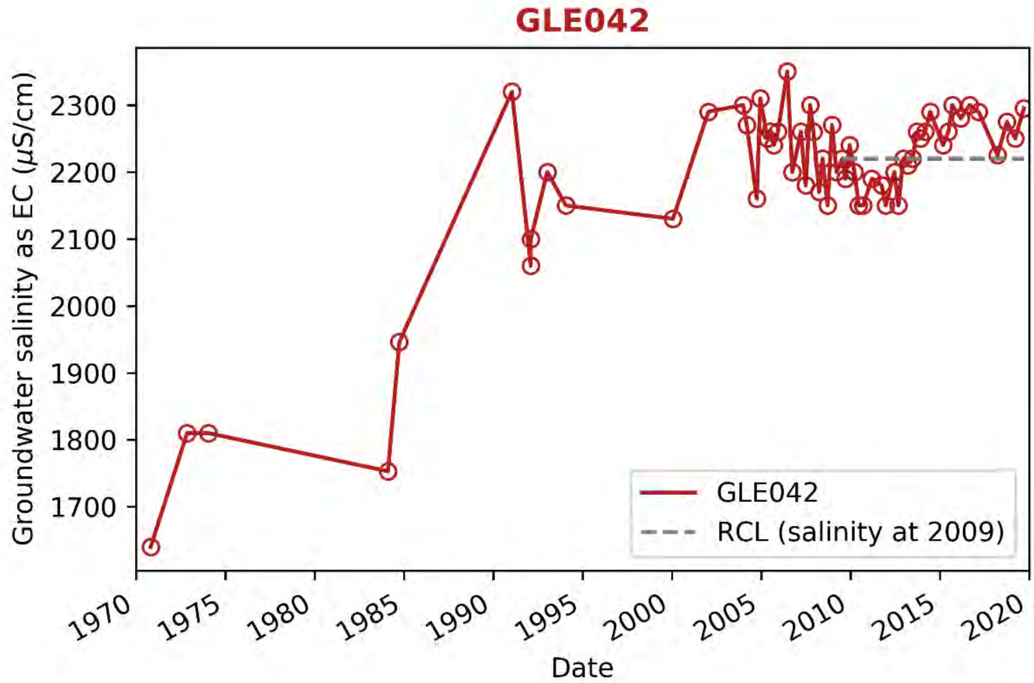

PAR036
40.0
39.8
39.5
39.2
39.0
38.8
38.5
38.2
Groundwater level (m AHD)
PAR036
RCL (June 2004)
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

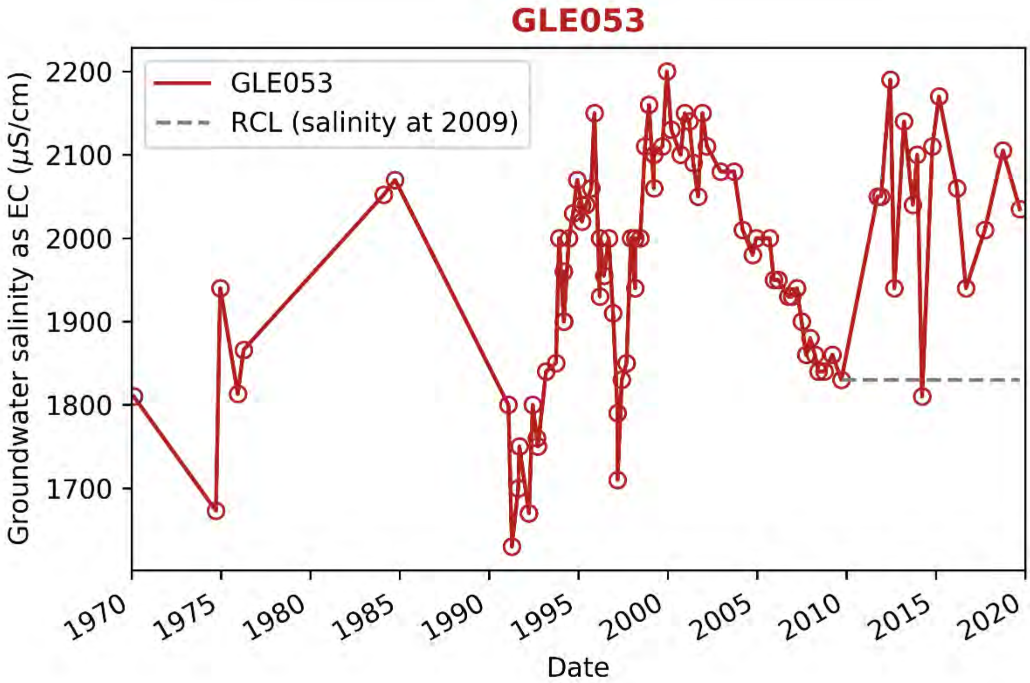

PAR039
49.0
48.5
48.0
47.5
47.0
Groundwater level (m AHD)
PAR039
RCL (June 2004)
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

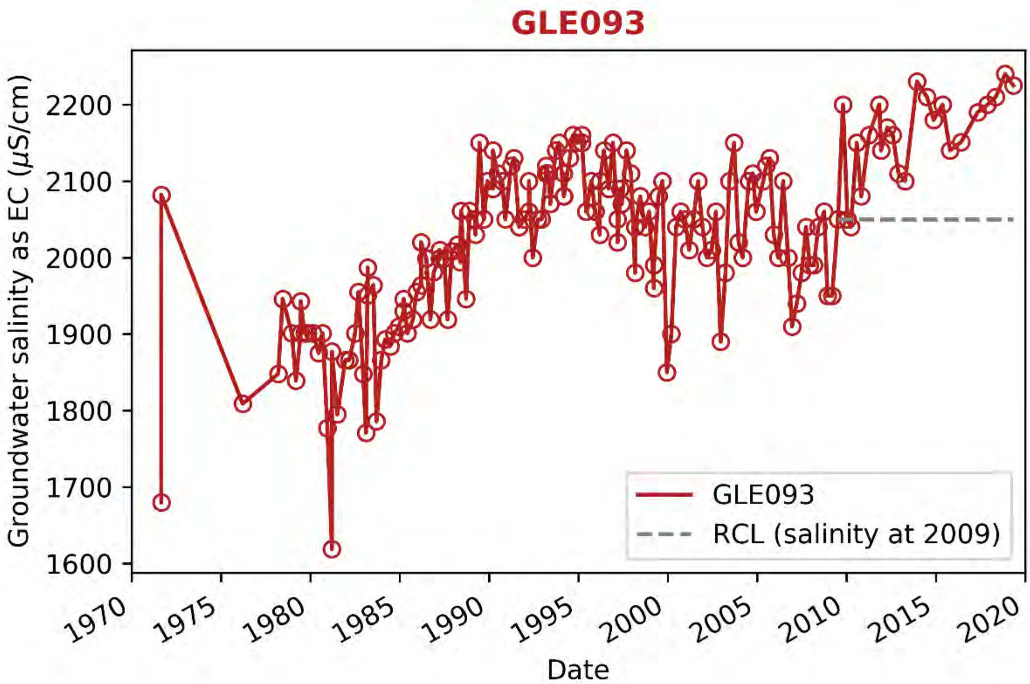

PAR044
Groundwater level (m AHD)
42.0
41.5
41.0
40.5
40.0
39.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date
PAR044
RCL (June 2004)

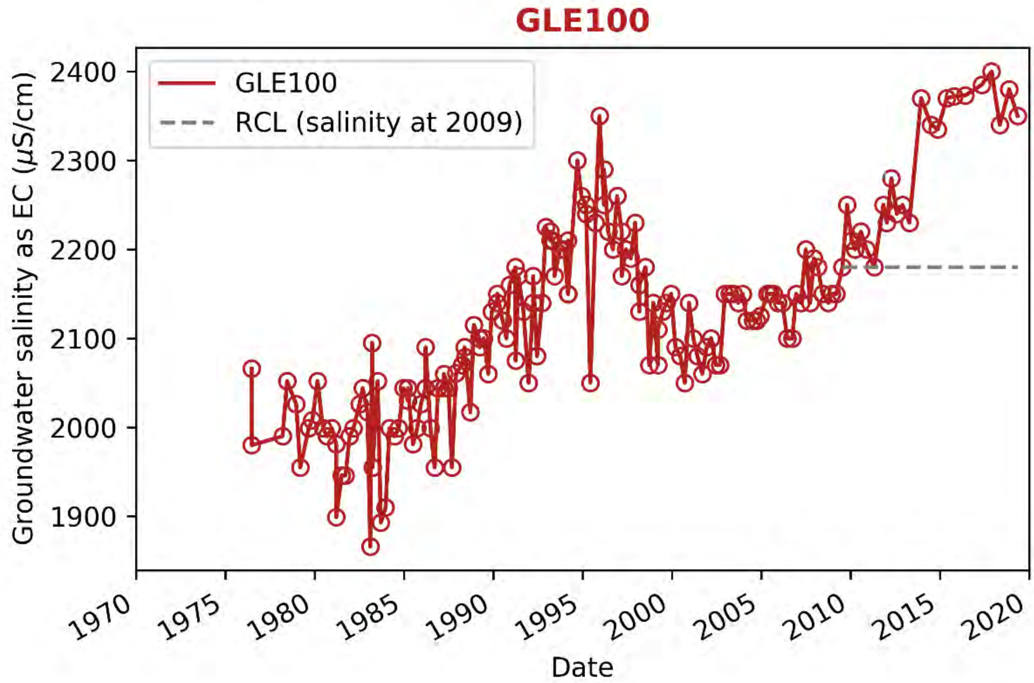
C. Groundwater salinity in the Padthaway PWA

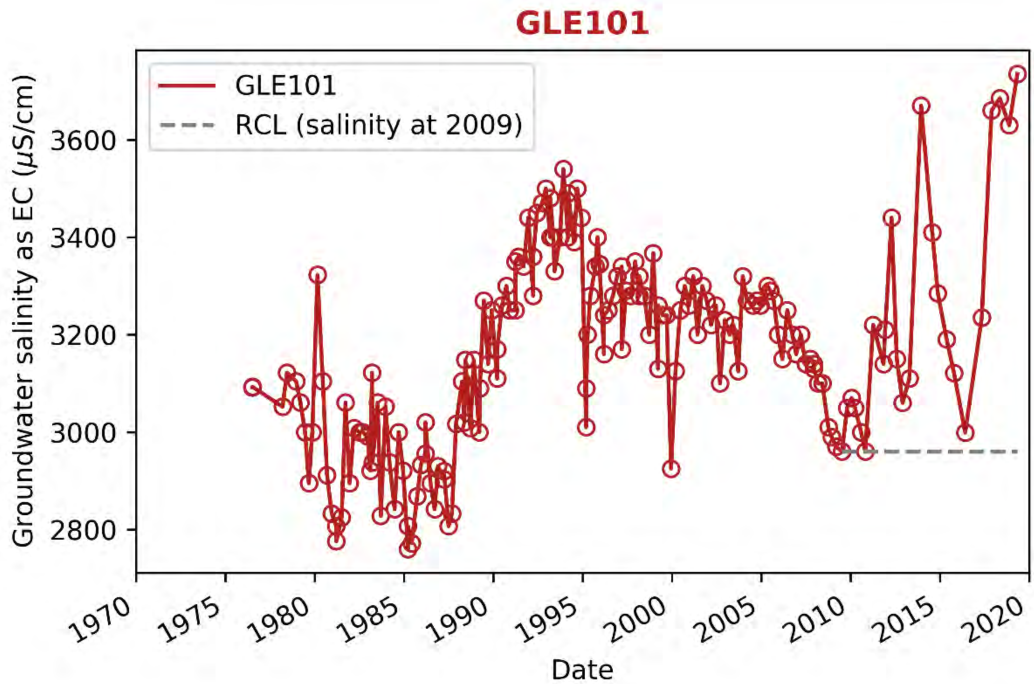


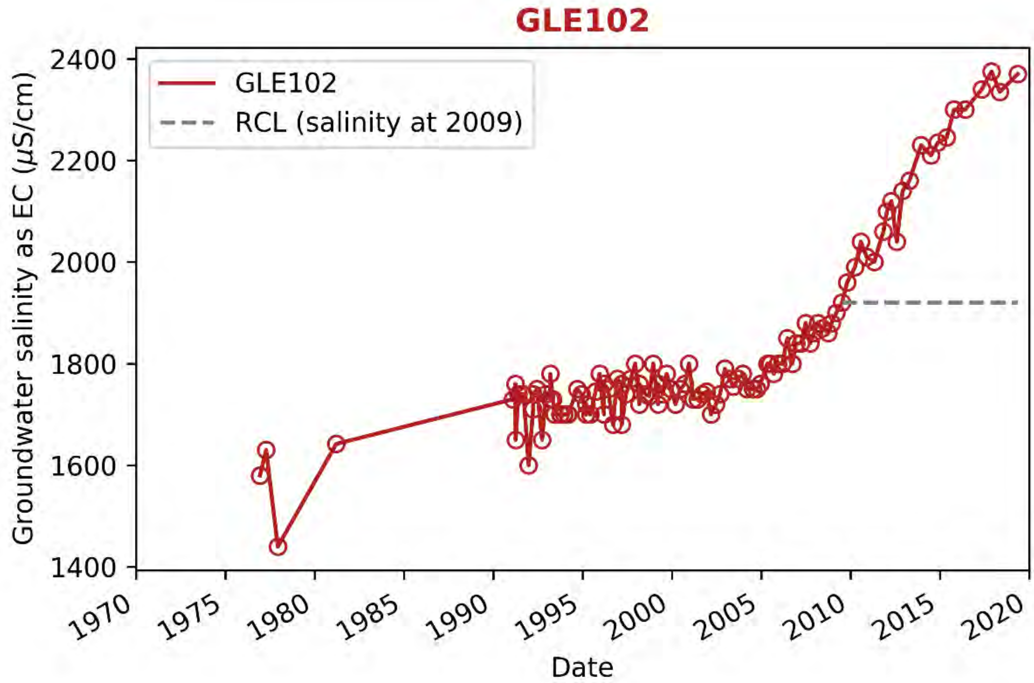


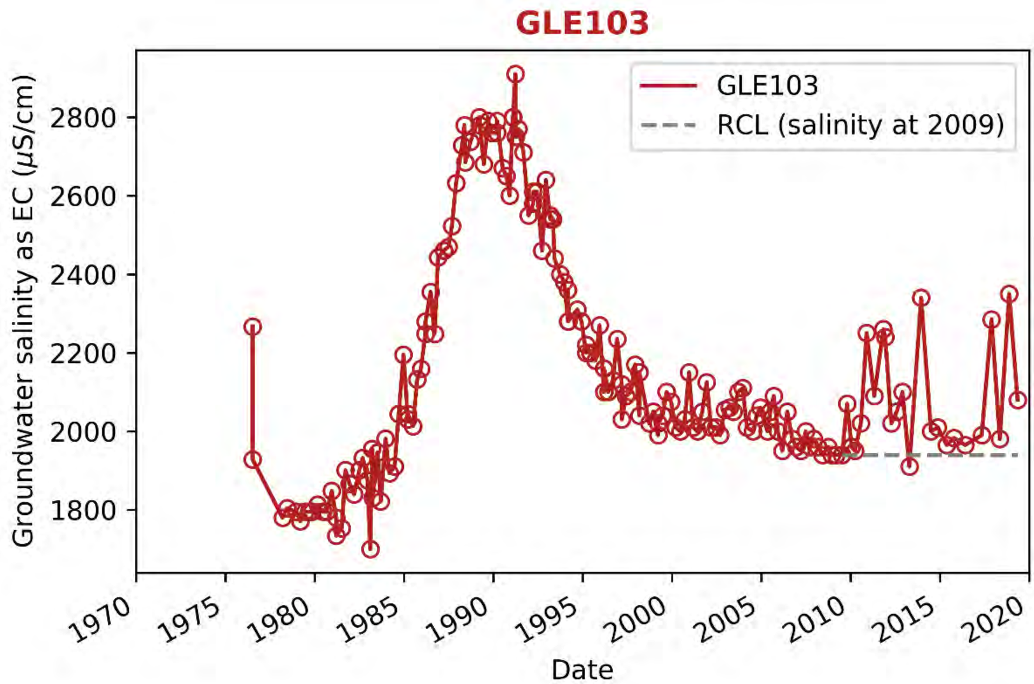

GLE053
GLE053
RCL (salinity at 2009)
Groundwater salinity as EC (µS/cm)
2200
2100
2000
1900
1800
1700
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

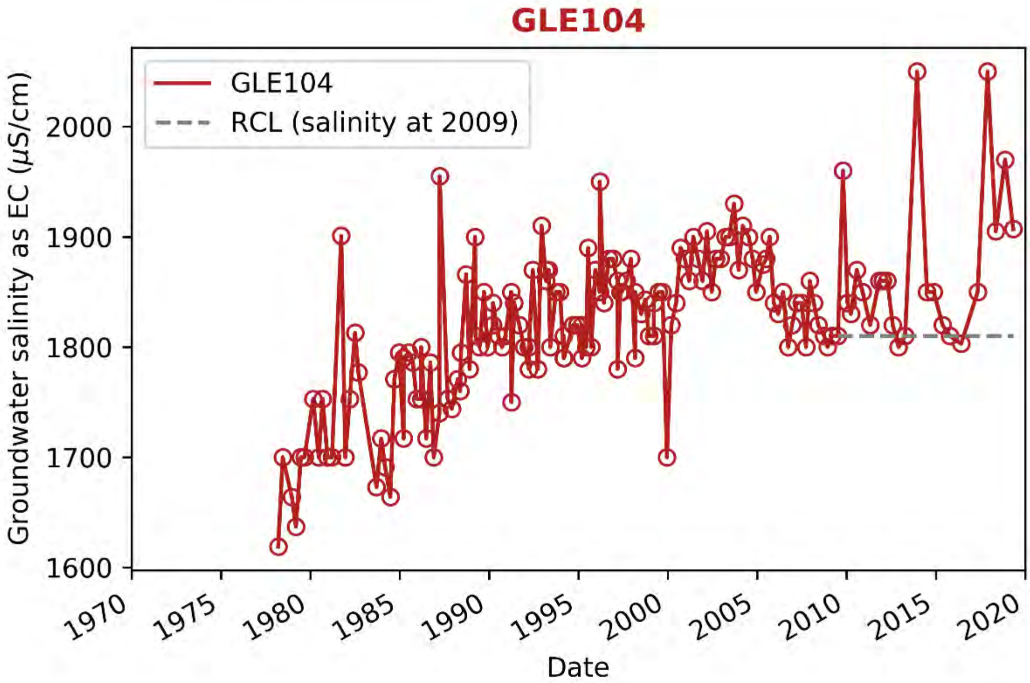

GLE093
GLE093
RCL (salinity at 2009)
Groundwater salinity as EC (µS/cm)
2200
2100
2000
1900
1800
1700
1600
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

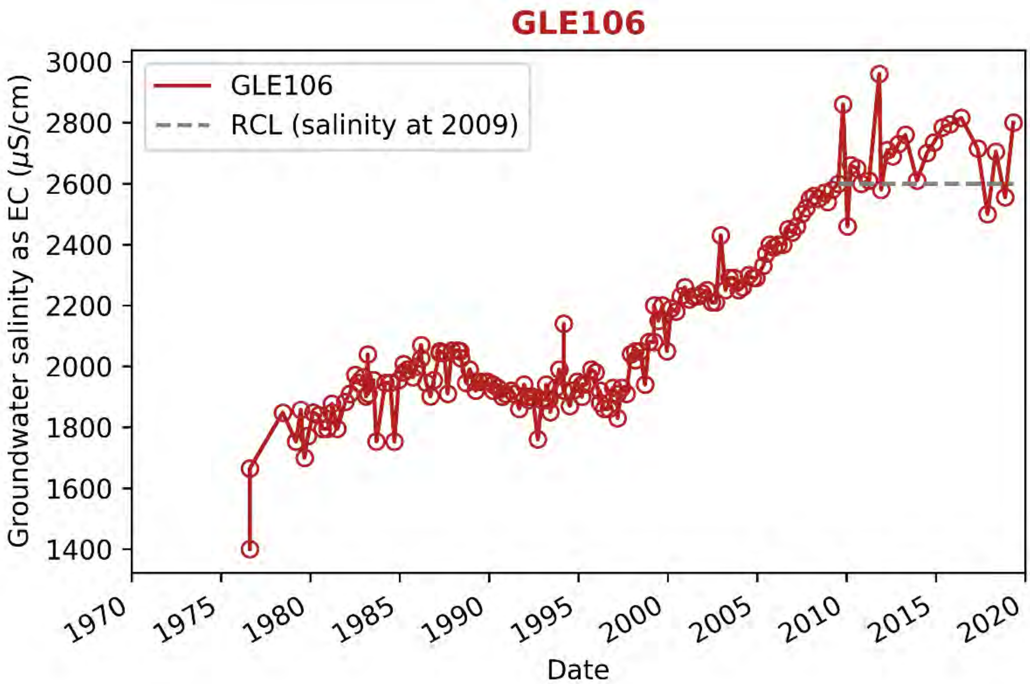

GLE100
GLE100
RCL (salinity at 2009)
Groundwater salinity as EC (µS/cm)
2400
2300
2200
2100
2000
1900
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

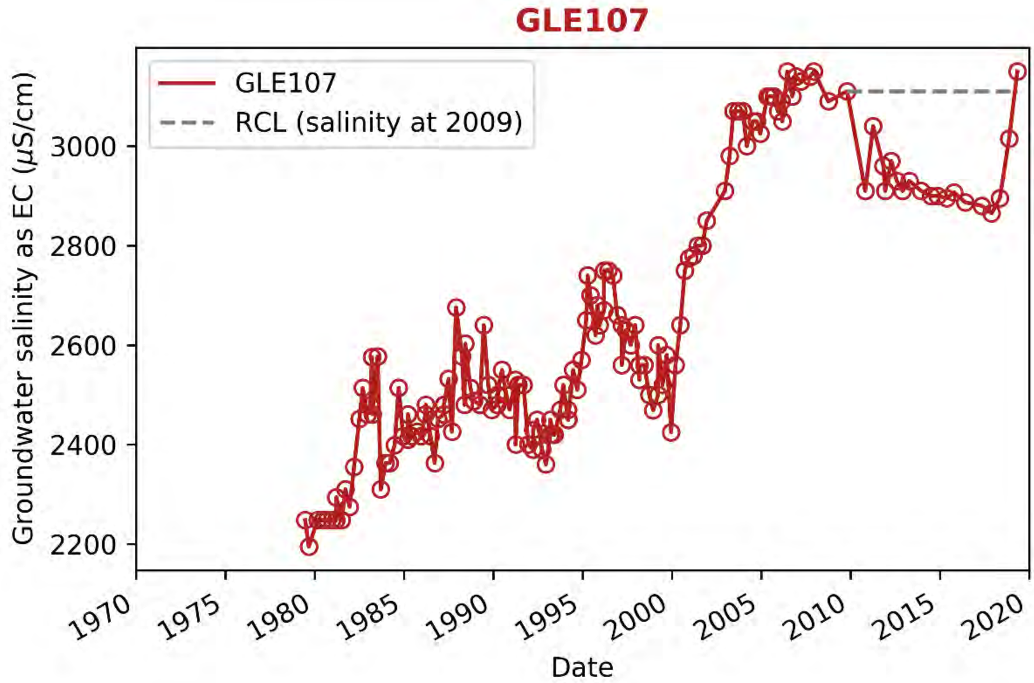

GLE101
GLE101
RCL (salinity at 2009)
Groundwater salinity as EC (µS/cm)
3600
3400
3200
3000
2800
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

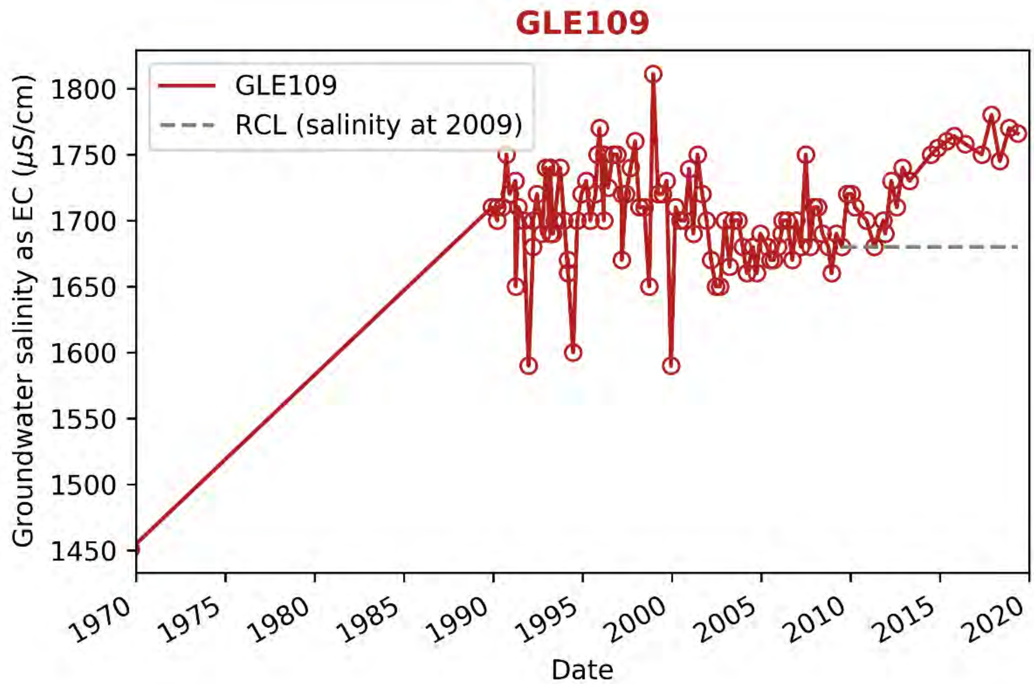

GLE102
GLE102
RCL (salinity at 2009)
Groundwater salinity as EC (µS/cm)
2400
2200
2000
1800
1600
1400
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

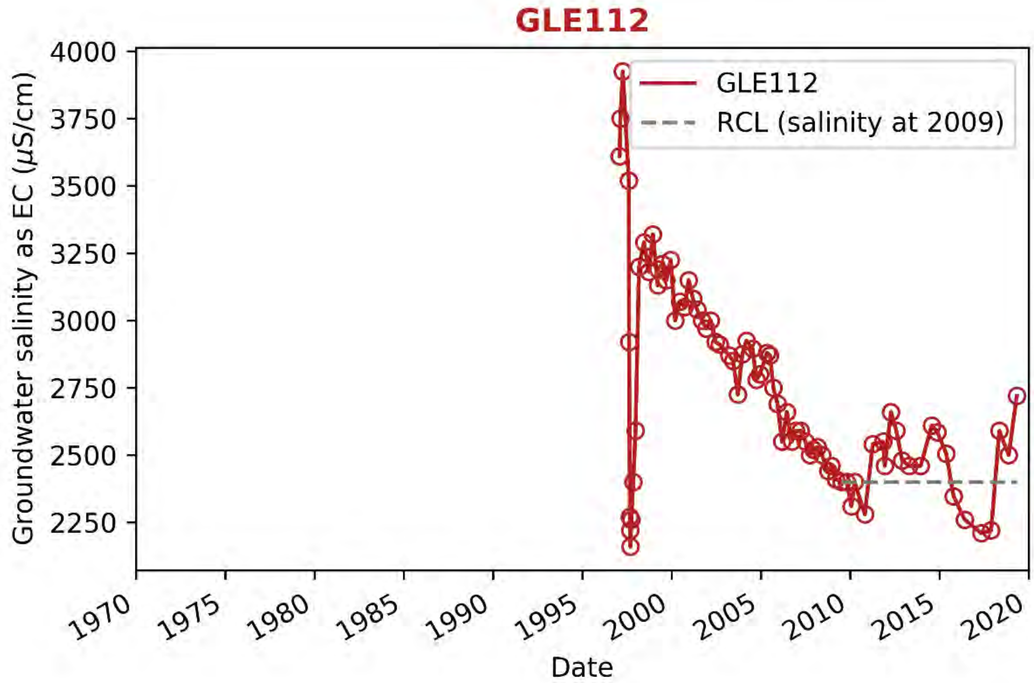

GLE103
GLE103
RCL (salinity at 2009)
Groundwater salinity as EC (µS/cm)
2800
2600
2400
2200
2000
1800
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

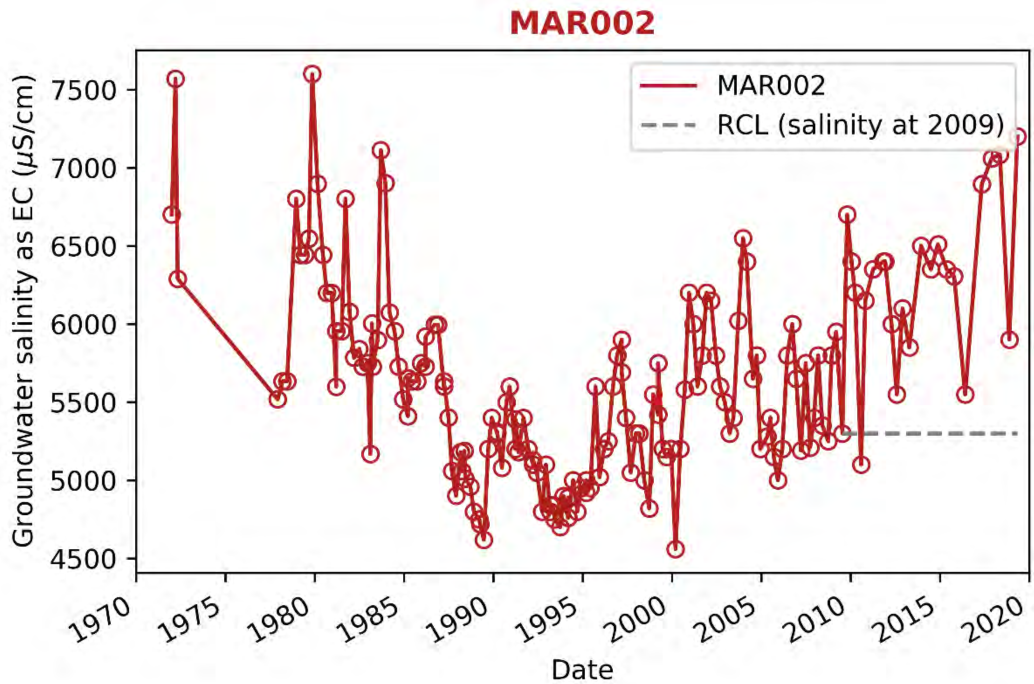

GLE104
GLE104
RCL (salinity at 2009)
Groundwater salinity as EC (µS/cm)
1600
1700
1800
1900
2000
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

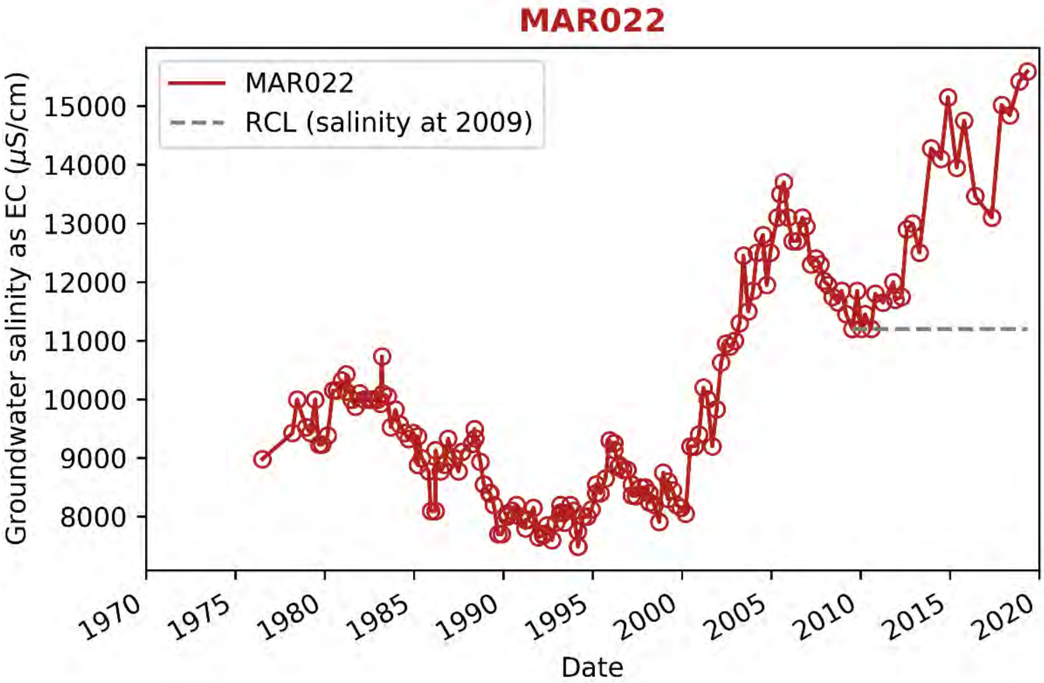

GLE106
GLE106
RCL (salinity at 2009)
Groundwater salinity as EC (µS/cm)
1400
1600
1800
2000
2200
2400
2600
2800
3000
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date


GLE107
GLE107
RCL (salinity at 2009)
Groundwater salinity as EC (µS/cm)
3000
2800
2600
2400
2200
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

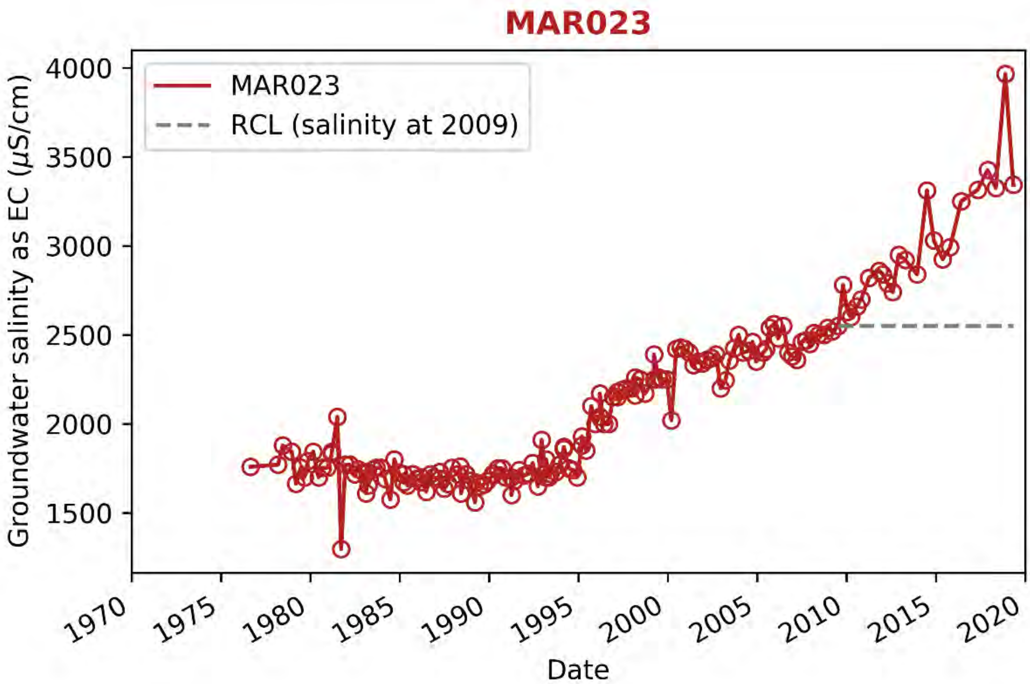

GLE109
GLE109
RCL (salinity at 2009)
Groundwater salinity as EC (µS/cm)
1800
1750
1700
1650
1600
1550
1500
1450
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date


GLE112
GLE112
RCL (salinity at 2009)
Groundwater salinity as EC (μS/cm)
4000
3750
3500
3250
3000
2750
2500
2250
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

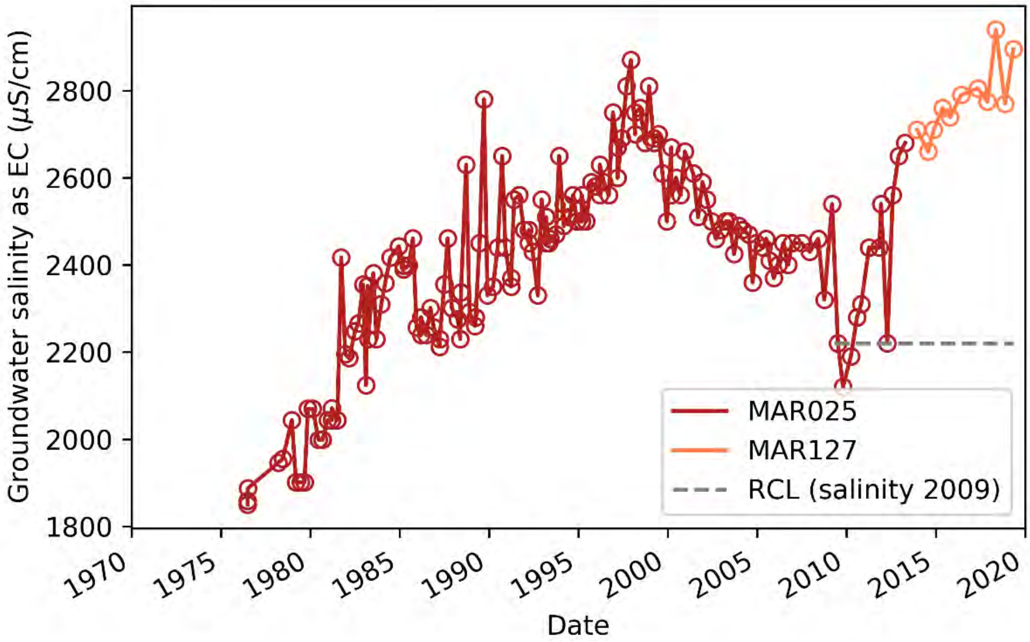

MAR002
MAR002
RCL (salinity at 2009)
Groundwater salinity as EC (μS/cm)
7500
7000
6500
6000
5500
5000
4500
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

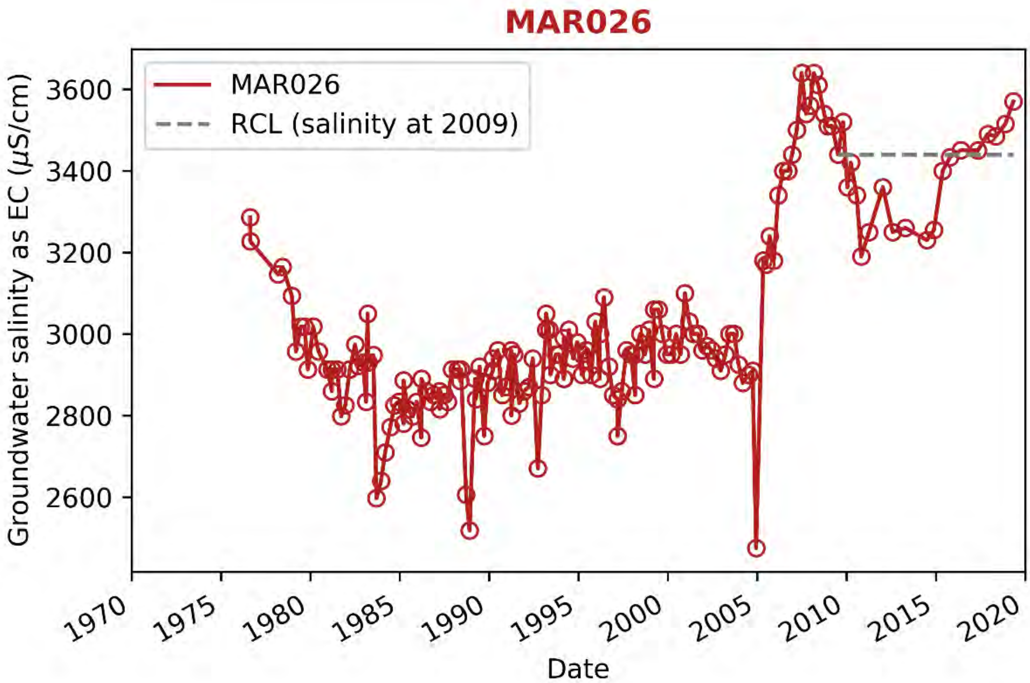


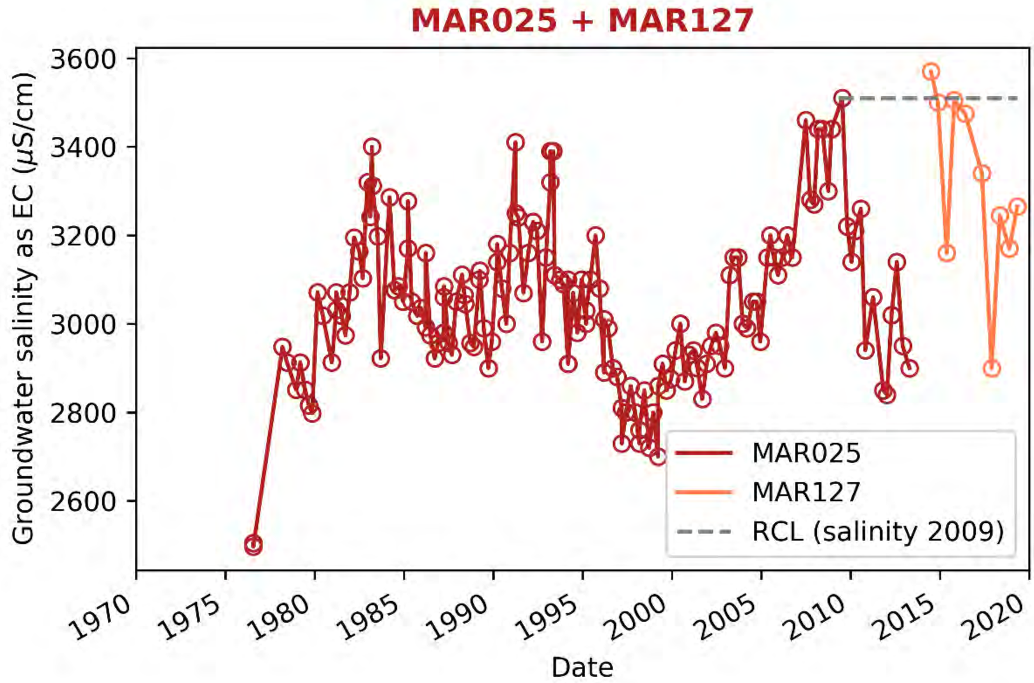
MAR022
MAR022
RCL (salinity at 2009)
Groundwater salinity as EC (μS/cm)
15000
14000
13000
12000
11000
10000
9000
8000
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

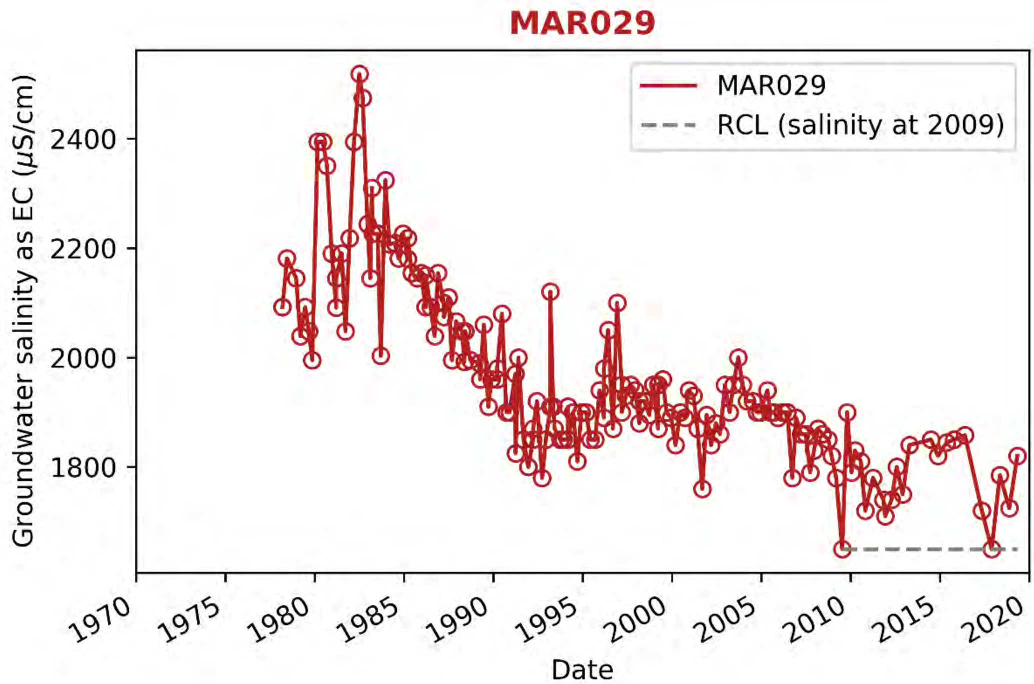


MAR023
MAR023
RCL (salinity at 2009)
Groundwater salinity as EC (μS/cm)
4000
3500
3000
2500
2000
1500
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

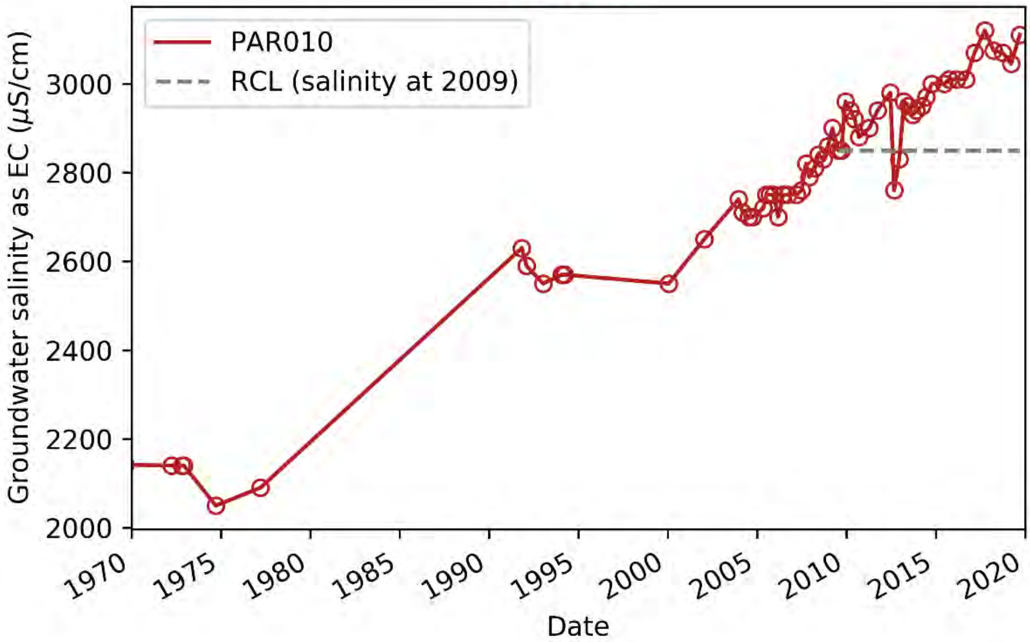

Groundwater salinity as EC (μS/cm)
1800
2000
2200
2400
2600
2800
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date
MAR025
MAR127
RCL (salinity 2009)


MAR026
Groundwater salinity as EC (μS/cm)
2600
2800
3000
3200
3400
3600
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date
MAR026
RCL (salinity at 2009)

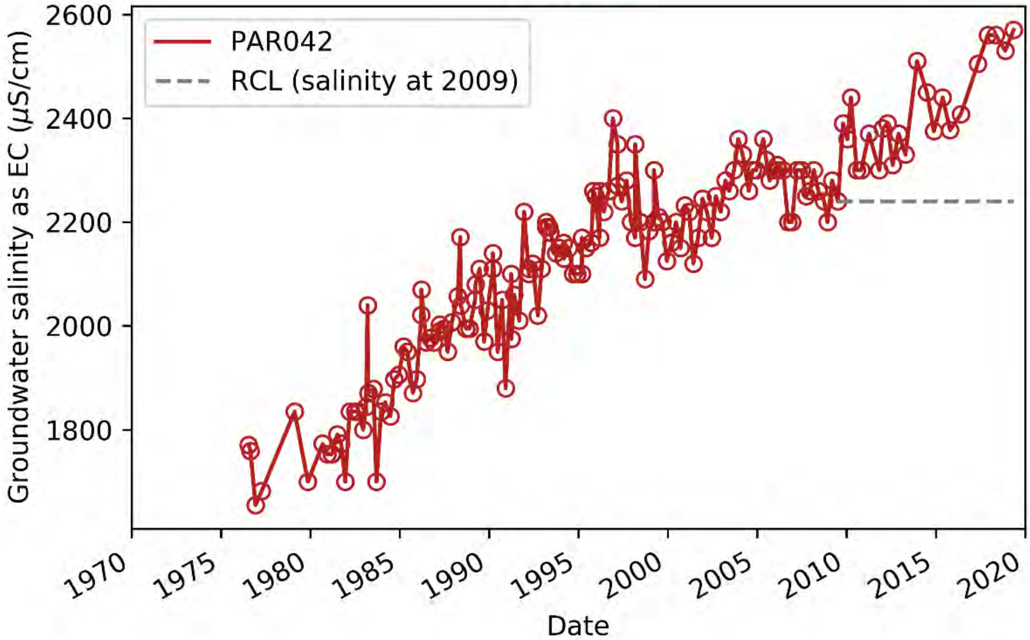

MAR025 + MAR127
Groundwater salinity as EC (µS/cm)
3600
3400
3200
3000
2800
2600
MAR025
MAR127
RCL (salinity 2009)
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

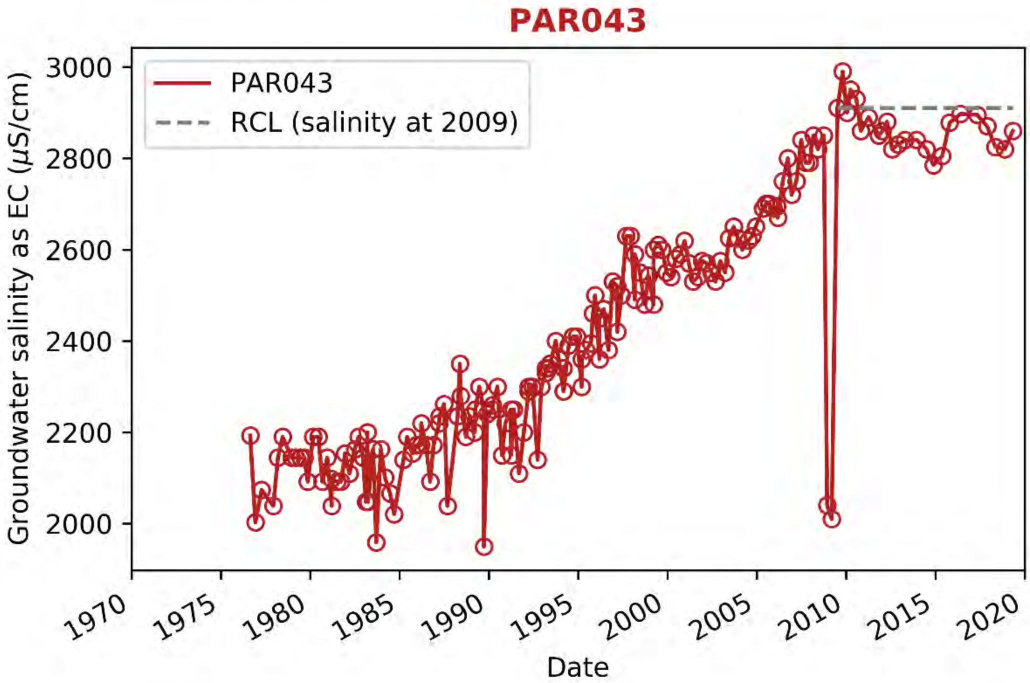

MAR029
Groundwater salinity as EC (µS/cm)
2400
2200
2000
1800
MAR029
RCL (salinity at 2009)
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

PAR010

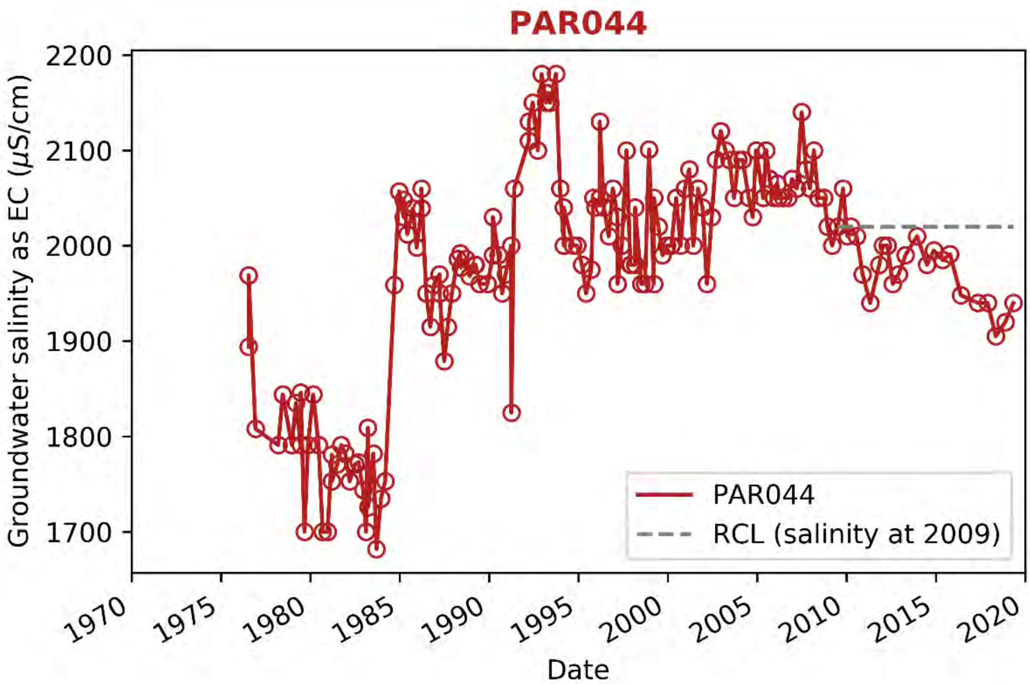


PAR042

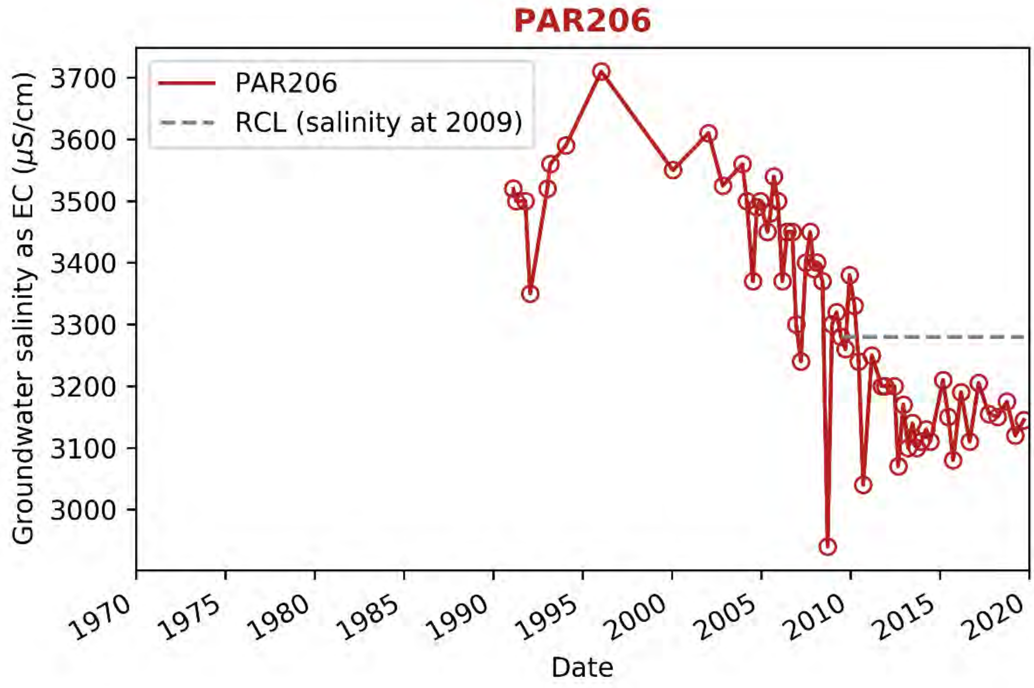




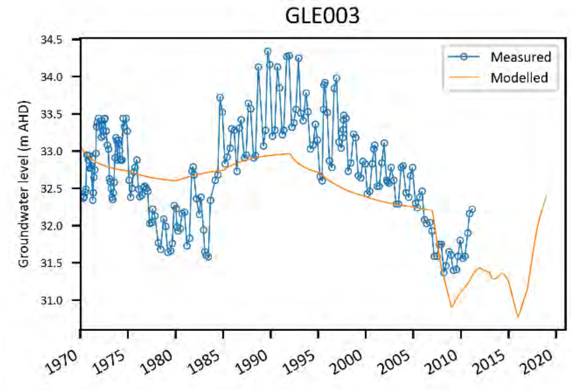
PAR043
PAR043
RCL (salinity at 2009)
Groundwater salinity as EC (µS/cm)
3000
2800
2600
2400
2200
2000
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

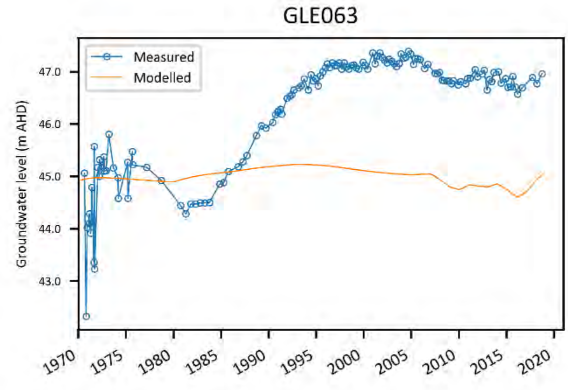


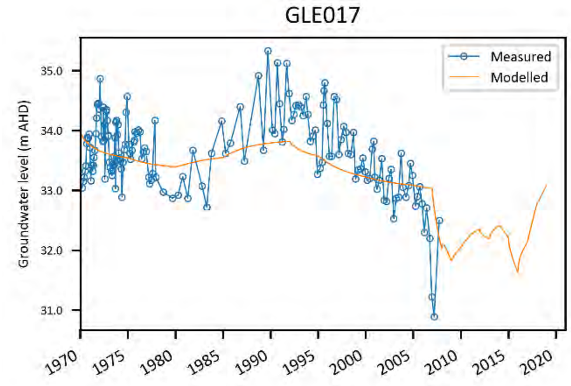
PAR044
PAR044
RCL (salinity at 2009)
Groundwater salinity as EC (µS/cm)
2200
2100
2000
1900
1800
1700
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

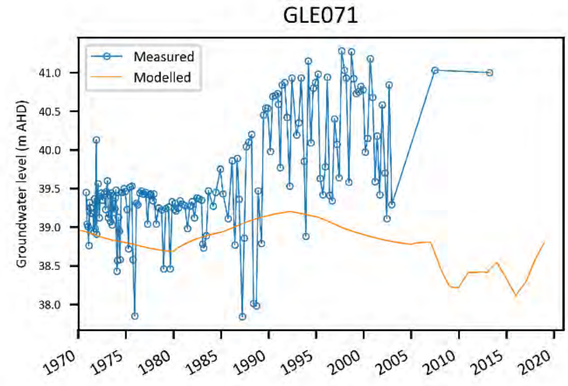

PAR206
PAR206
RCL (salinity at 2009)
Groundwater salinity as EC (µS/cm)
3700
3600
3500
3400
3300
3200
3100
3000
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

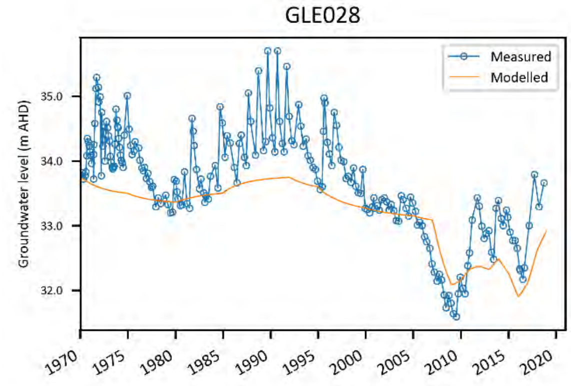
D. Measured and modelled groundwater levels

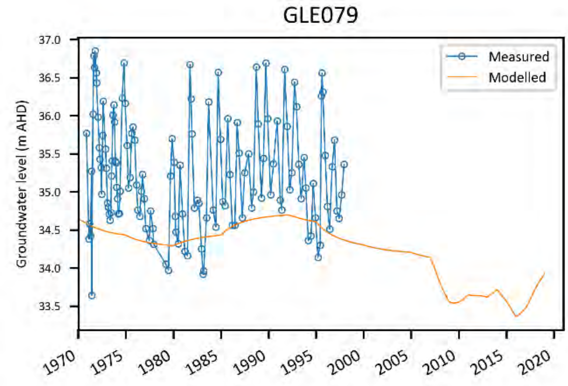


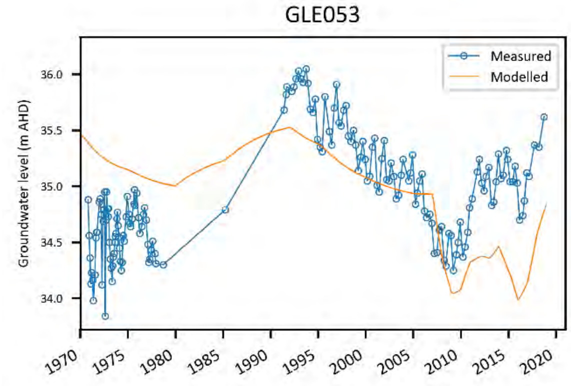


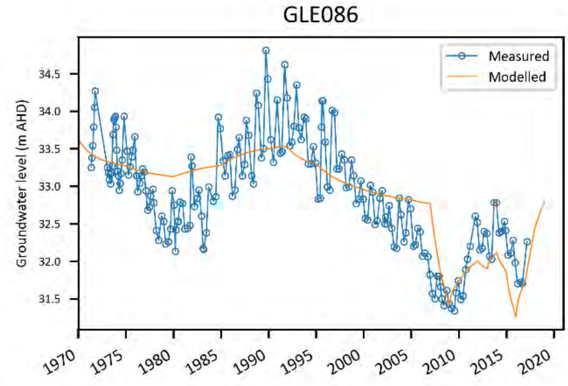


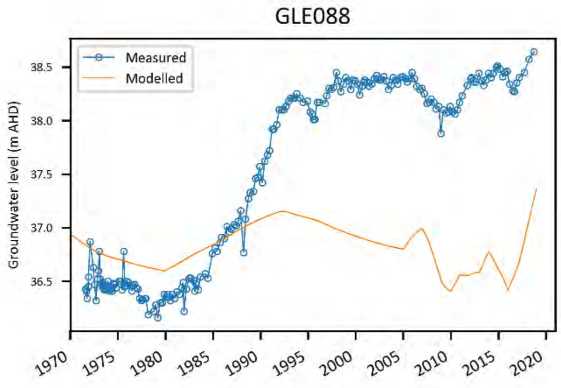


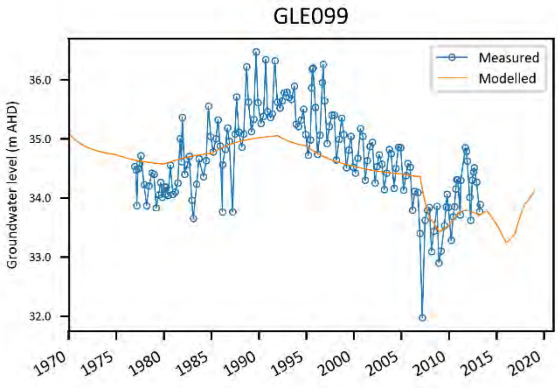


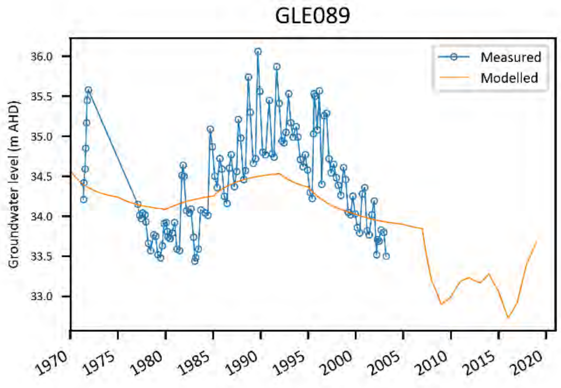


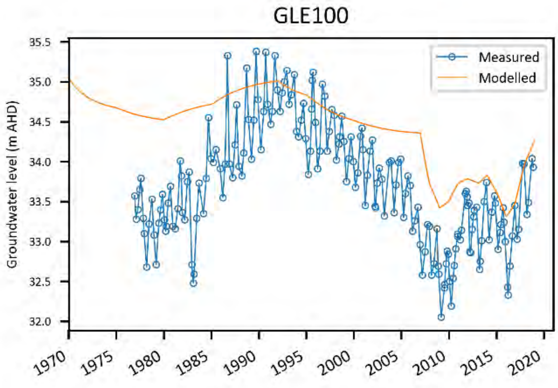


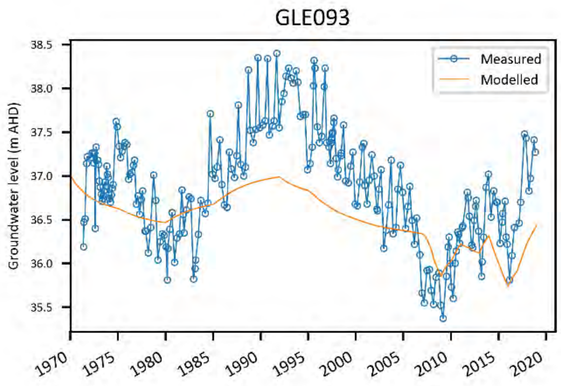


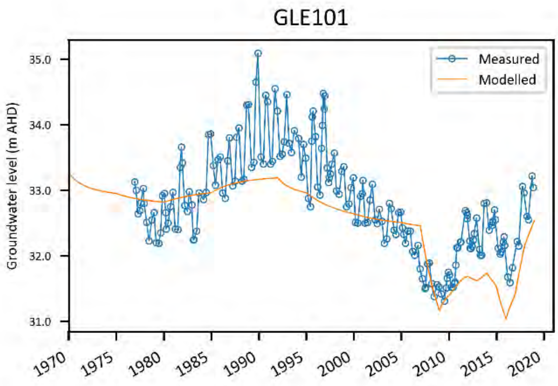

GLE088
Measured
Modelled
Groundwater level (m AHD)

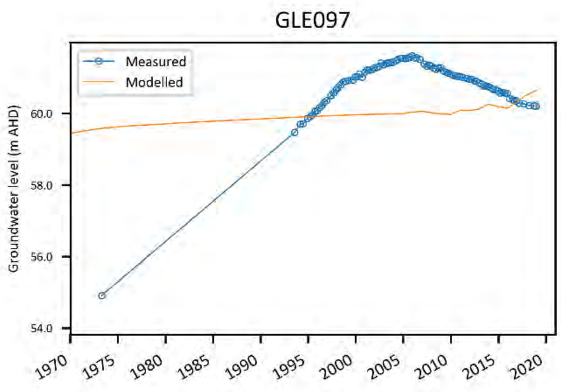

GLE099
Measured
Modelled
Groundwater level (m AHD)

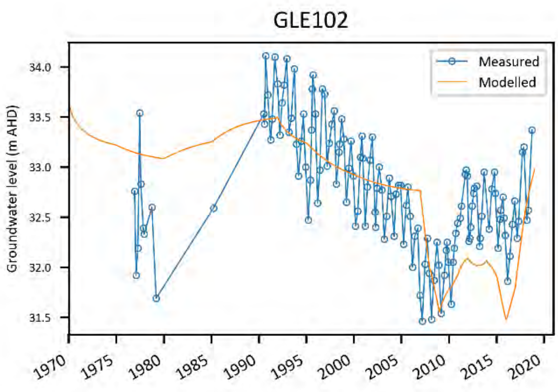

GLE089
Measured
Modelled
Groundwater level (m AHD)


GLE100
Measured
Modelled
Groundwater level (m AHD)

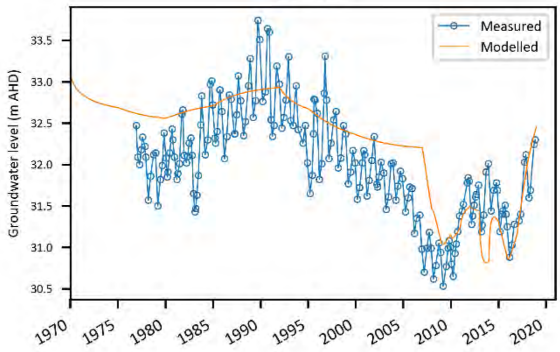

GLE093
Measured
Modelled
Groundwater level (m AHD)


GLE101
Measured
Modelled
Groundwater level (m AHD)

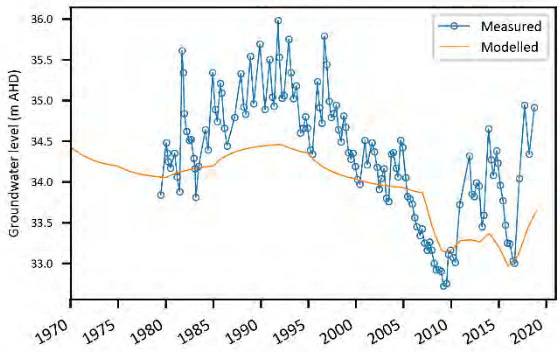

GLE097
Measured
Modelled
Groundwater level (m AHD)


GLE102
Measured
Modelled
Groundwater level (m AHD)

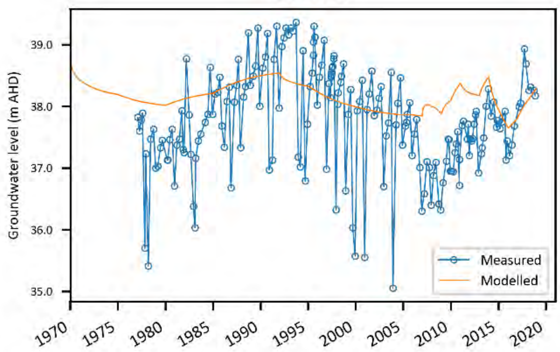
GLE103



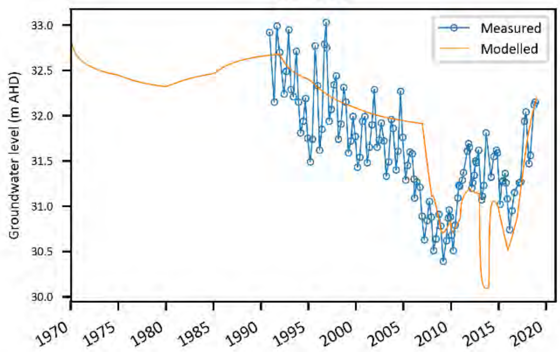
GLE108



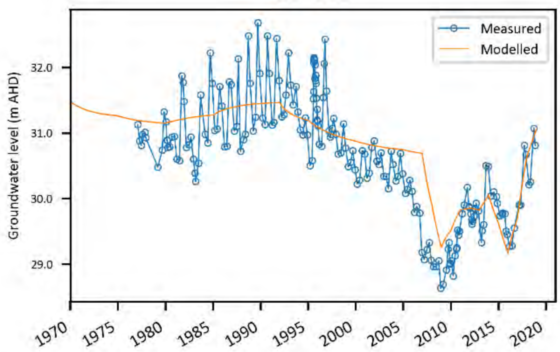
GLE104



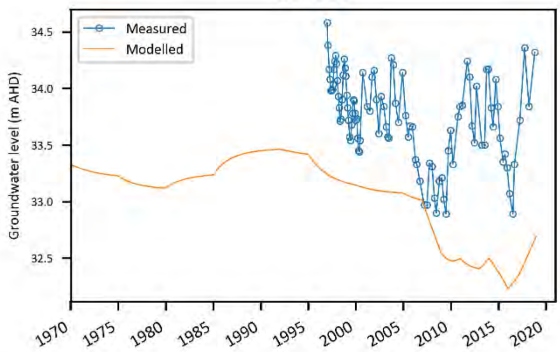
GLE109



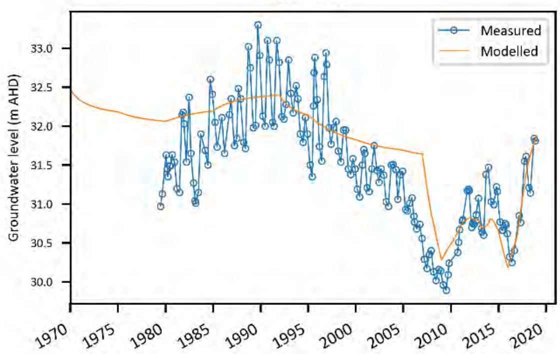
GLE106



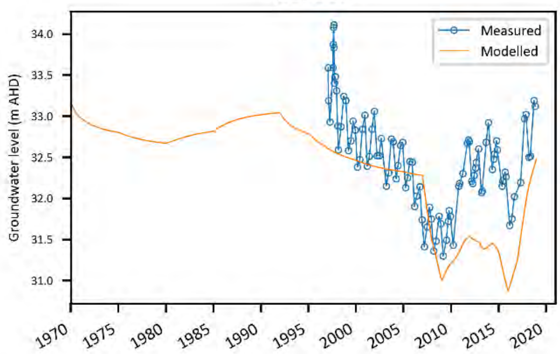
GLE110

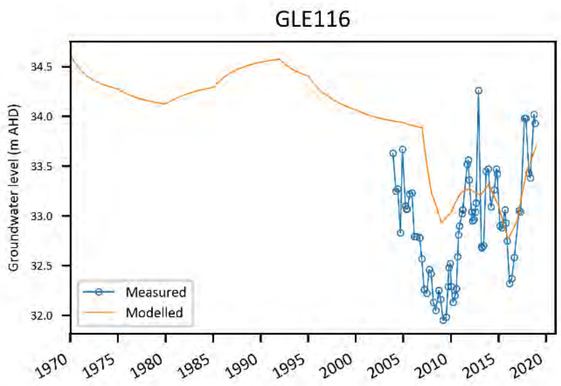


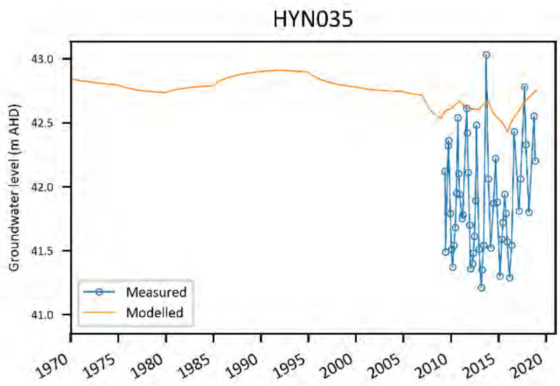
GLE107

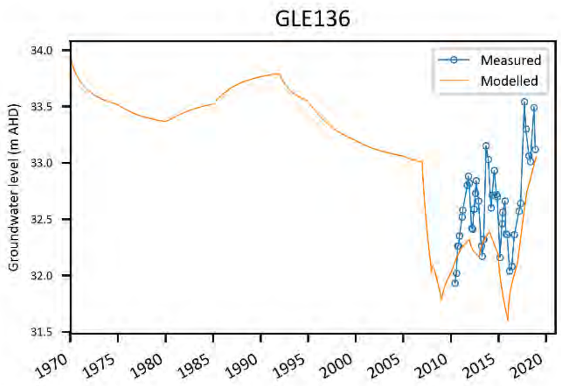


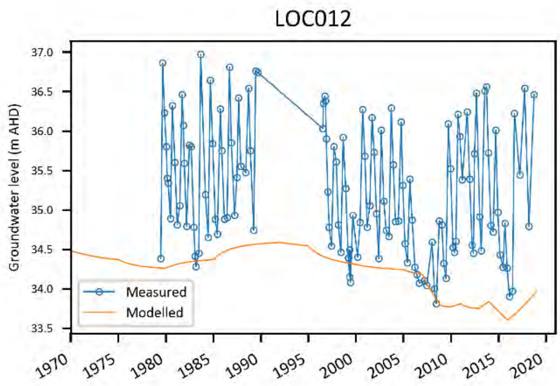
GLE112

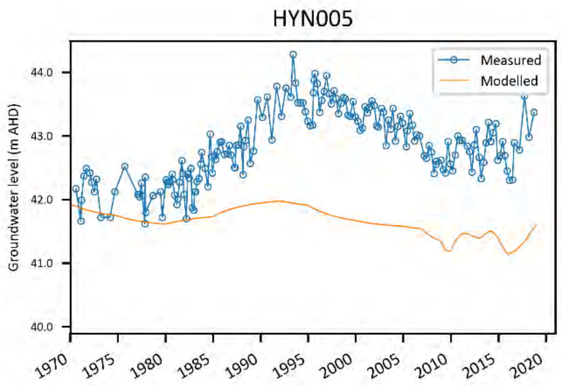


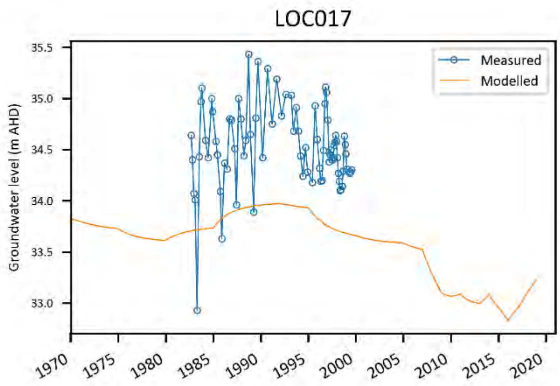

GLE116
Groundwater level (m AHD)
Measured
Modelled

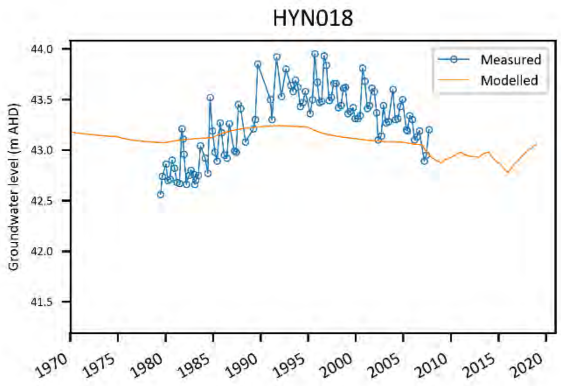

HYN035
Groundwater level (m AHD)
Measured
Modelled

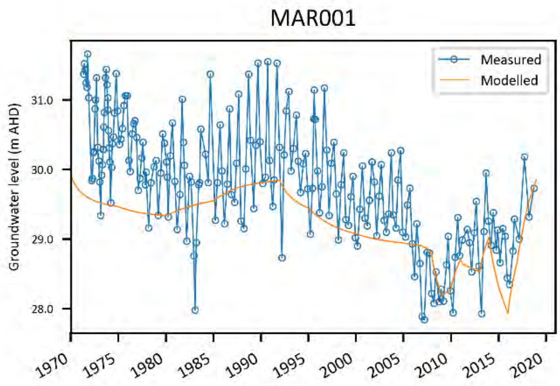

GLE136
Groundwater level (m AHD)
Measured
Modelled

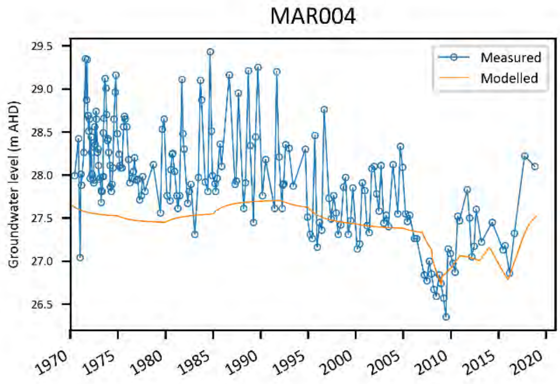

LOC012
Groundwater level (m AHD)
Measured
Modelled

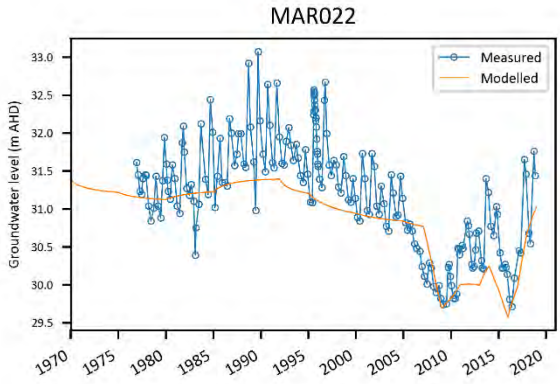

HYN005
Groundwater level (m AHD)
Measured
Modelled

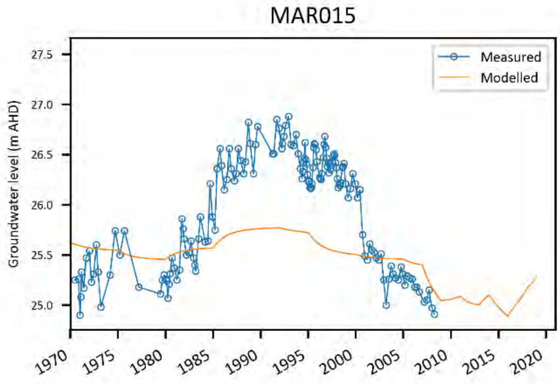

LOC017
Groundwater level (m AHD)
Measured
Modelled

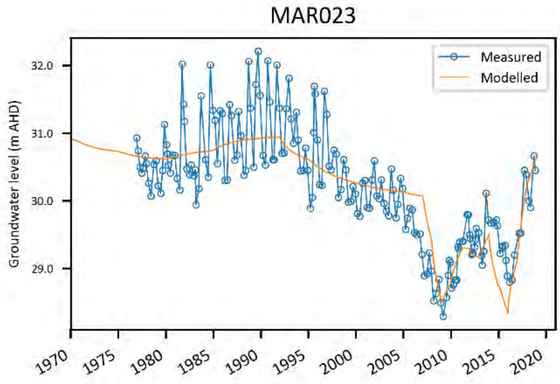

HYN018
Groundwater level (m AHD)
Measured
Modelled

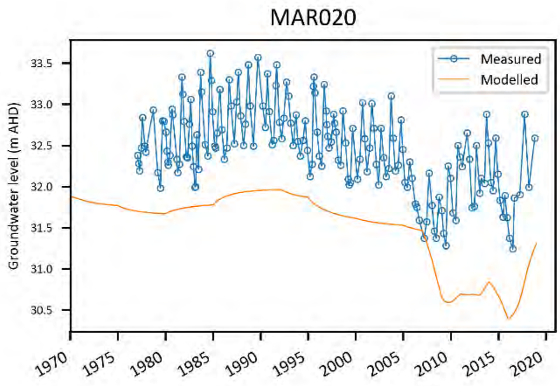

MAR001
Groundwater level (m AHD)
Measured
Modelled

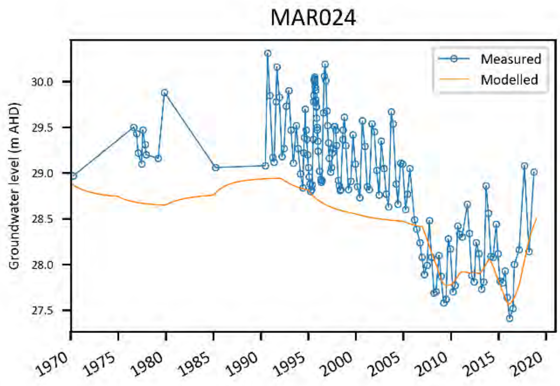

MAR004
Groundwater level (m AHD)
Measured
Modelled

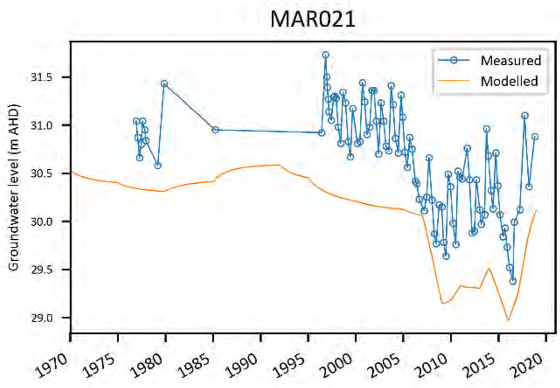

MAR022
Groundwater level (m AHD)
Measured
Modelled

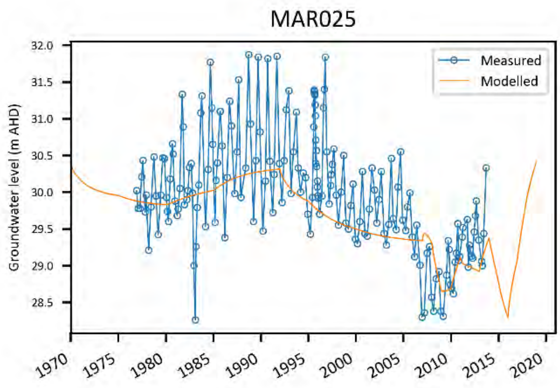

MAR015
Groundwater level (m AHD)
Measured
Modelled

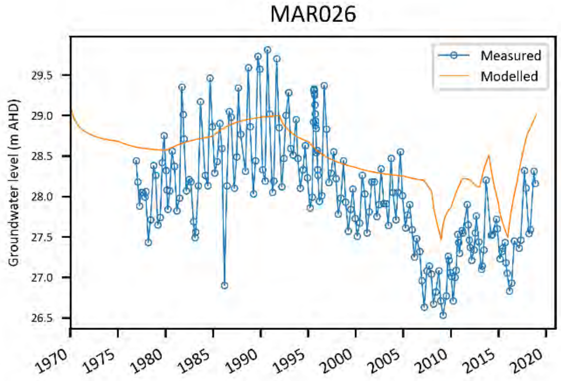

MAR023
Groundwater level (m AHD)
Measured
Modelled

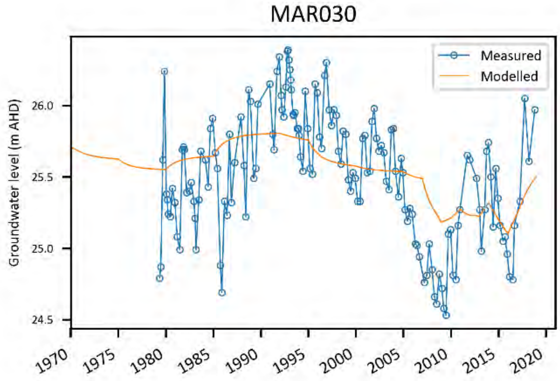

MAR020
Groundwater level (m AHD)
Measured
Modelled

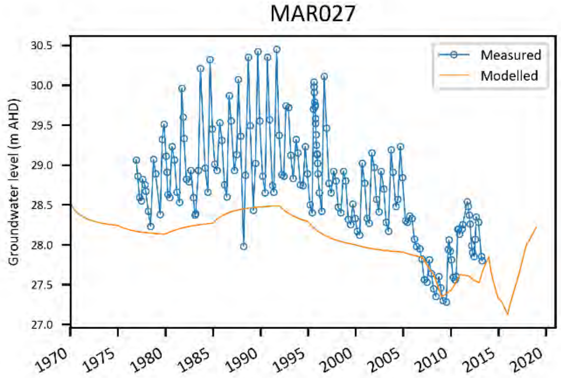

MAR024
Groundwater level (m AHD)
Measured
Modelled

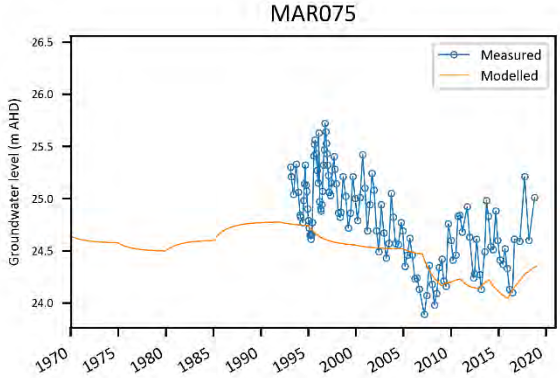

MAR021
Groundwater level (m AHD)
Measured
Modelled

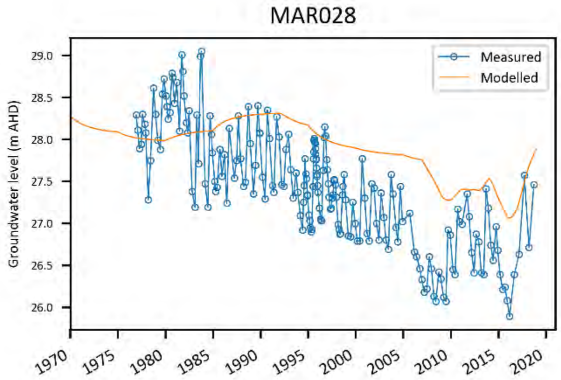

MAR025
Groundwater level (m AHD)
Measured
Modelled

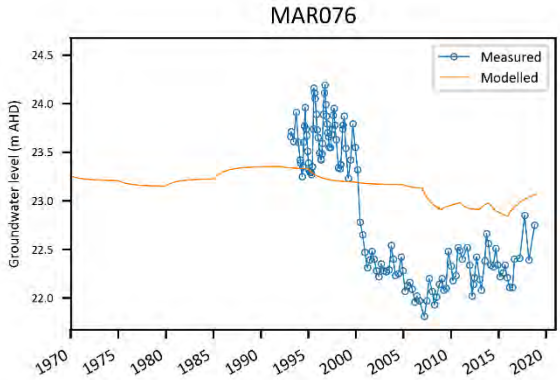

MAR026
Measured
Modelled
Groundwater level (m AHD)

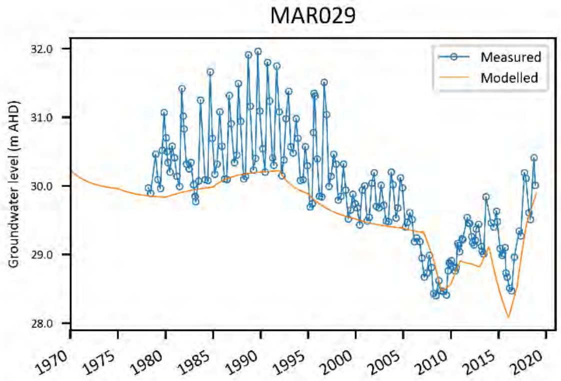

MAR030
Measured
Modelled
Groundwater level (m AHD)

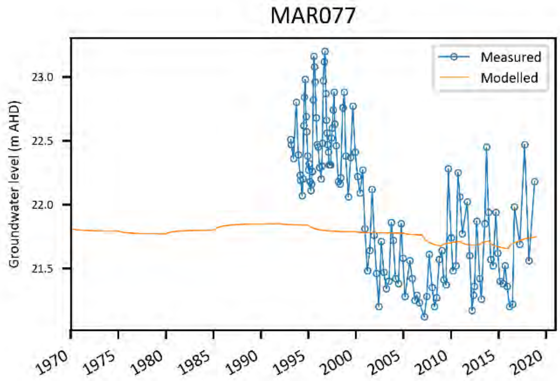

MAR027
Measured
Modelled
Groundwater level (m AHD)

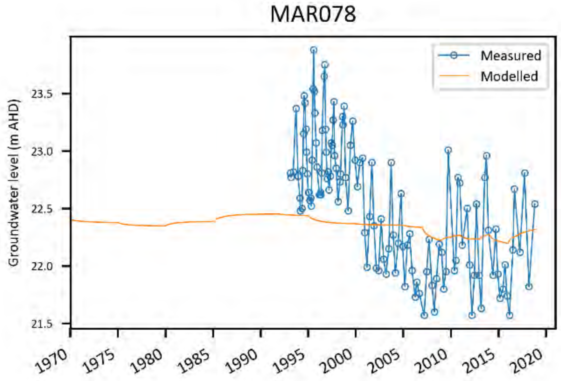

MAR075
Measured
Modelled
Groundwater level (m AHD)

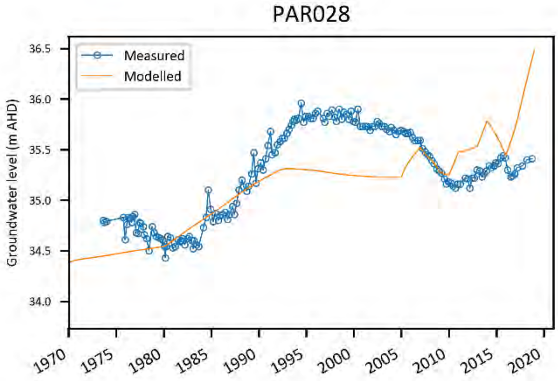

MAR028
Measured
Modelled
Groundwater level (m AHD)

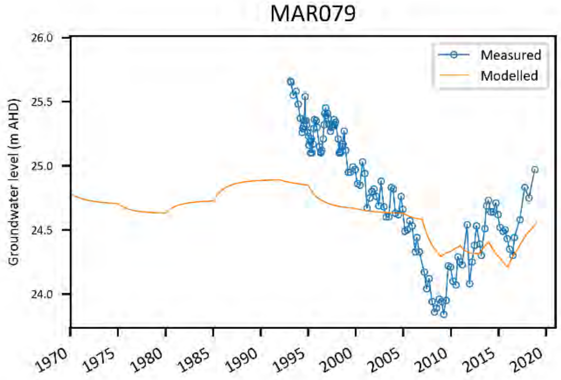

MAR076
Measured
Modelled
Groundwater level (m AHD)

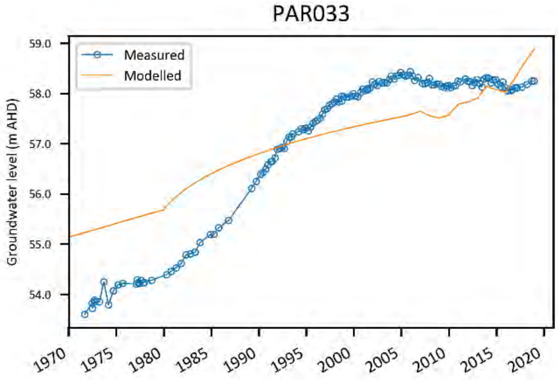

MAR029
Measured
Modelled
Groundwater level (m AHD)

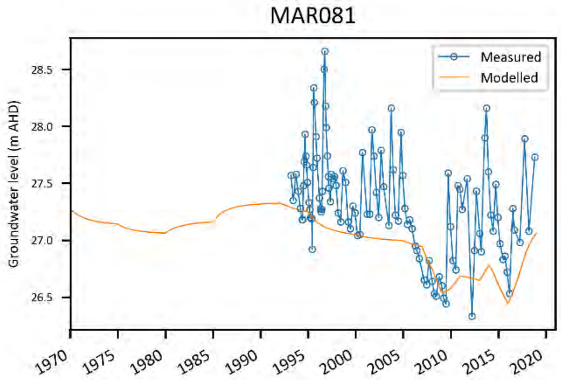

MAR077
Measured
Modelled
Groundwater level (m AHD)

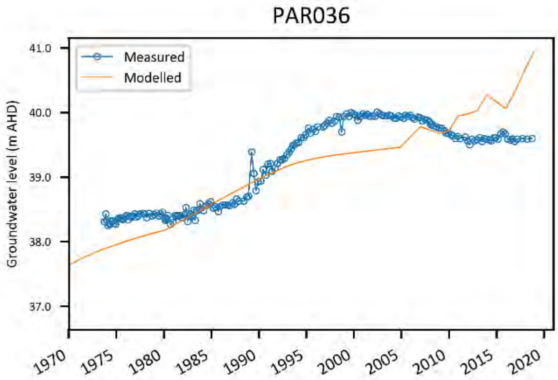

MAR078
Groundwater level (m AHD)
Measured
Modelled
21.5
22.0
22.5
23.0
23.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

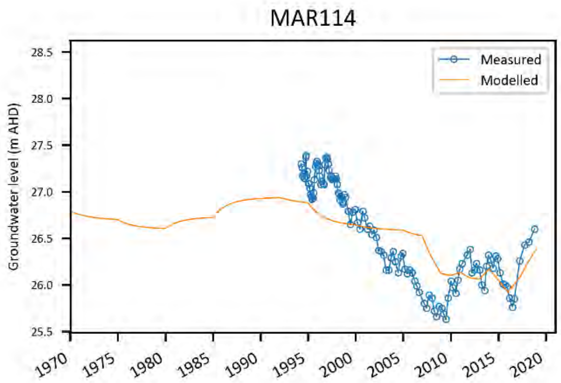

PAR028
Groundwater level (m AHD)
Measured
Modelled
34.0
34.5
35.0
35.5
36.0
36.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

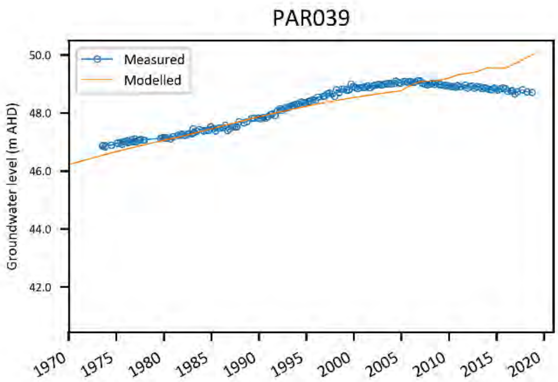

MAR079
Groundwater level (m AHD)
Measured
Modelled
24.0
24.5
25.0
25.5
26.0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

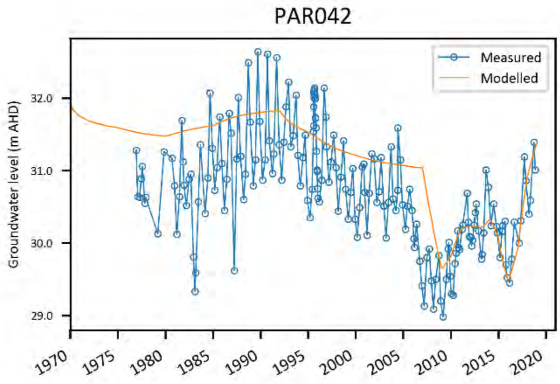

PAR033
Groundwater level (m AHD)
Measured
Modelled
54.0
55.0
56.0
57.0
58.0
59.0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

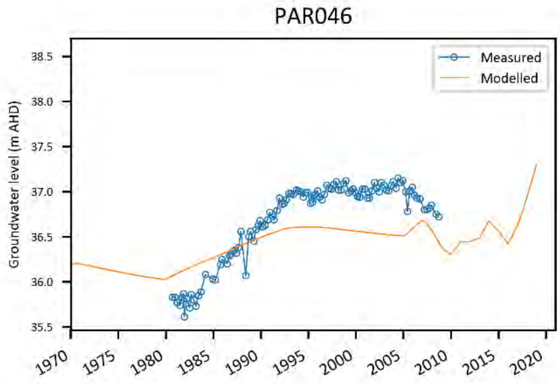

MAR081
Groundwater level (m AHD)
Measured
Modelled
26.5
27.0
27.5
28.0
28.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

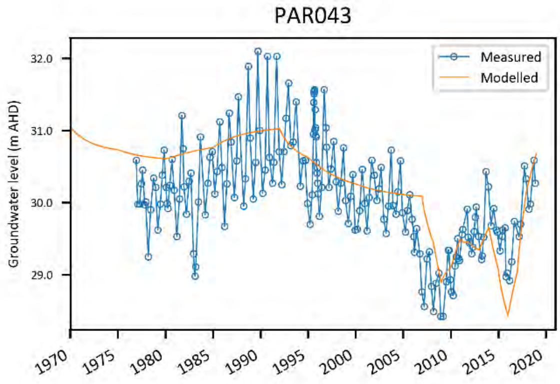

PAR036
Groundwater level (m AHD)
Measured
Modelled
37.0
38.0
39.0
40.0
41.0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

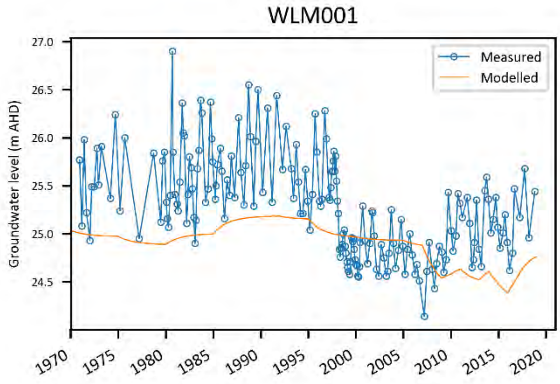

MAR114
Groundwater level (m AHD)
Measured
Modelled
25.5
26.0
26.5
27.0
27.5
28.0
28.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

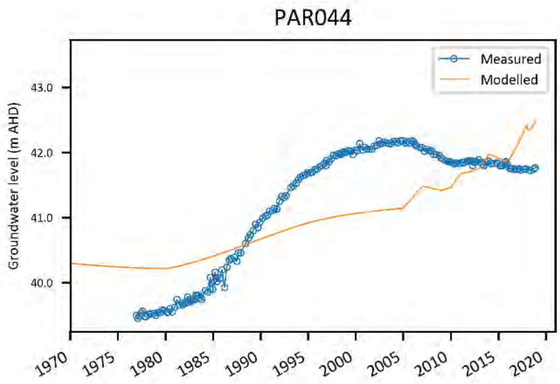

PAR039
Groundwater level (m AHD)
Measured
Modelled
42.0
44.0
46.0
48.0
50.0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

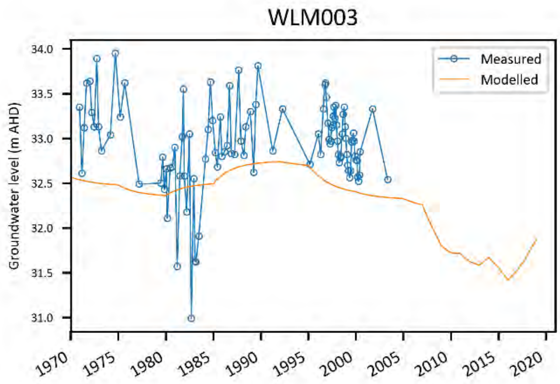

PAR042
Measured
Modelled
Groundwater level (m AHD)

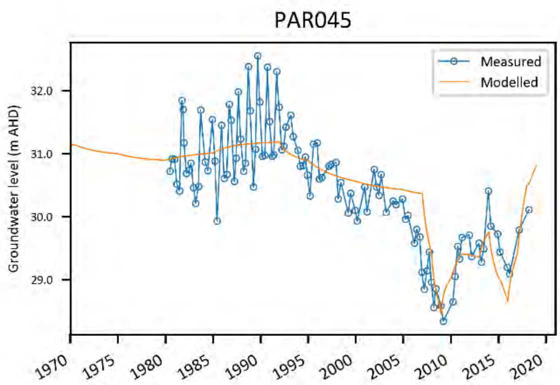

PAR046
Measured
Modelled
Groundwater level (m AHD)

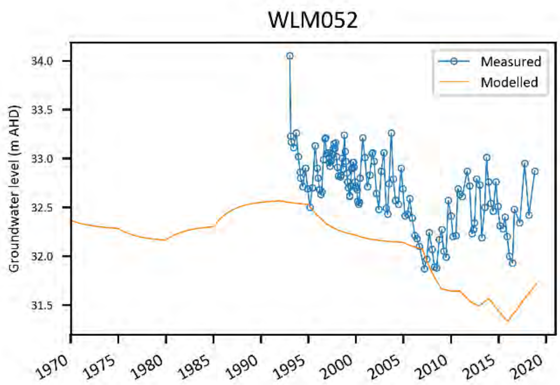

PAR043
Measured
Modelled
Groundwater level (m AHD)

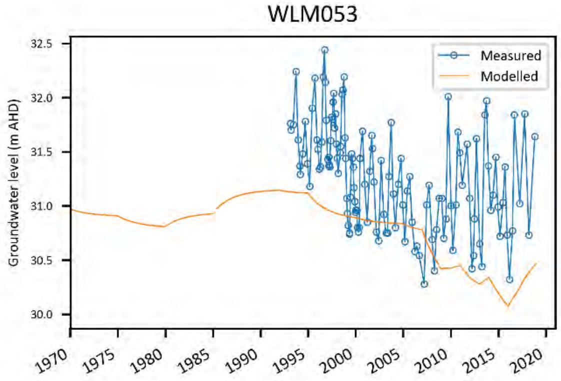

WLM001
Measured
Modelled
Groundwater level (m AHD)

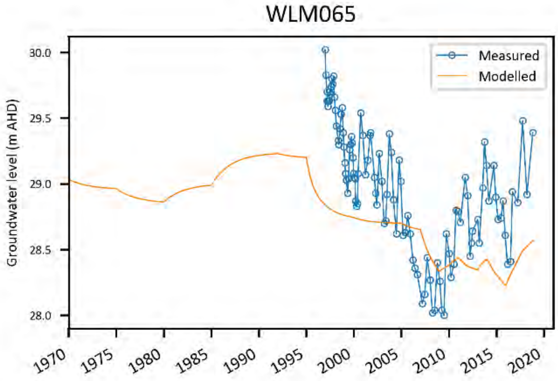

PAR044
Measured
Modelled
Groundwater level (m AHD)

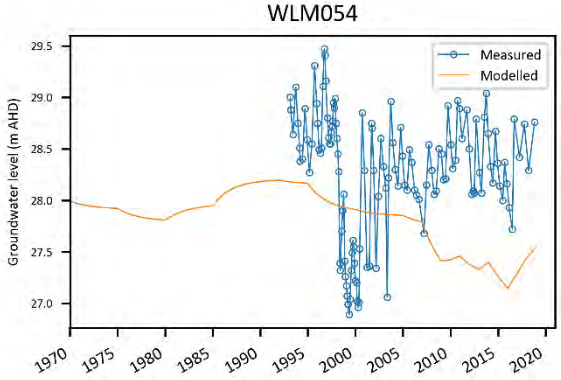

WLM003
Measured
Modelled
Groundwater level (m AHD)

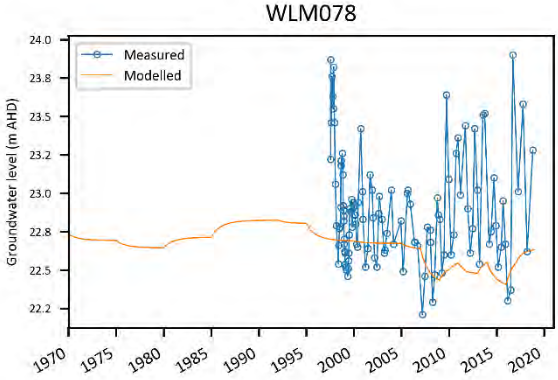

PAR045
Measured
Modelled
Groundwater level (m AHD)

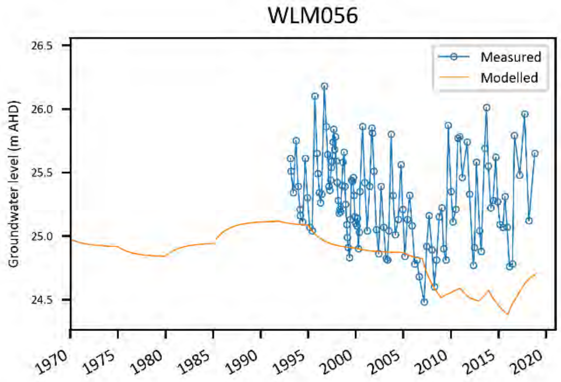

WLM052
Measured
Modelled
Groundwater level (m AHD)


WLM053
Measured
Modelled
Groundwater level (m AHD)

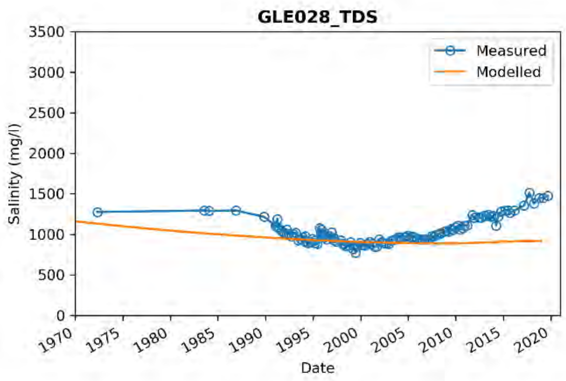

WLM065
Measured
Modelled
Groundwater level (m AHD)

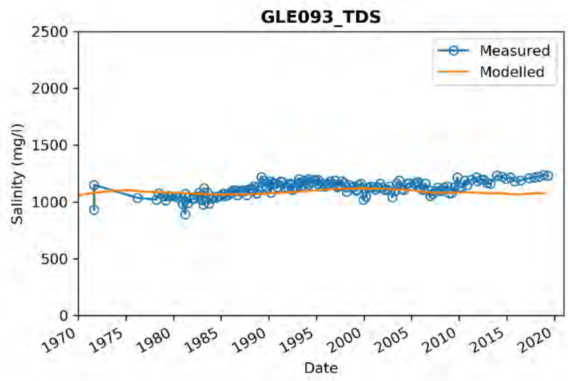

WLM054
Measured
Modelled
Groundwater level (m AHD)

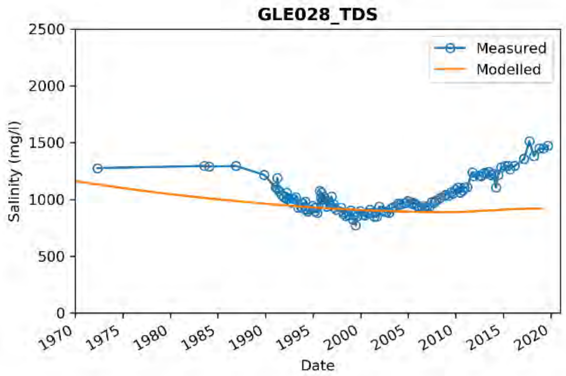

WLM078
Measured
Modelled
Groundwater level (m AHD)

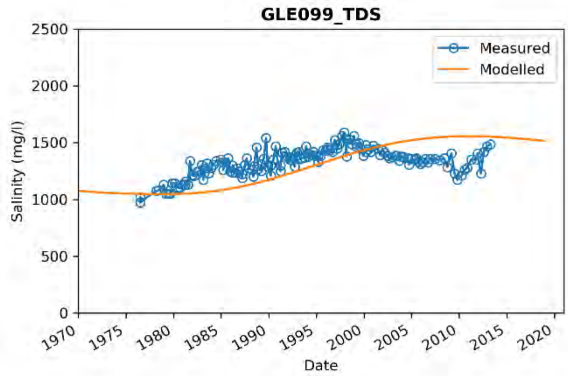

WLM056
Measured
Modelled
Groundwater level (m AHD)

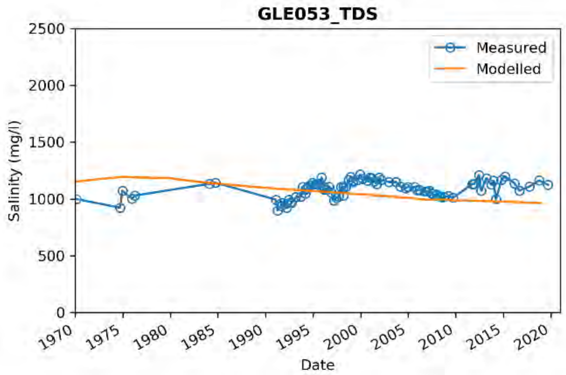
E. Measured and modelled groundwater salinity

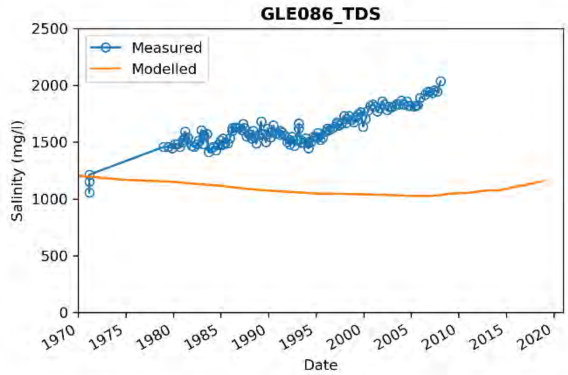


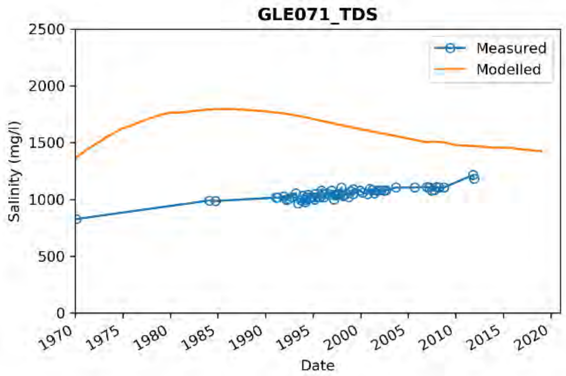


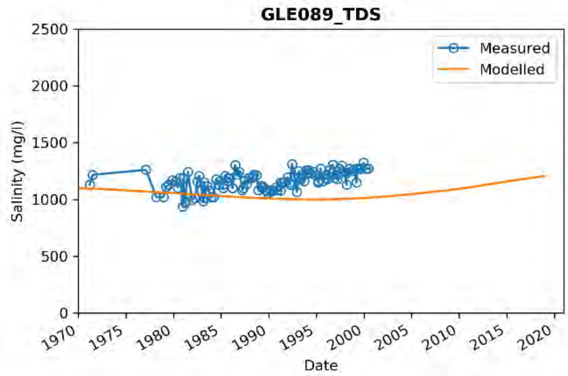


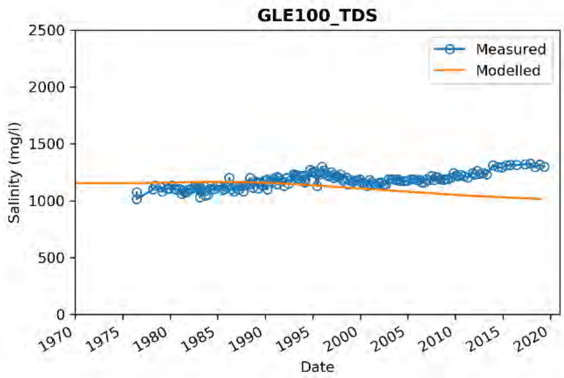


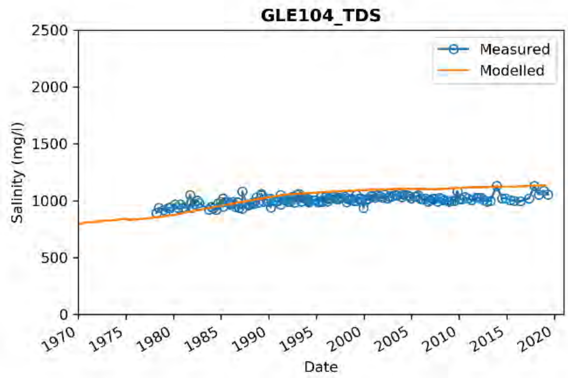


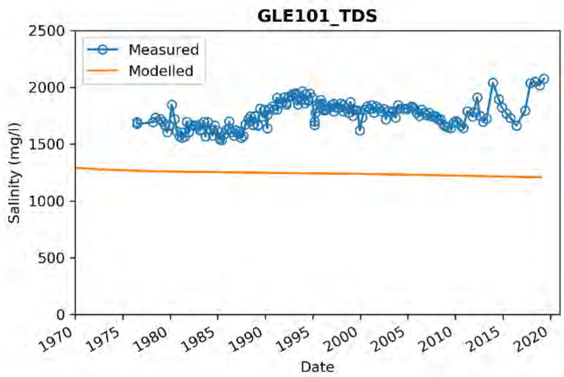


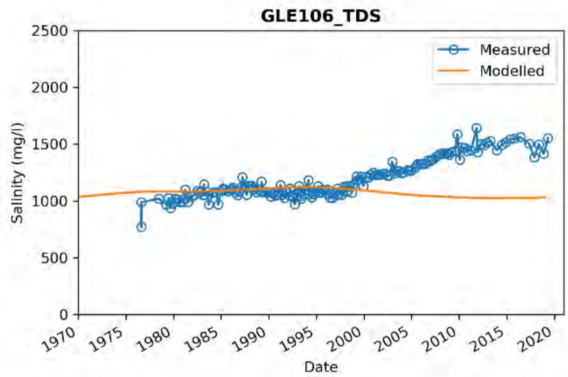


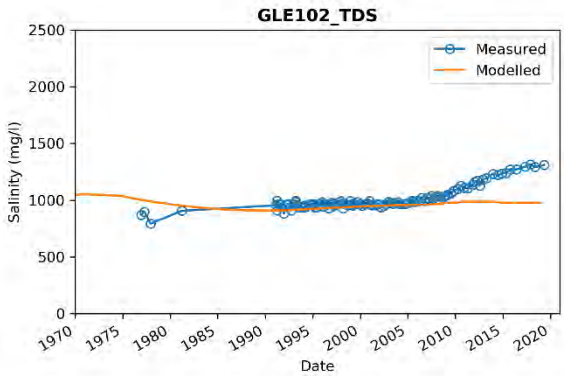


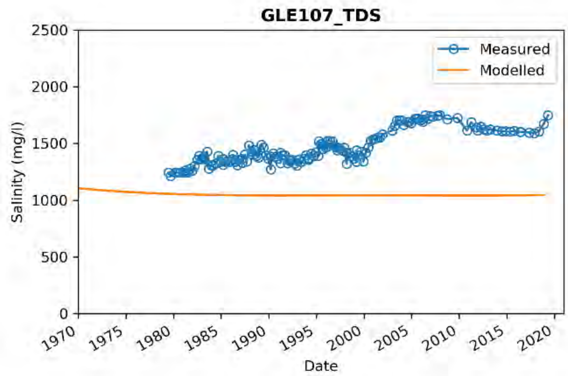

GLE100_TDS
Measured
Modelled
Salinity (mg/l)
Date

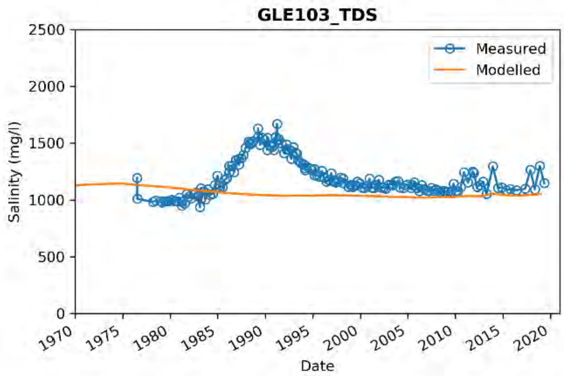

GLE104_TDS
Measured
Modelled
Salinity (mg/l)
Date

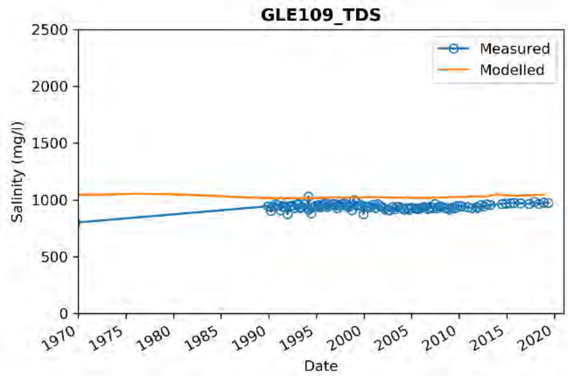

GLE101_TDS
Measured
Modelled
Salinity (mg/l)
Date

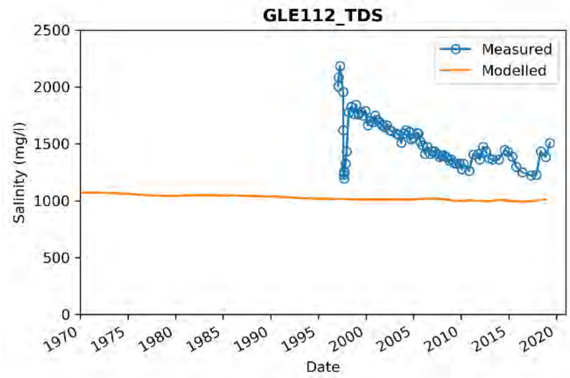

GLE106_TDS
Measured
Modelled
Salinity (mg/l)
Date

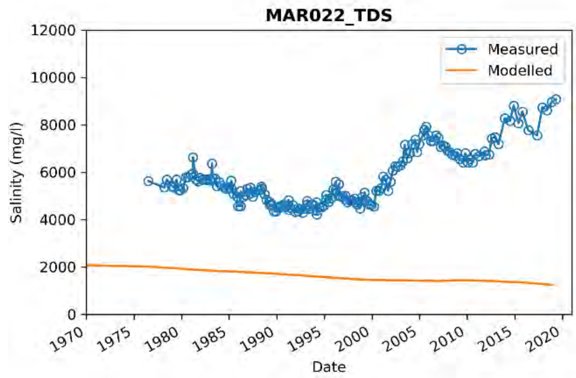

GLE102_TDS
Measured
Modelled
Salinity (mg/l)
Date

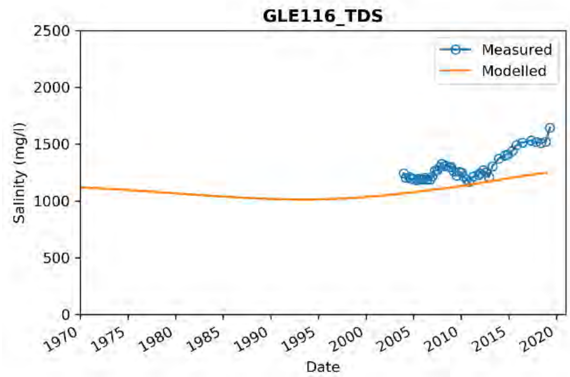

GLE107_TDS
Measured
Modelled
Salinity (mg/l)
Date

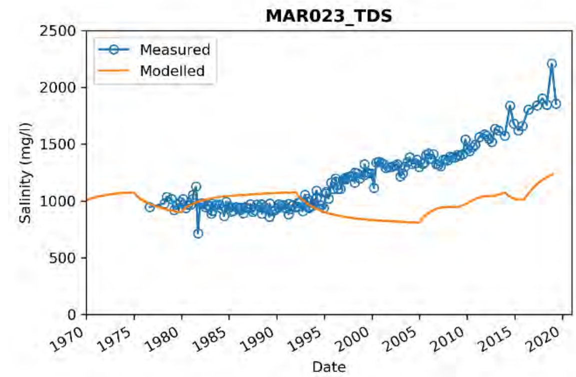

GLE103_TDS
Measured
Modelled
Salinity (mg/l)
Date

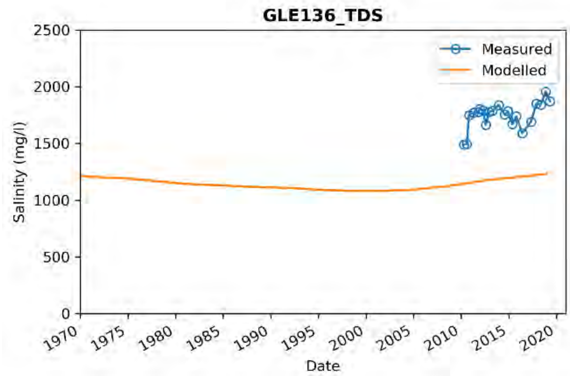

GLE109_TDS
Measured
Modelled
Salinity (mg/l)
Date

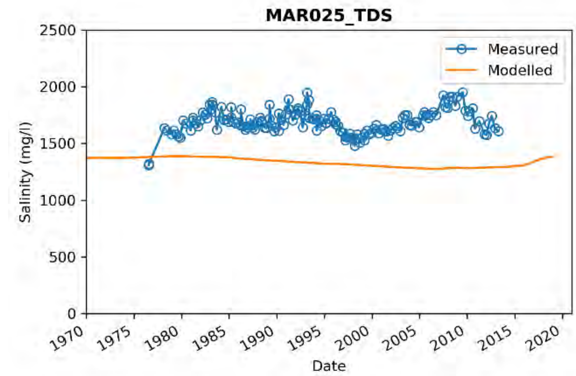

GLE112_TDS
Measured
Modelled
Salinity (mg/l)
Date

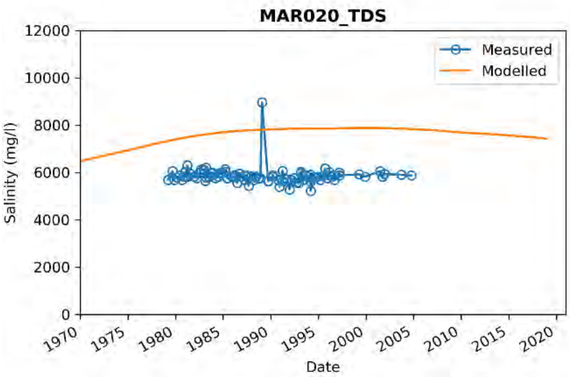

MAR022_TDS
Measured
Modelled
Salinity (mg/l)
Date

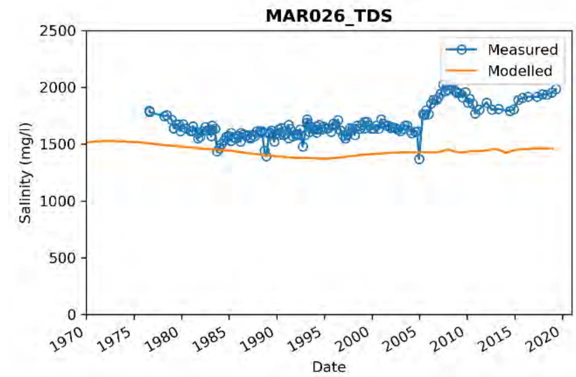

GLE116_TDS
Measured
Modelled
Salinity (mg/l)
Date

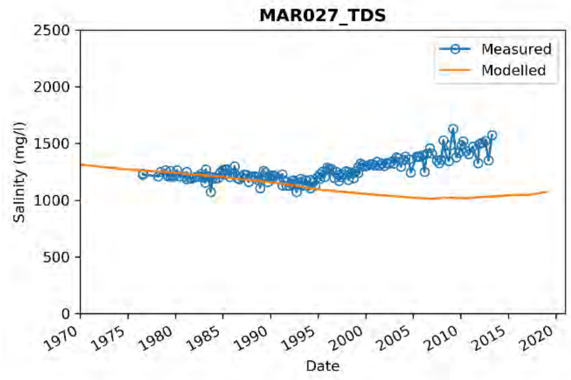

MAR023_TDS
Measured
Modelled
Salinity (mg/l)
Date

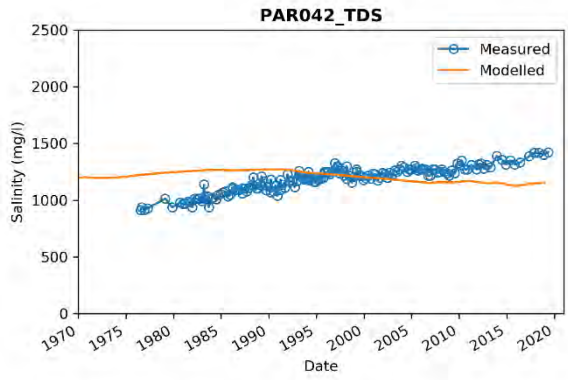

GLE136_TDS
Measured
Modelled
Salinity (mg/l)
Date

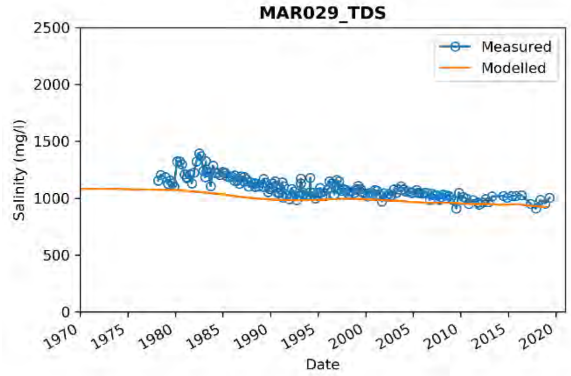

MAR025_TDS
Measured
Modelled
Salinity (mg/l)
Date

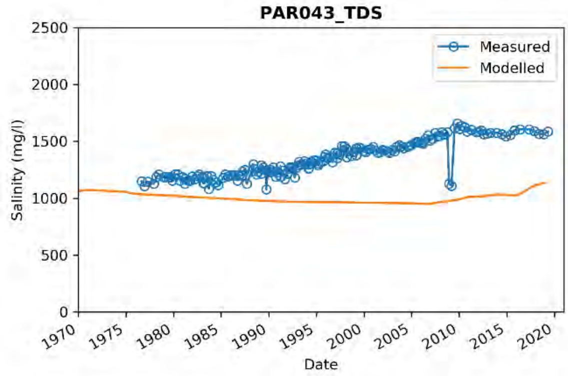

MAR020_TDS
Measured
Modelled
Salinity (mg/l)
Date

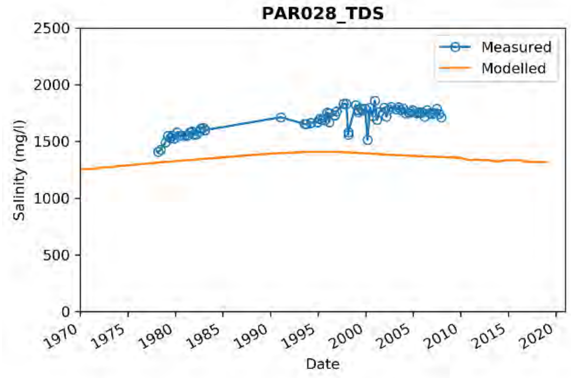

MAR026_TDS
Measured
Modelled
Salinity (mg/l)
Date

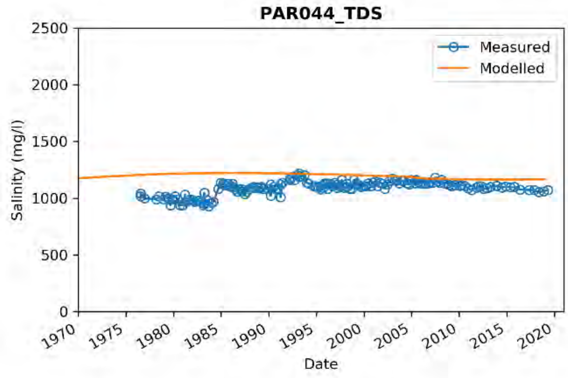

MAR027_TDS
Measured
Modelled
Salinity (mg/l)
Date

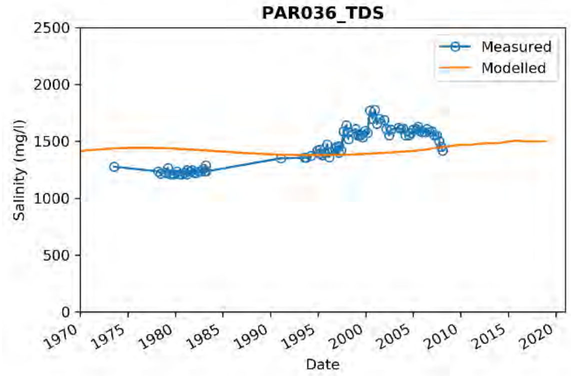

PAR042_TDS
Measured
Modelled
Salinity (mg/l)
Date


MAR029_TDS
Measured
Modelled
Salinity (mg/l)
Date

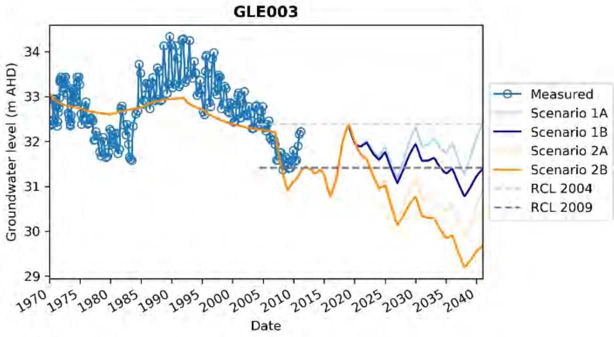

PAR043_TDS
Measured
Modelled
Salinity (mg/l)
Date

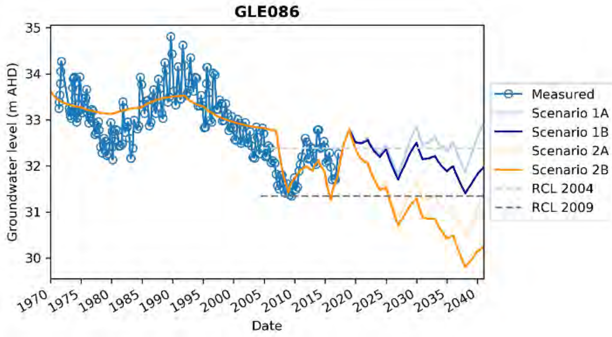

PAR028_TDS
Measured
Modelled
Salinity (mg/l)
Date

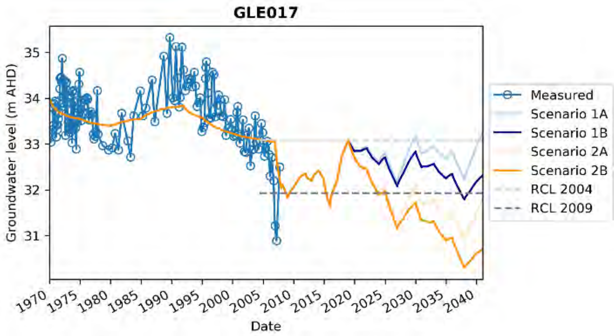

PAR044_TDS
Measured
Modelled
Salinity (mg/l)
Date

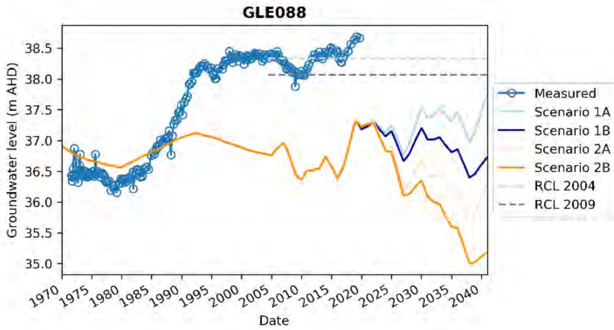

PAR036_TDS
Measured
Modelled
Salinity (mg/l)
Date

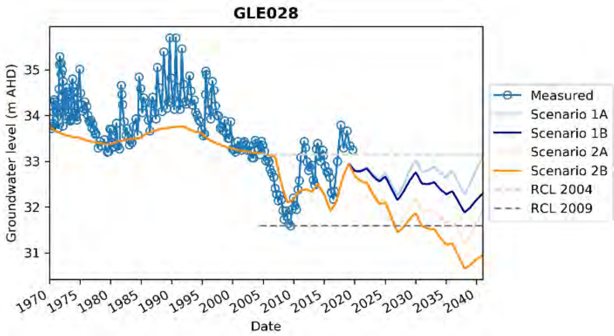
F. Measured and modelled groundwater levels (scenarios)

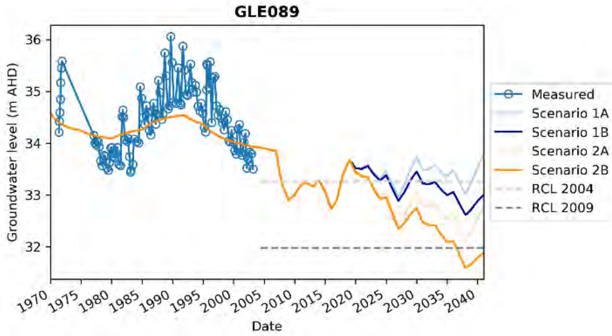


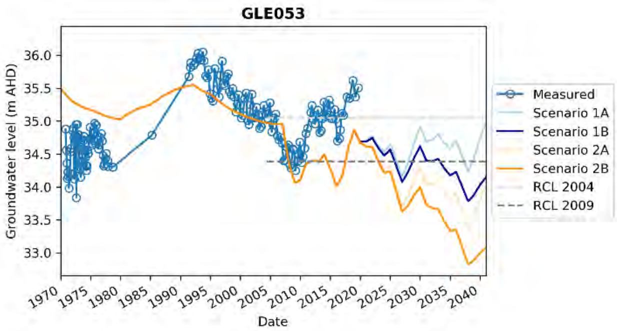


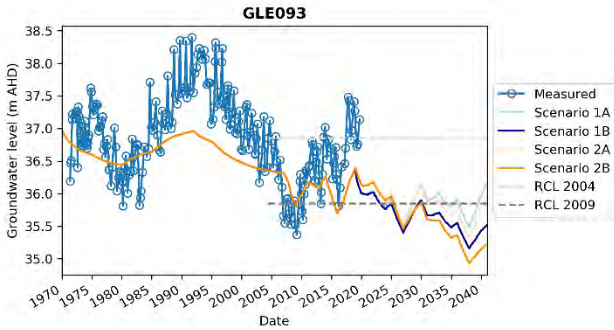


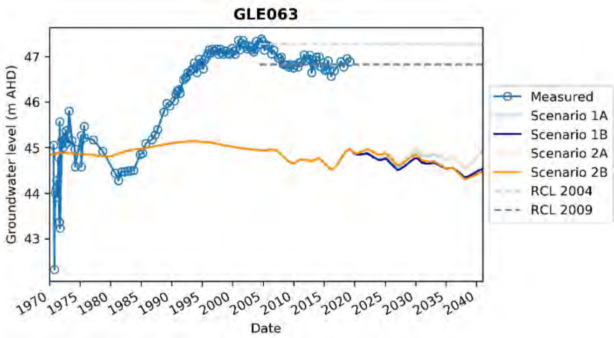


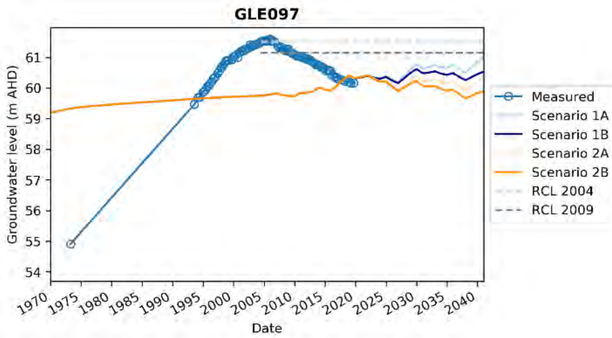


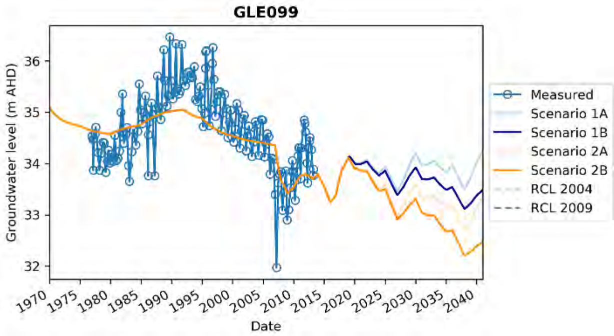


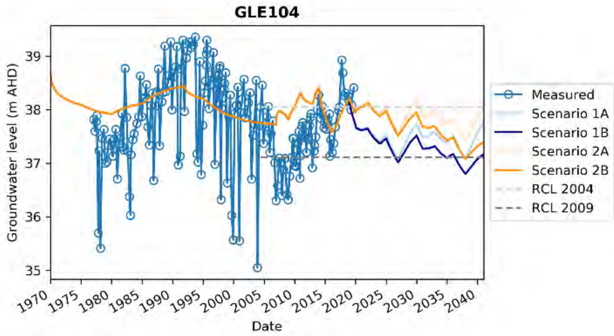


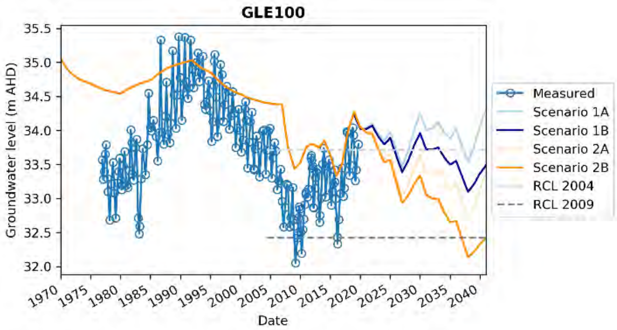


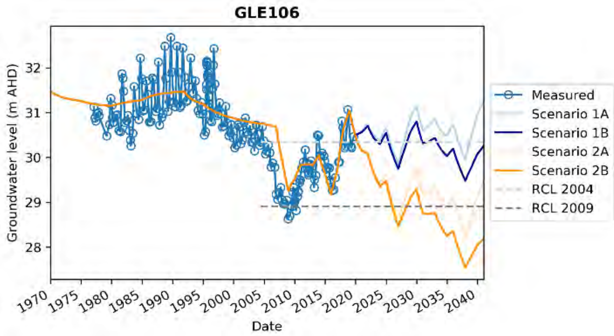


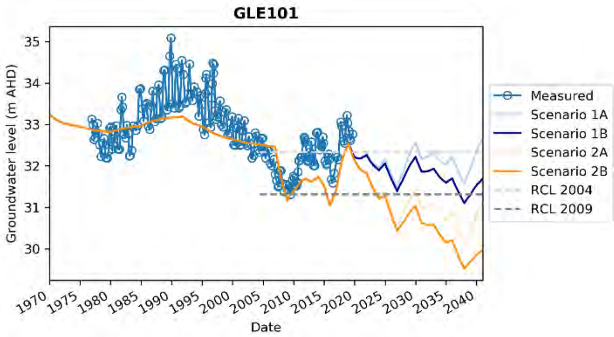


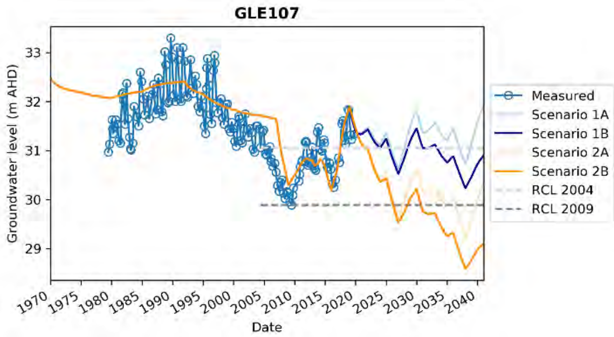

GLE099
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

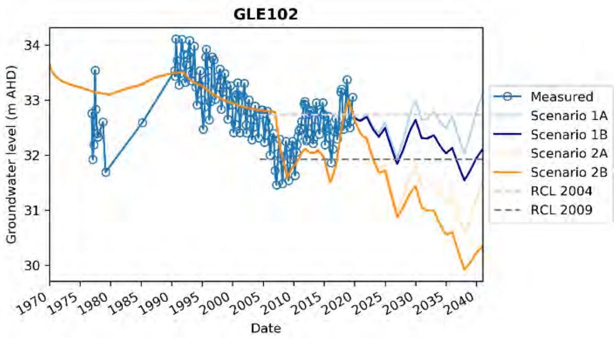

GLE104
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

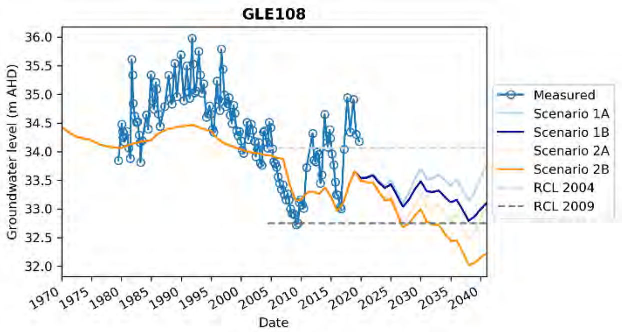

GLE100
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

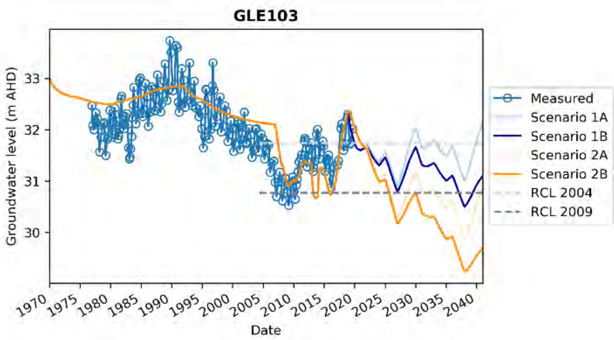

GLE106
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

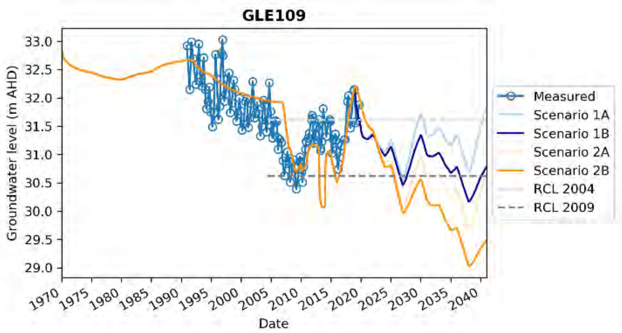

GLE101
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

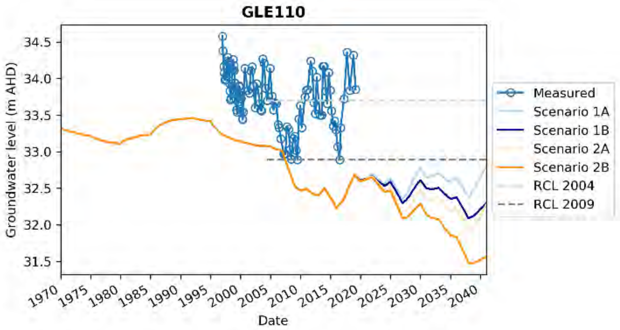

GLE107
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

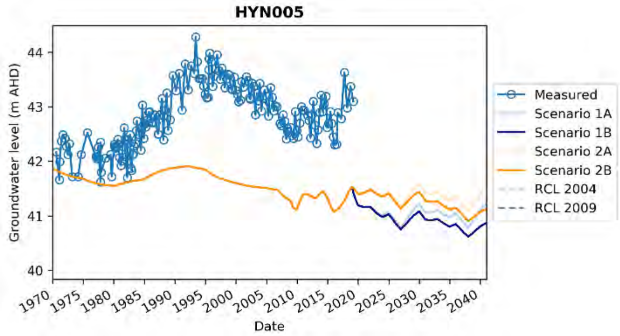

GLE102
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

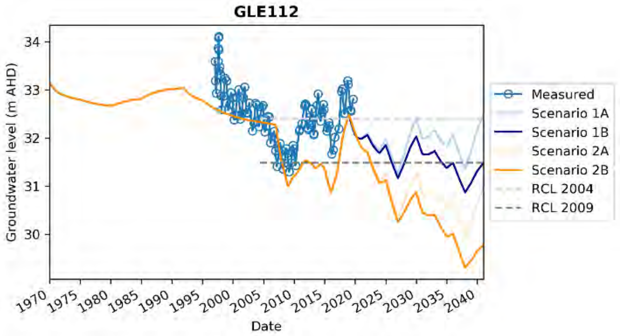

GLE108
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

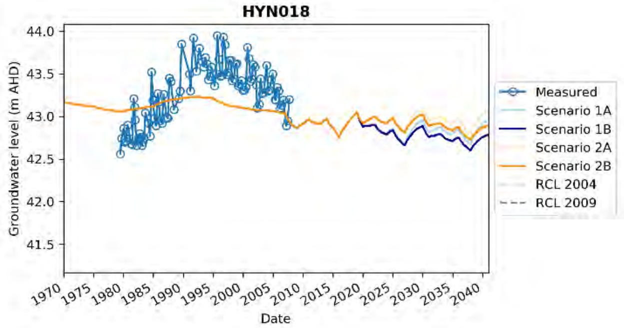

GLE103
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

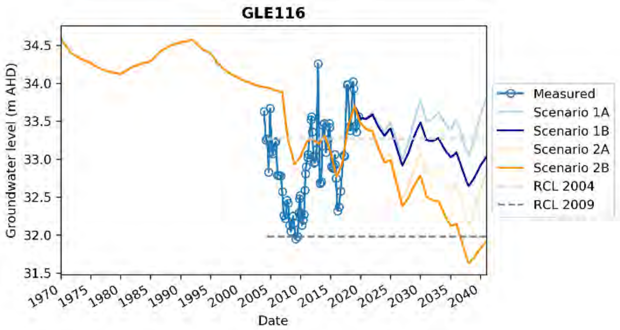

GLE109
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

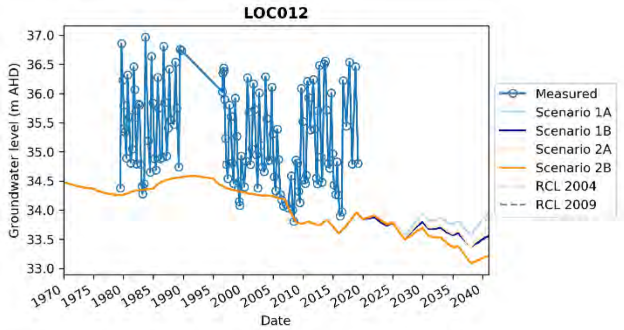

GLE110
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

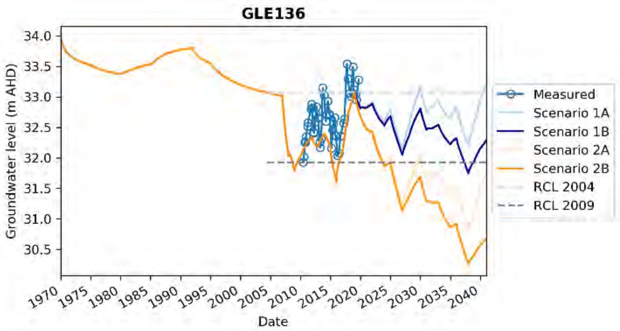

HYN005
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

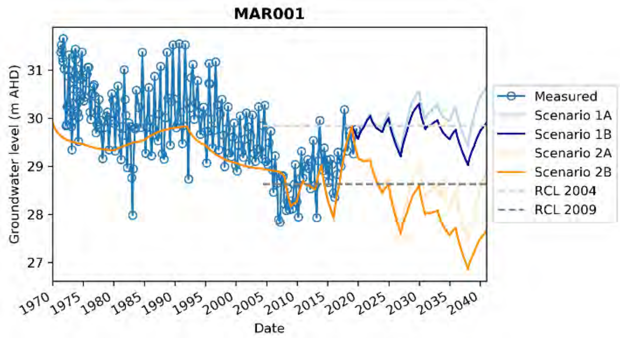

GLE112
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

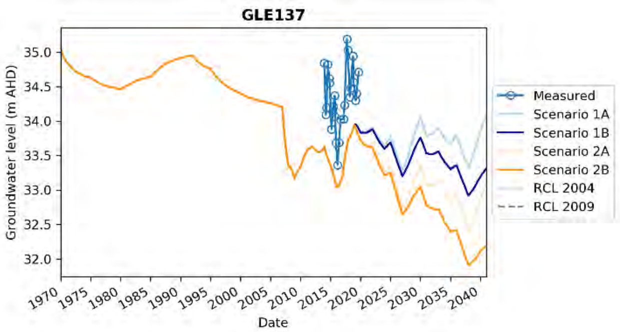

HYN018
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

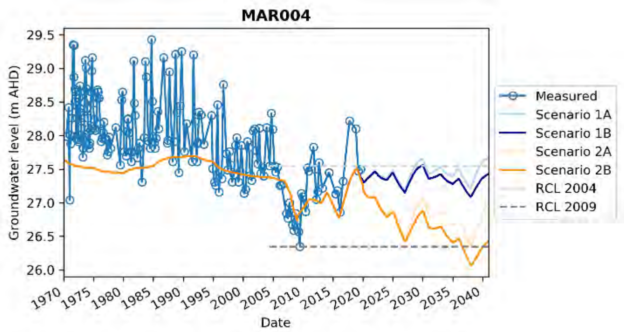

GLE116
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

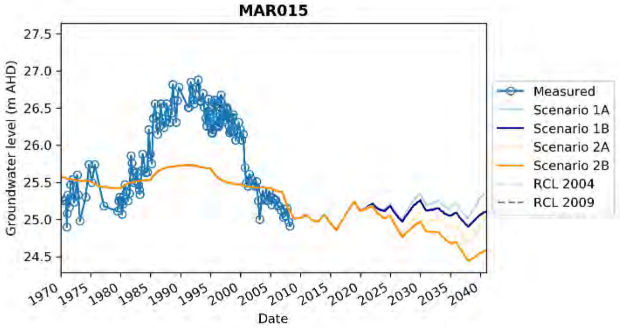

LOC012
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

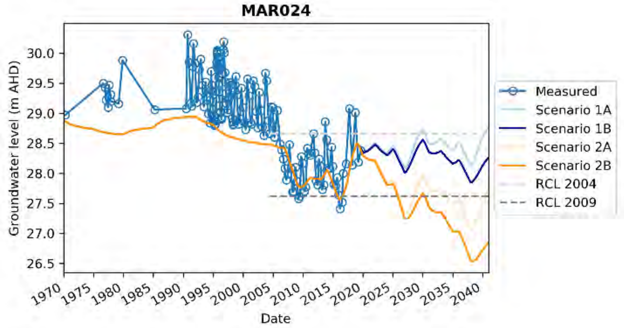

GLE136
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

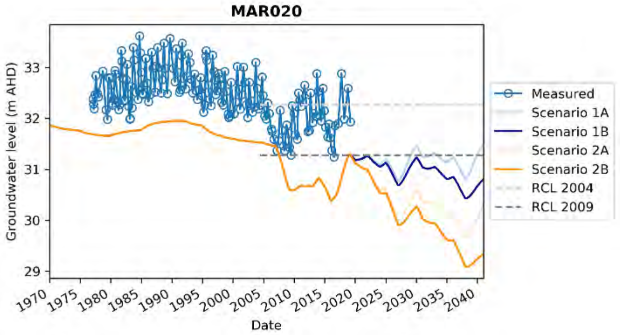

MAR001
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

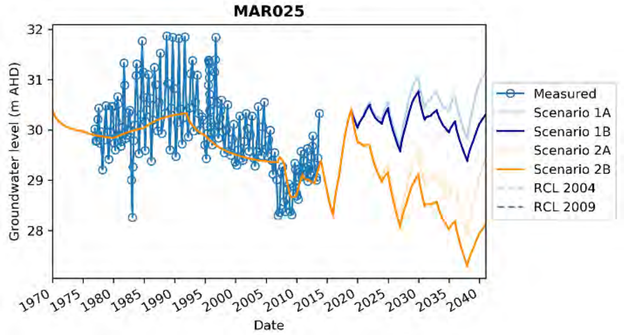

GLE137
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

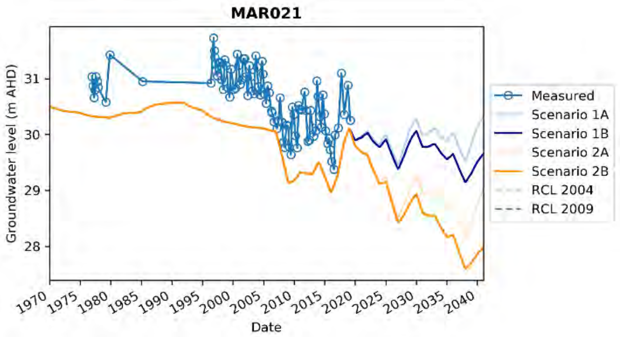

MAR004
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

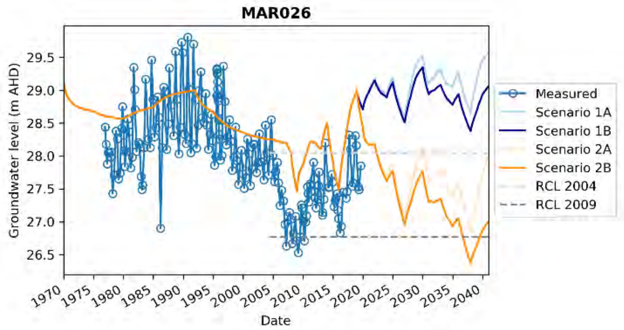

MAR015
Groundwater level (m AHD)
24.5 25.0 25.5 26.0 26.5 27.0 27.5
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

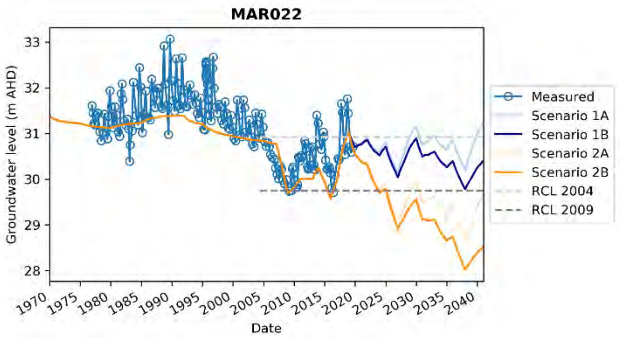

MAR024
Groundwater level (m AHD)
26.5 27.0 27.5 28.0 28.5 29.0 29.5 30.0
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

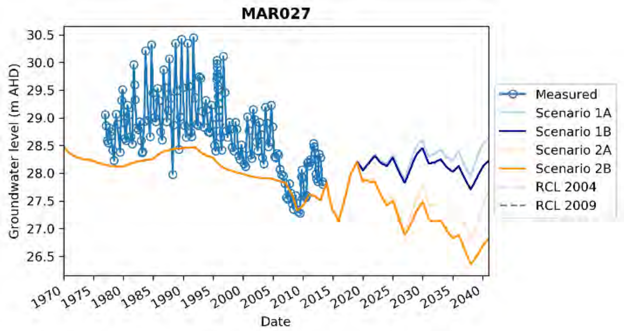

MAR020
Groundwater level (m AHD)
29 30 31 32 33
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

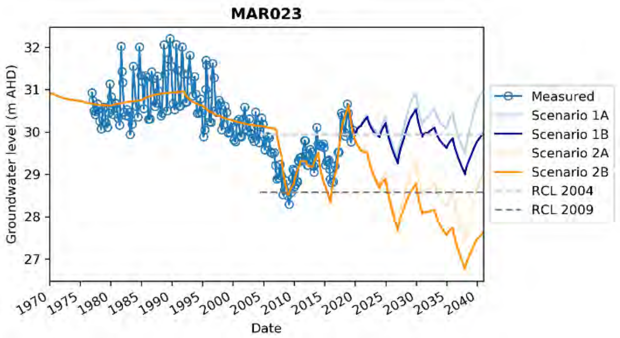

MAR025
Groundwater level (m AHD)
28 29 30 31 32
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

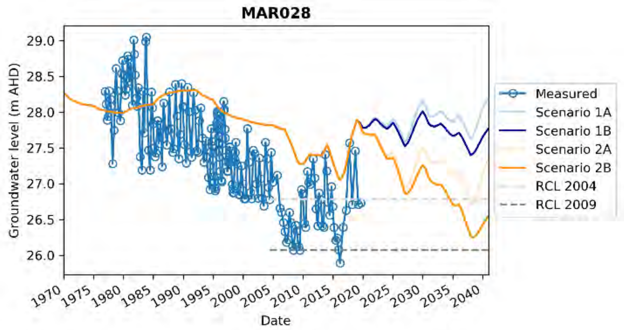

MAR021
Groundwater level (m AHD)
28 29 30 31
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

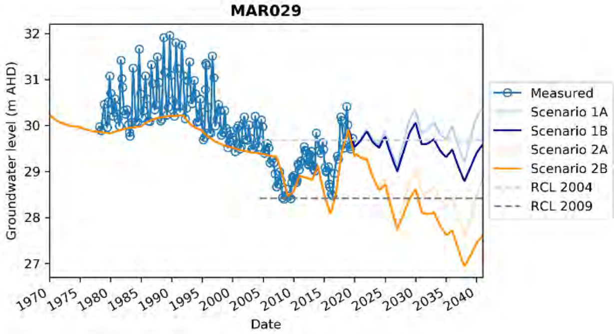

MAR026
Groundwater level (m AHD)
26.5 27.0 27.5 28.0 28.5 29.0 29.5
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

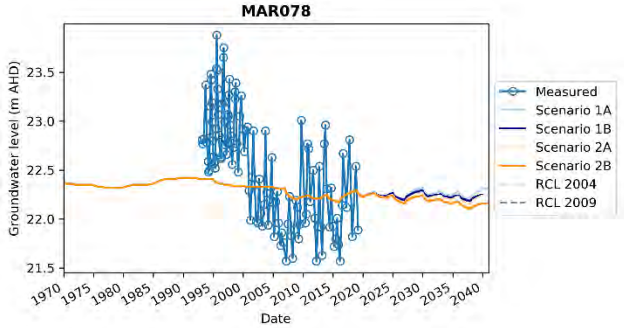

MAR022
Groundwater level (m AHD)
28 29 30 31 32 33
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

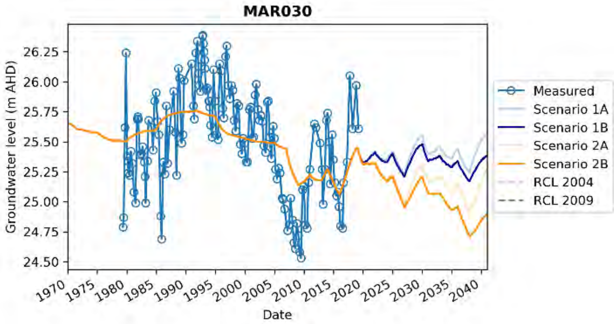

MAR027
Groundwater level (m AHD)
26.5 27.0 27.5 28.0 28.5 29.0 29.5 30.0 30.5
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

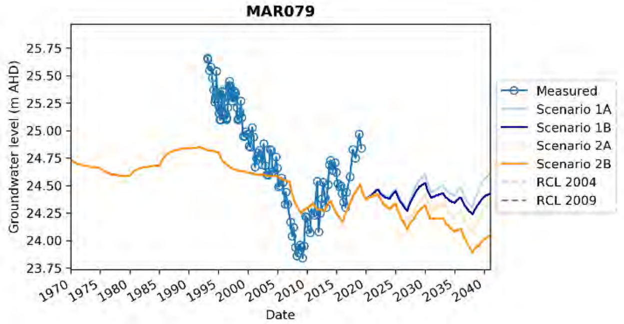

MAR023
Groundwater level (m AHD)
27 28 29 30 31 32
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

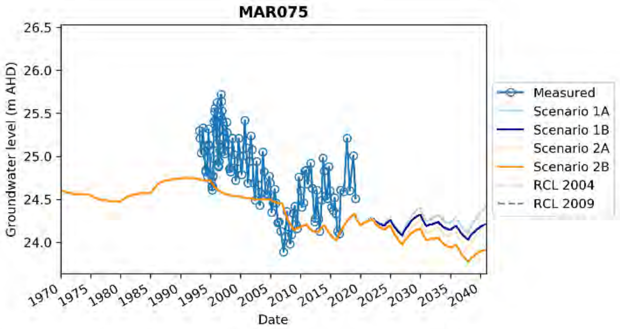

MAR028
Groundwater level (m AHD)
26.0 26.5 27.0 27.5 28.0 28.5 29.0
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

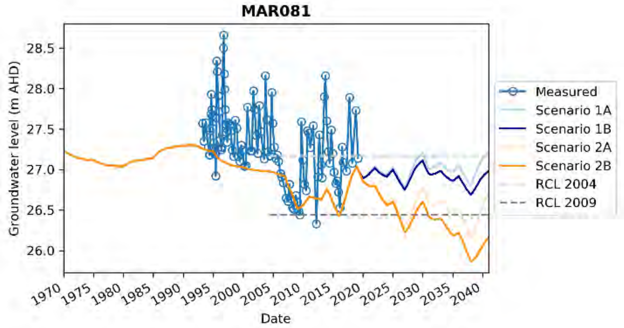

MAR029
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

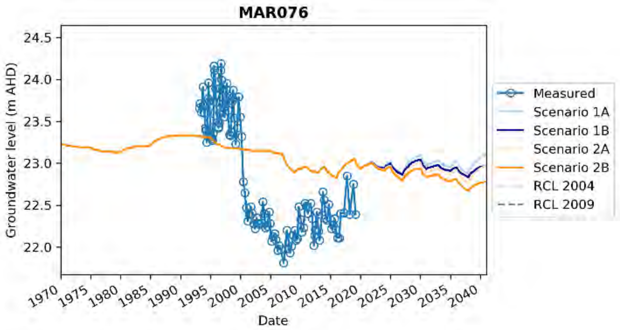

MAR078
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

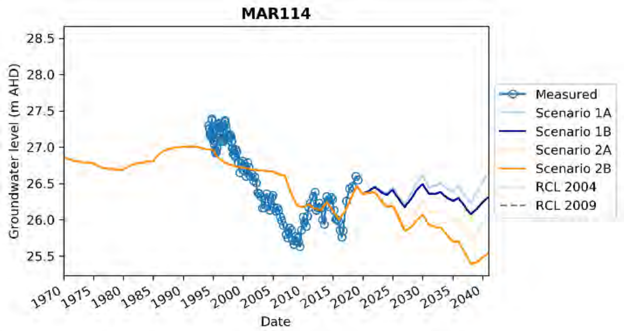

MAR030
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

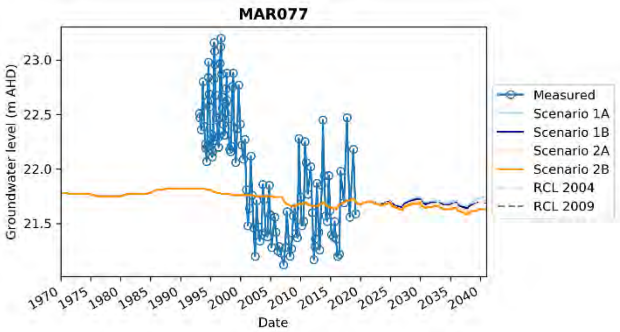

MAR079
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

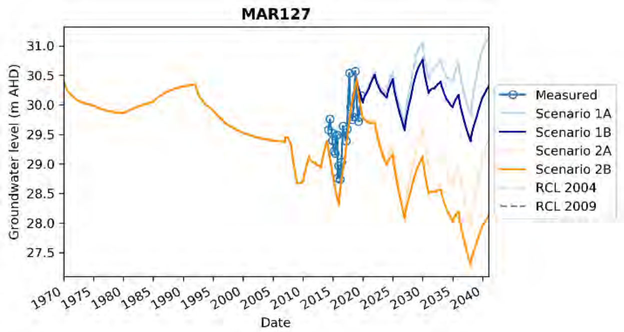

MAR075
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

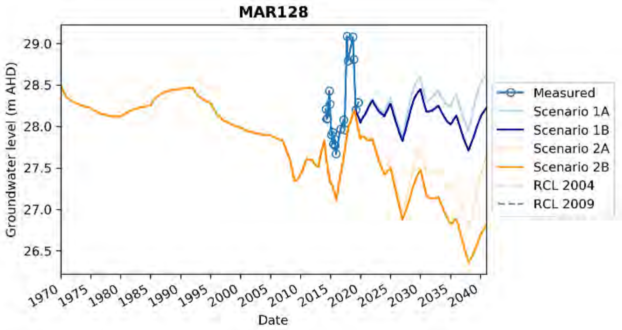

MAR081
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

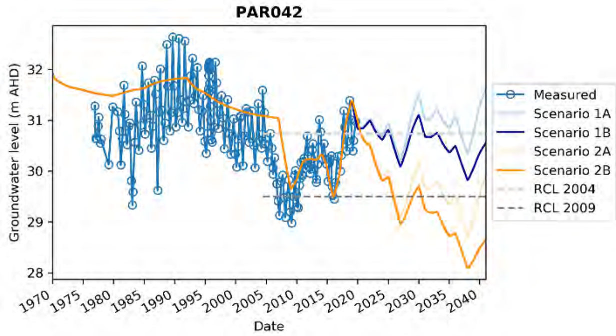

MAR076
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

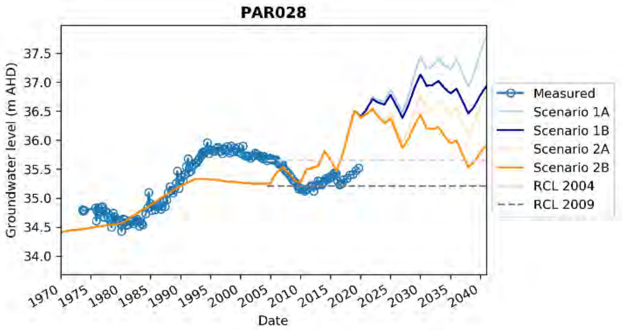

MAR114
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

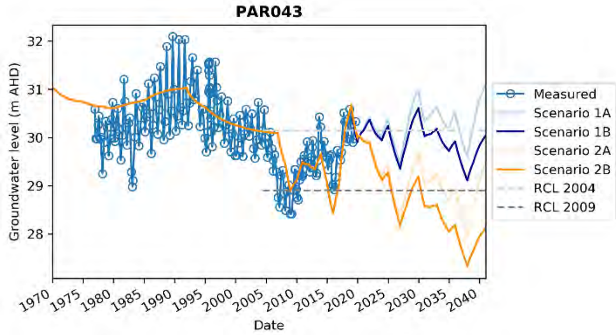

MAR077
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

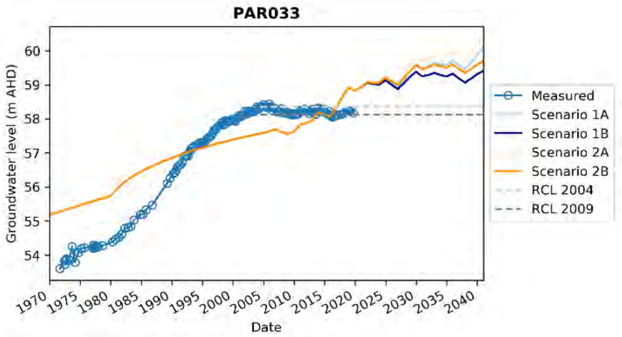

MAR127
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

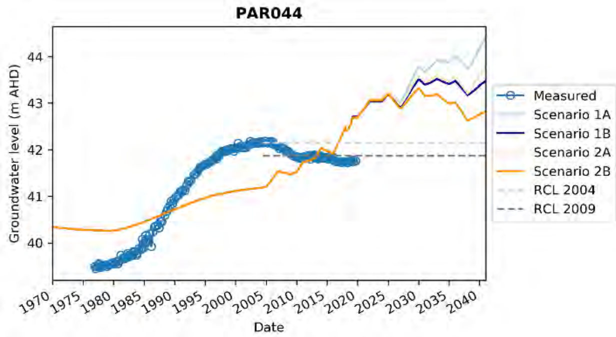

MAR128
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

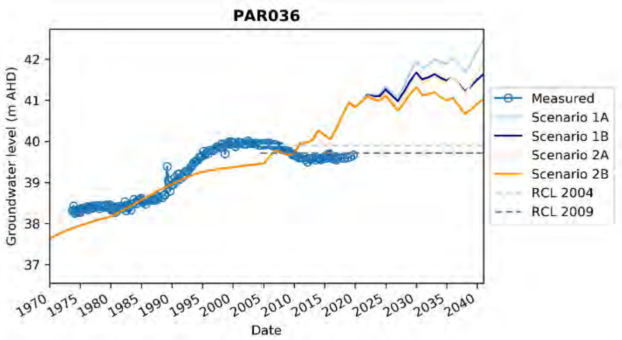

PAR042
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

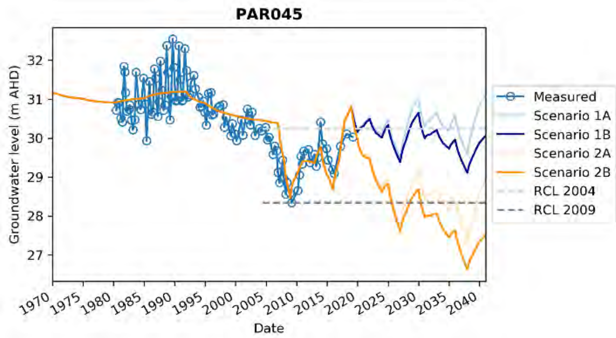

PAR028
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

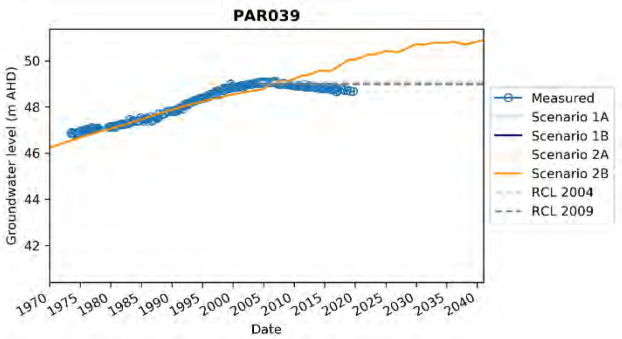

PAR043
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

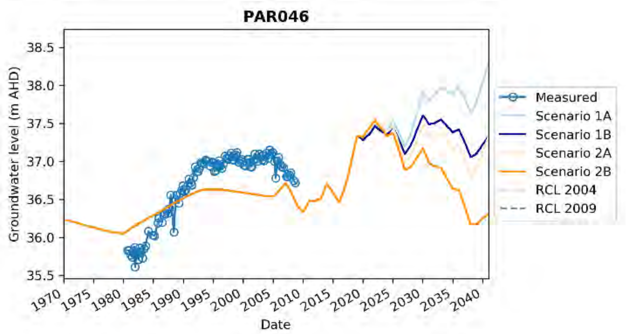

PAR033
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009


PAR044
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

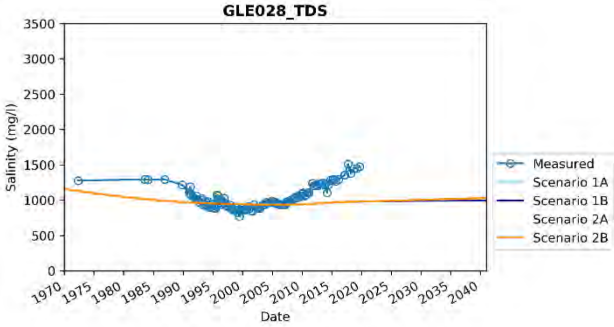

PAR036
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

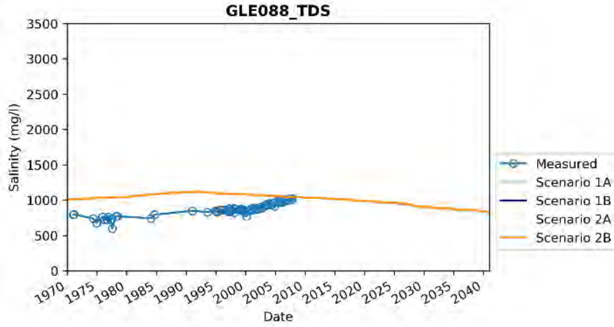

PAR045
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

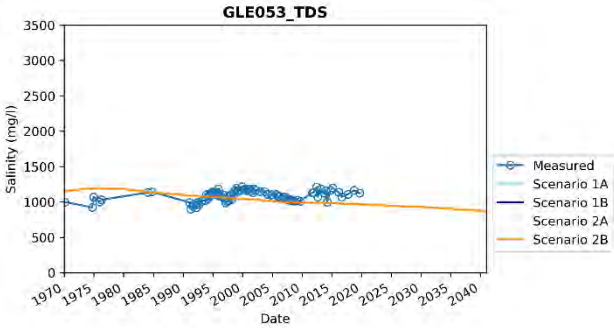

PAR039
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

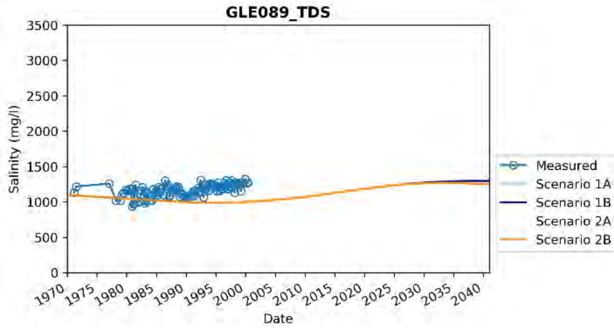

PAR046
Groundwater level (m AHD)
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B
RCL 2004
RCL 2009

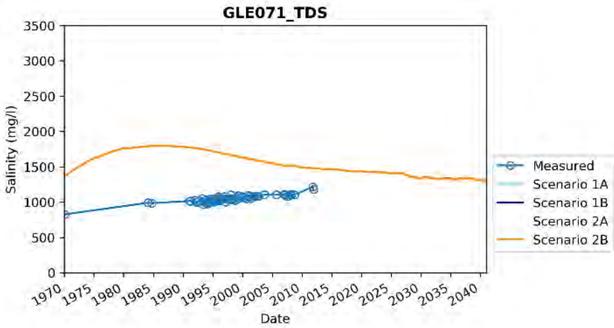
G. Measured and modelled groundwater salinity (scenarios)

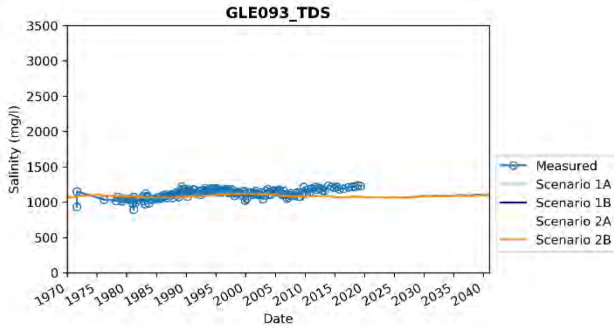


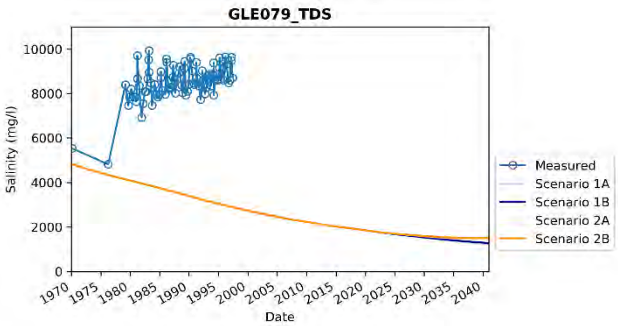


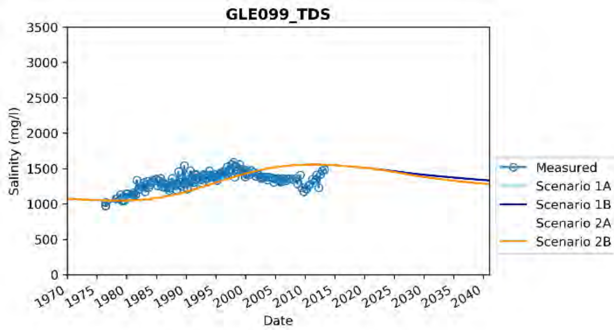


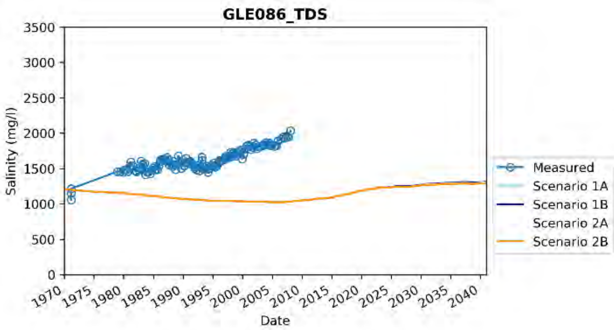


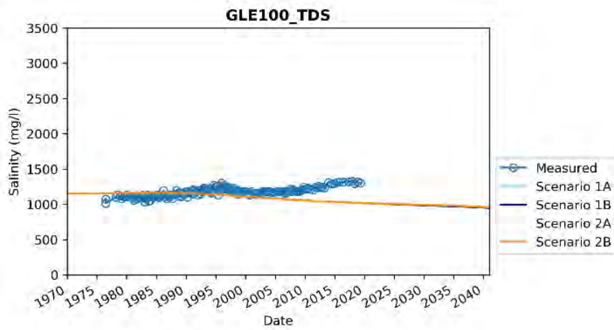


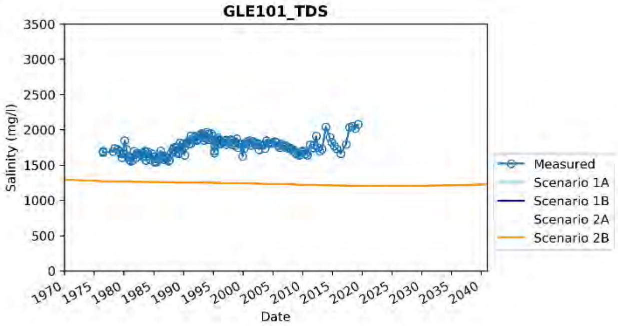


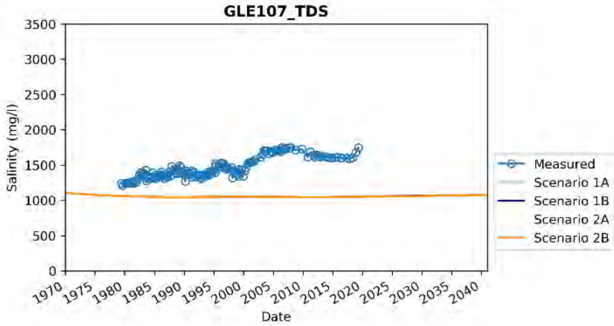


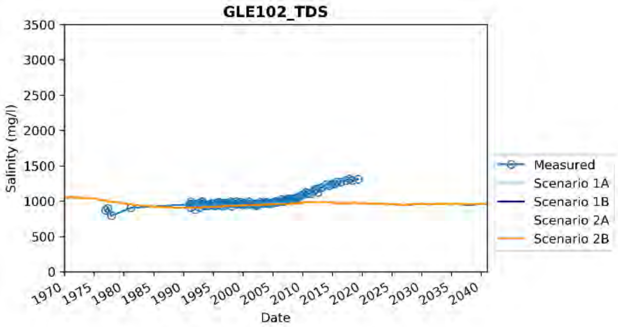







GLE101_TDS
Salinity (mg/l)
0
500
1000
1500
2000
2500
3000
3500
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B


GLE107_TDS
Salinity (mg/l)
0
500
1000
1500
2000
2500
3000
3500
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B


GLE102_TDS
Salinity (mg/l)
0
500
1000
1500
2000
2500
3000
3500
1970
1975
1980
1985
1990
1995
2000
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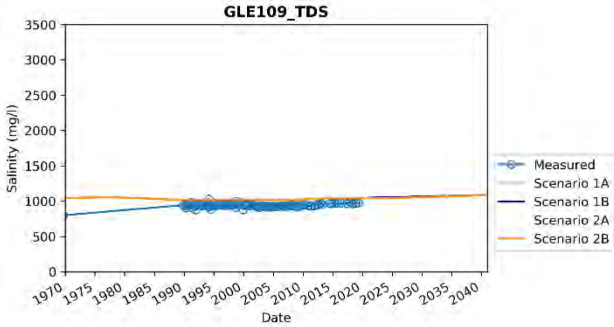
2020
2025
2030
2035
2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B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Salinity (mg/l)
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1000
1500
2000
2500
3000
3500
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1980
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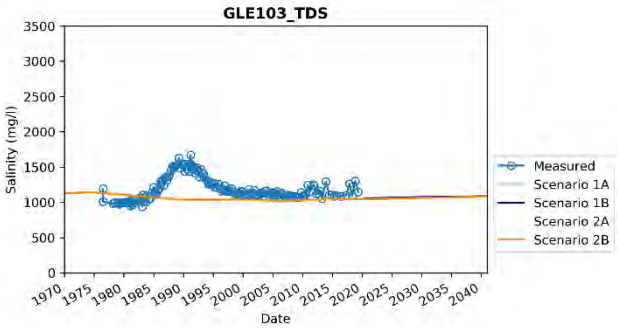
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B


GLE103_TDS
Salinity (mg/l)
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1000
1500
2000
2500
3000
3500
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1980
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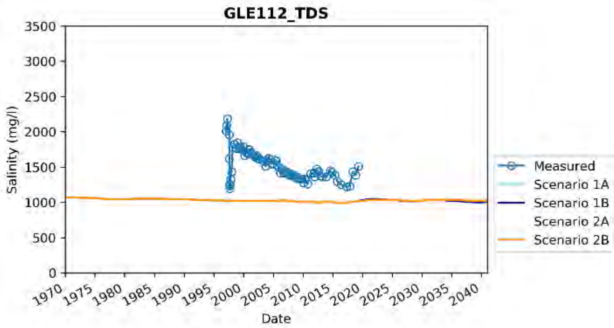
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B


GLE112_TDS
Salinity (mg/l)
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1000
1500
2000
2500
3000
3500
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2030
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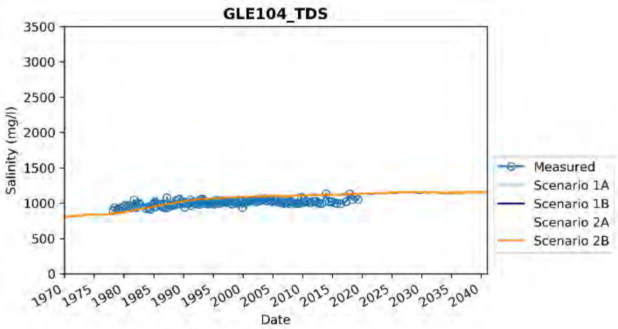
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B


GLE104_TDS
Salinity (mg/l)
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1500
2000
2500
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3500
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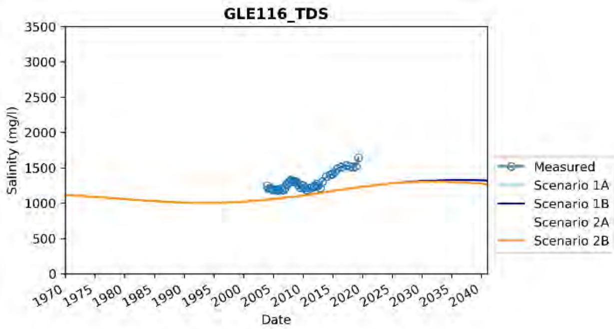
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B


GLE116_TDS
Salinity (mg/l)
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2000
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3500
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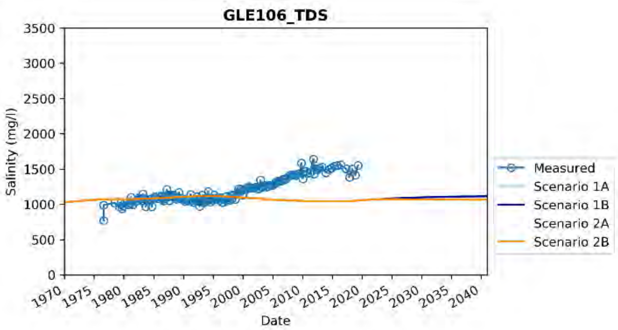
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B


GLE106_TDS
Salinity (mg/l)
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1500
2000
2500
3000
3500
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1980
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2025
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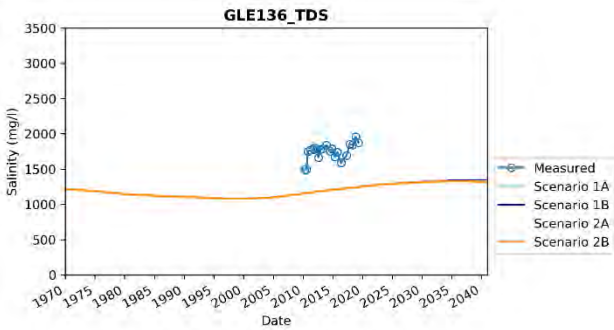
2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B


GLE136_TDS
Salinity (mg/l)
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2000
2500
3000
3500
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1995
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2025
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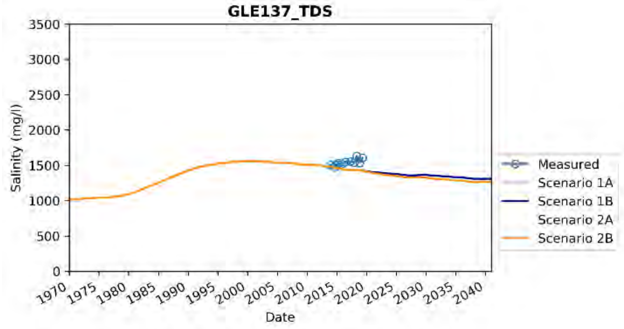
2035
2040
Date
Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B


GLE137_TDS
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Date
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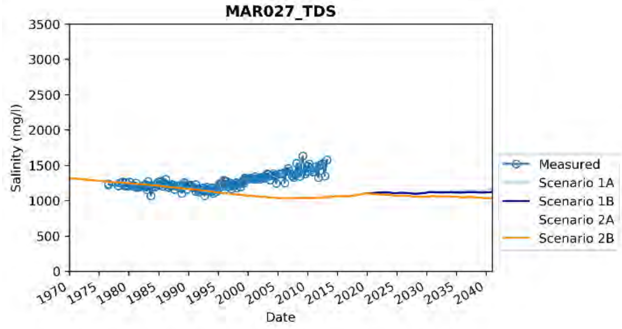
Scenario 2A
Scenario 2B


MAR027_TDS
Salinity (mg/l)
Date
Measured
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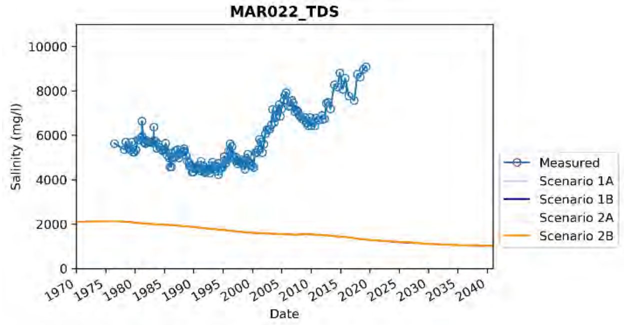
Scenario 2A
Scenario 2B


MAR022_TDS
Salinity (mg/l)
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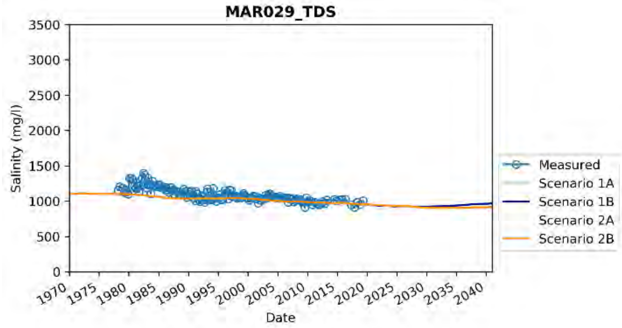
Scenario 2A
Scenario 2B


MAR029_TDS
Salinity (mg/l)
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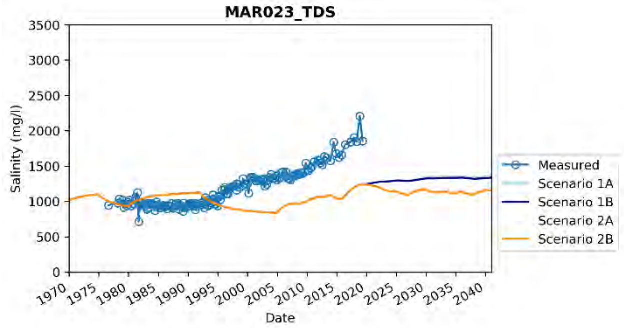
Scenario 2B


MAR023_TDS
Salinity (mg/l)
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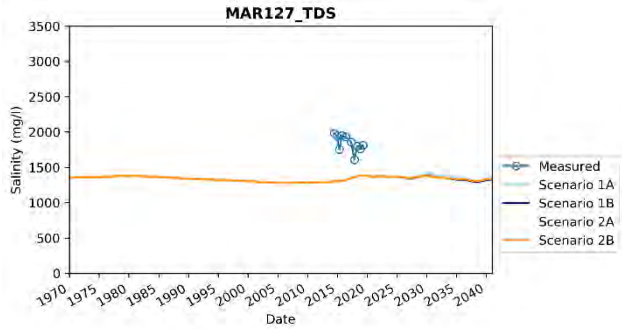
Scenario 2B


MAR127_TDS
Salinity (mg/l)
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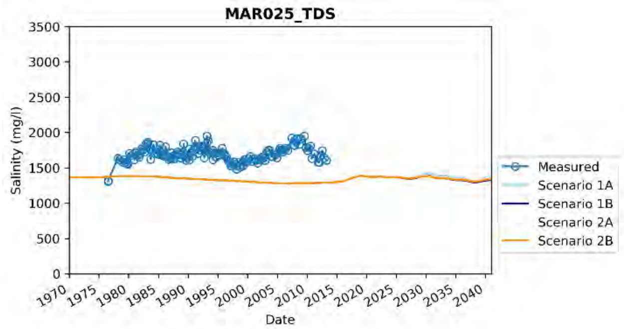
Scenario 2A
Scenario 2B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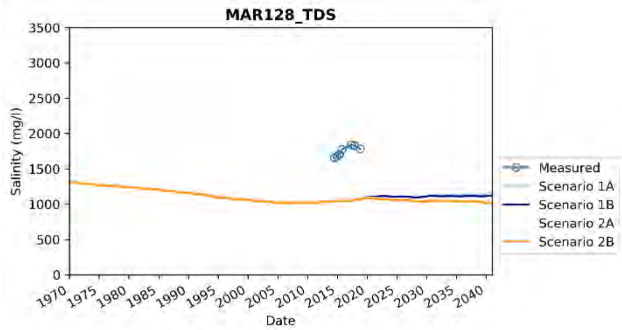
Scenario 2B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Salinity (mg/l)
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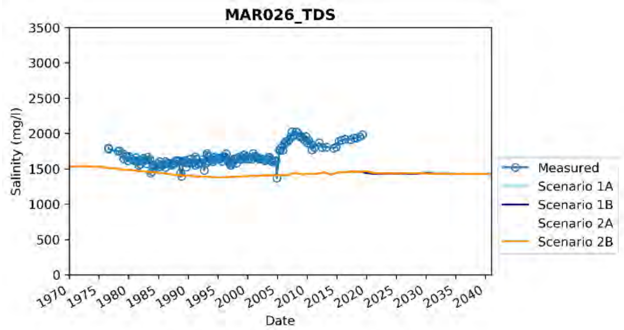
Scenario 1B
Scenario 2A
Scenario 2B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Salinity (mg/l)
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Measured
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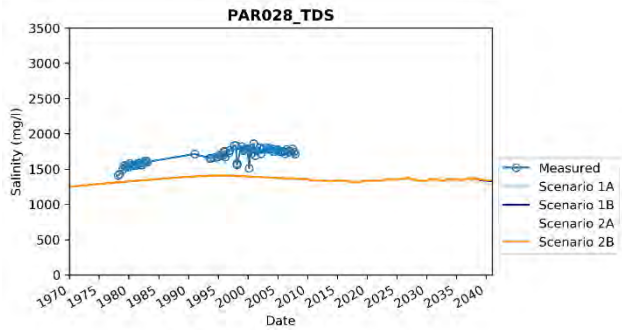
Scenario 2A
Scenario 2B


PAR028_TDS
Salinity (mg/l)
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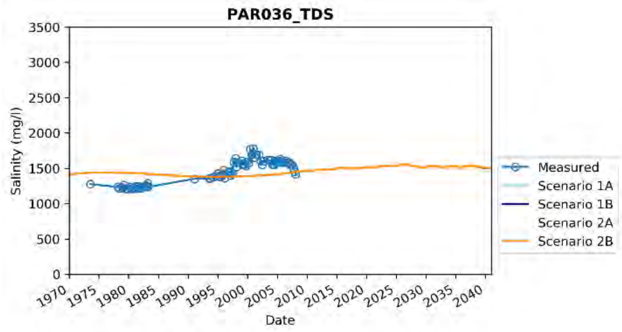
Scenario 2A
Scenario 2B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Salinity (mg/l)
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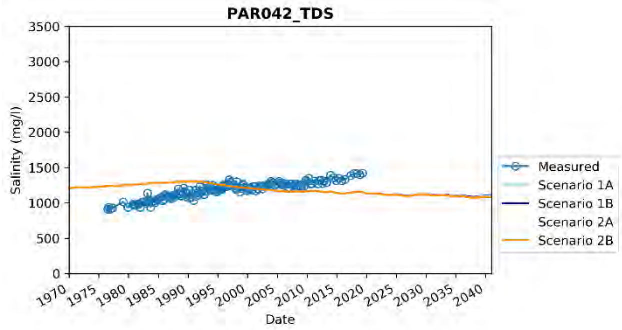
Scenario 2B


PAR042_TDS
Salinity (mg/l)
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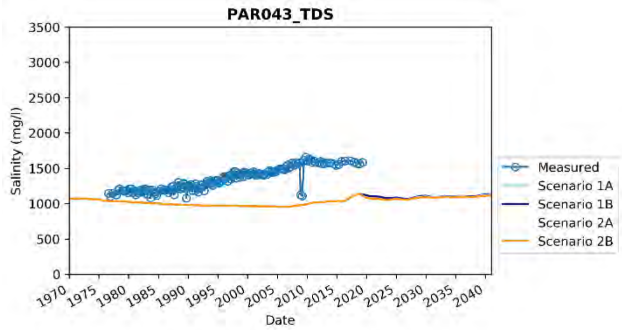
Scenario 2A
Scenario 2B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Salinity (mg/l)
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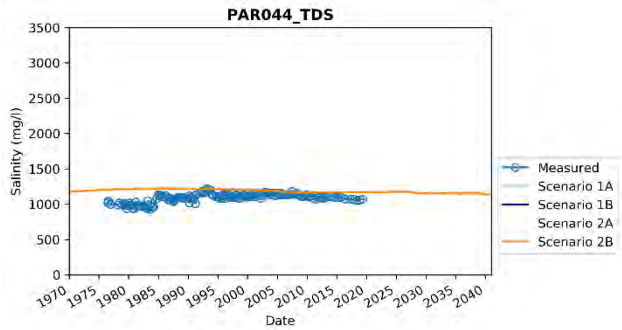
Scenario 2A
Scenario 2B


PAR044_TDS
Salinity (mg/l)
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Measured
Scenario 1A
Scenario 1B
Scenario 2A
Scenario 2B

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