Australasian Groundwater & Environmental Consultants

Report on

GS44 Upper Lachlan Alluvium Stage 5

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GS44 – Upper Lachlan Alluvium

Stage 5 – Assessment through multiple lines of evidence

The Upper Lachlan Alluvium (GS44) is located within the Lachlan catchment in central New South Wales bounded by Forbes and Parkes in the north, Cowra in the east, Lake Cargelligo in the west, and the towns of West Wyalong, Temora, and Cootamundra in the south (Figure 1). GS44 comprises valley-filled alluvial sediments within semiconfined/unconfined aquifers of the shallow Cowra Formation and the deeper Lachlan Formation. The shallow aquifer relationship is losing-connected to the Lachlan River and its tributaries (Crosbie et al., 2023); and given the water level depths, river leakage resulting from groundwater pumping is subdued and/or delayed (NSW DPE, 2022b). Lake Cowal is an ephemeral lake north-west of West Wyalong, with its main source of water being from Bland Creek. GS44 has eight jurisdictional management zones, and groundwater entitlements are concentrated along the Lachlan River between Cowra and Condobolin, with the highest-yielding bores located in Zone 3 near Forbes (Figure 1). GS44 spans approximately 13,341 km², with a Sustainable Diversion Limit (SDL) of 94.20 GL/year and a long-term average recharge estimate of 186.50 GL/year (Table 1). Between 2013 and 2023, average annual groundwater extraction was 55.54 GL/year, representing 30% of estimated recharge and 59% of the SDL (Figure 2). Groundwater use supports intensive irrigation, industry, stock and domestic, and local water utilities, supplementing surface water supply during years of below-average rainfall (Figure 2). Long-term climate observations show a relatively persistent below-average rainfall signal for the 2000–2010 period, with two cycles of above- and below-average rainfall between 2010 and 2020, and a sustained above-average rainfall period post-2020 (Figure 3). GS44 is characterised as mostly semiarid conditions with short periods of arid and sub-humid conditions based on the precipitation-to-evaporation ratio (Figure 3).

The water table fluctuates from 0 m to 10 m below the ground surface proximal to the Lachlan River in the western section of GS44 (Zones 8 and 5) and 10 m to 25 m below ground level in the eastern section of GS44 (Zones 1, 2, 3, 4, and 6; Figure 4a). Groundwater levels range from 0 m - 10 m up to >40 m in the central and southern parts of GS44 south of Lake Cowal (Zone 7). The deeper water levels in this zone are due to the observations being derived from the main source aquifer of that area, which is the deep alluvium. Groundwater flows from east to west along the Lachlan River valley (Zones 1 through 6), and south to north along the Bland Creek plain (Zone 7), with lower water levels in the west, towards Lake Cargelligo (Zone 8) (Figure 4b). Long-term (1974-2024) and short-term (2012-2024) median groundwater levels show spatial agreement and are contained within a well-defined multi-decadal fluctuation zone of up to 20 m thick (Figure 5). In some parts of GS44, the base of the groundwater fluctuation zone aligns with the recent (short-term) median water level (Figure 5; e.g. near Forbes in Zone 3), indicating that current levels are close to the deepest observed since 1974. Groundwater salinity ranges through all three RRAM classes (MDBA, 2020) and the Cowra and Lachlan Formations have differing water quality. There is typically higher quality water present in upgradient zones of the south and east, and saline water downgradient in Zone 8 (Figure 6). Water level trends vary spatially but show declines over the long-term (since the 1970s and 1980s), with multi-decadal variability (Figure 7; Figure 9). Short-term declining trends persist south of Lake Cowal (Zone 7), near Forbes (Zone 3), and west of Cowra (Zone 1) (Figure 10). However, the proportion of bores with sufficient data that have declining trends decreased from 75% in the long-term to 25% in the short-term. The understanding of temporal salinity trends is limited due to poor data availability (Figure 8).

MDBA (2020) previously reported recharge at 186.50 GL/year for GS44 derived from a calibrated groundwater model that includes diffuse, irrigation, floodplain, and in-stream recharge processes. The MD-SY2 project estimated diffuse recharge alone from WAVES modelling at 195.41 GL/year (Crosbie et al., 2025). Based on this, the estimate from the numerical modelling (186.50 GL/year) has been used for this assessment. Table 1 shows a storage-to-recharge ratio (S/R) of 744 using this estimate of recharge and the WERP estimate of storage (Rojas et al., 2022), suggesting high buffering capacity and limited vulnerability to short-term climate variability (S/R is above the “low responsiveness” threshold[1] defined in Rojas *et al.*, 2022). However, the moderate extraction-to-SDL (E/SDL, 0.59) and SDL-to-recharge (SDL/R, 0.51) ratios (Table 1) suggest moderate pressure on the productive base.

The productive base shows signs of stress, with long-term and short-term water level declines along the Lachlan River (Table 1; Figure 9; Figure 10). Statistically significant (α=0.05) declines of up to 0.5 m/year to 1 m/year have occurred since 1974 on the central and western areas of GS44. Statistically significant trends for the short-term show a shift towards better resource conditions (fewer bores with declining trends of high magnitude) in the areas where long-term declines are observed. The short-term period (2012-2024) is characterised by a mixed below- and above-average rainfall signal prior to 2020 and a positive annual rainfall anomaly post-2020 (Figure 3), and a substantial reduction in annual groundwater take post-2019 (Figure 2). Despite this alleviation of pressures, declining trends persist in GS44 in the short-term, which suggests that they may be attributed to legacy declines, including the impact of the millennium drought. Persisting groundwater declines are unlikely to affect surface water connectivity given groundwater level depths in GS44 proximal to Lake Cowal and the rivers and creeks (NSW DPE, 2022c), with most reaches of the Lachlan River classified as ‘always losing’ or ‘mostly losing’ during 2000-2019 by Crosbie et al. (2023). This adds uncertainty to potential impacts on groundwater-dependent ecosystems (GDEs) present along the Lachlan River, particularly between Forbes and Condobolin.

Stage 4 of this BPR technical groundwater review provided a quantitative assessment of resource condition indicators within a 5 km buffer around extraction points (asset area). Long-term groundwater level declines were observed in 46% of the productive base asset area, 47% of the river connectivity asset area, and 45% of the GDE asset area (Table 2). In the short-term, these percentages decreased markedly to 11%, 8%, and 9%, respectively (Table 2). In terms of asset areas showing improving or stable trends, the long-term areas ranged from 4% to 8% and show improved values in the short-term (42% to 43%), thus indicating partial recovery or stabilisation (Table 2). Across all ESLT values, the proportion of the asset area with uncertain trends is close to 50% for each asset area. Furthermore, the level of uncertainty has remained essentially unchanged- between the long- and short-term (minimal vertical displacement of points in Figure 11). The exception is the water quality (salinity) ESLT asset area, where recent data gaps have increased, with the long-term and short-term asset area fully classified as having ‘insufficient data’ to determine temporal trends.

The NSW state-based risk assessment (NSW DPE, 2022a) assigns variable risk ratings across ESLT values of GS44. For the productive base, risks are rated low to high. Local drawdown reducing groundwater access by consumptive users is rated as high risk, with a high tolerable residual risk. Risks to the structural integrity of aquifer systems, as well as risks of growth in water utilities and basic landholder rights (BLR), reducing groundwater availability are rated medium. River connectivity risks are rated medium to high for groundwater take impacting in-stream ecological values, which is spite of the observed groundwater depths and the disconnected-losing classification of the Lachlan River and main creeks in GS44. Risks to GDEs range from low to high depending on category: risks of groundwater extraction causing local drawdown impacting GDEs are rated high, with a high and tolerable residual risk; risks of climate change reducing groundwater availability to GDEs, and poor water quality to GDEs are rated low. Finally, the risk of groundwater extraction inducing connection with poor quality groundwater is rated as high, with a high and tolerable residual risk. Data availability is moderate for water levels but substantially more limited for salinity and riverine GDEs, contributing to residual uncertainty in the risk profile for those ESLT values.

[1] S/R ratio: High responsiveness: 29 to 111.
Medium responsiveness: 11 to 333.
Low responsiveness: >333.

Future projections from the MD-SY2 project suggest that diffuse recharge in GS44 may increase by 2050 due to more intense rainfall events (Crosbie et al., 2025). In contrast, overbank flood recharge and in-stream recharge are projected to decline by 38% and 9.4% relative to current conditions, respectively (Crosbie et al., 2025), potentially reducing (localised) episodic recharge and groundwater availability during dry periods. These opposing trends introduce uncertainty regarding net future recharge in GS44. Stage 6 of this BPR technical groundwater review found that the future area of drawdown (Area of Influence, AoI[2]) is projected to expand under climate change scenarios, with the median future AoI (P50) marginally exceeding the present AoI, indicating likely increases in deteriorating areas (Figure 12). In relation, the SDL/R ratio is also projected to change slightly, remaining close to 0.5. The Stage 6 assessment classified the pressure from future climate change on GS44 groundwater resources as high (based on long- and short-term water level evidence).

Overall, long-term (1974-2024) and short-term (2012–2024) groundwater trends suggest conditions for ESLT values in GS44 have improved significantly towards improving/stable conditions, while uncertainty levels are largely unchanged from the long-term assessment (1974–2024). Despite this improvement, some declining trends remain that may be due to legacy drawdown, despite a recent rainfall increase and a take decrease. Groundwater demand in GS44 is within a setting of insecure surface water supply, with the Lachlan River running dry in extended droughts. As such, management is active and the community is responsive to interventions, such as a current limit for licence holders in Zone 1 to 30% of their shares. Mining is also present in the region of GS44 and take of groundwater for resources development is managed using triggers and volumetric limits. Although there a known patterns of fresh and saline water in the aquifers of GS44, uncertainty in monitoring data for salinity trends has remained high, with 100% of the short-term asset area now classified as insufficient data to inform temporal trends. Since 2020, groundwater extraction remained well below the SDL and the aquifer has strong buffering capacity; however, the SDL/R ratio is high (0.51) and declining water level trends persist. The state-based risk assessment supports this concern, highlighting medium to high risks for water quality and local drawdowns. Climate projections indicate reduced episodic (localised) recharge from floodplain processes. Collectively, the analysis suggests that there is moderate pressure on the productive base of GS44, and high pressure from future climatic variability.

[2] Area of influence is defined as the area impacted by drawdown caused by groundwater extraction. For the quantitative assessment of Stage 4, this is equivalent to the percentage asset area showing a deteriorating resource condition, which is a statistically significant declining trend in groundwater level.

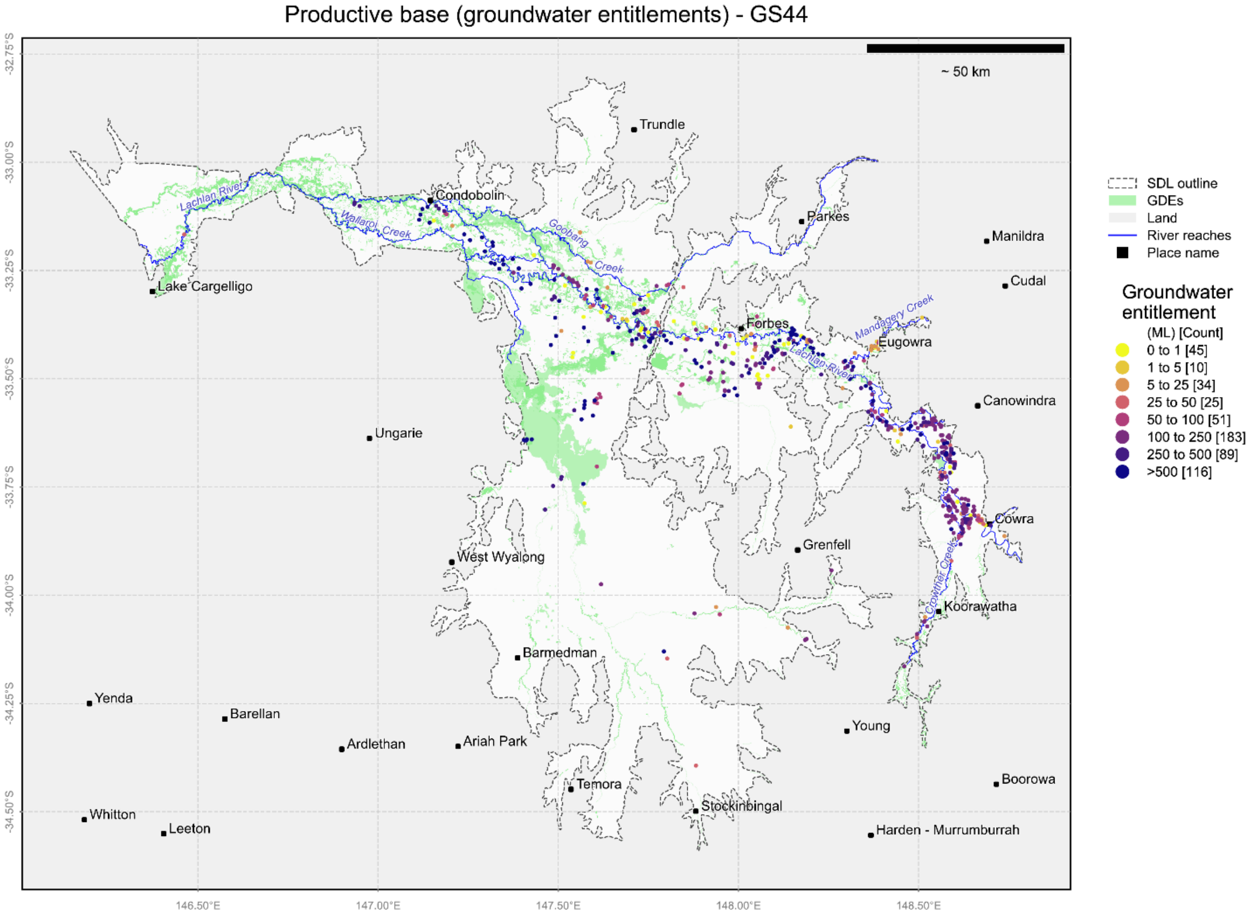


Figure 1 Productive base (groundwater entitlements)

Figure 2 Groundwater take in the SDL since 2012

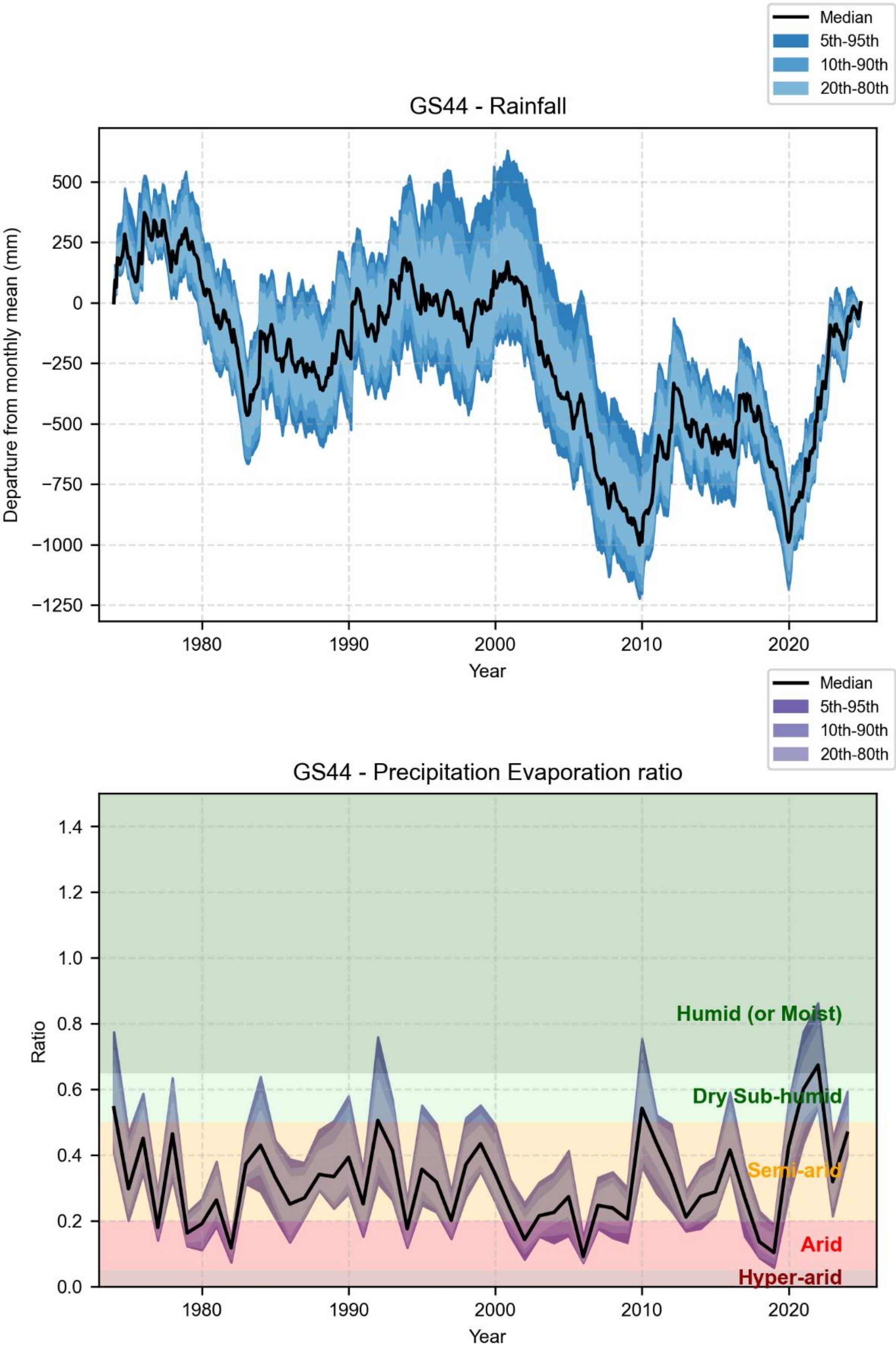
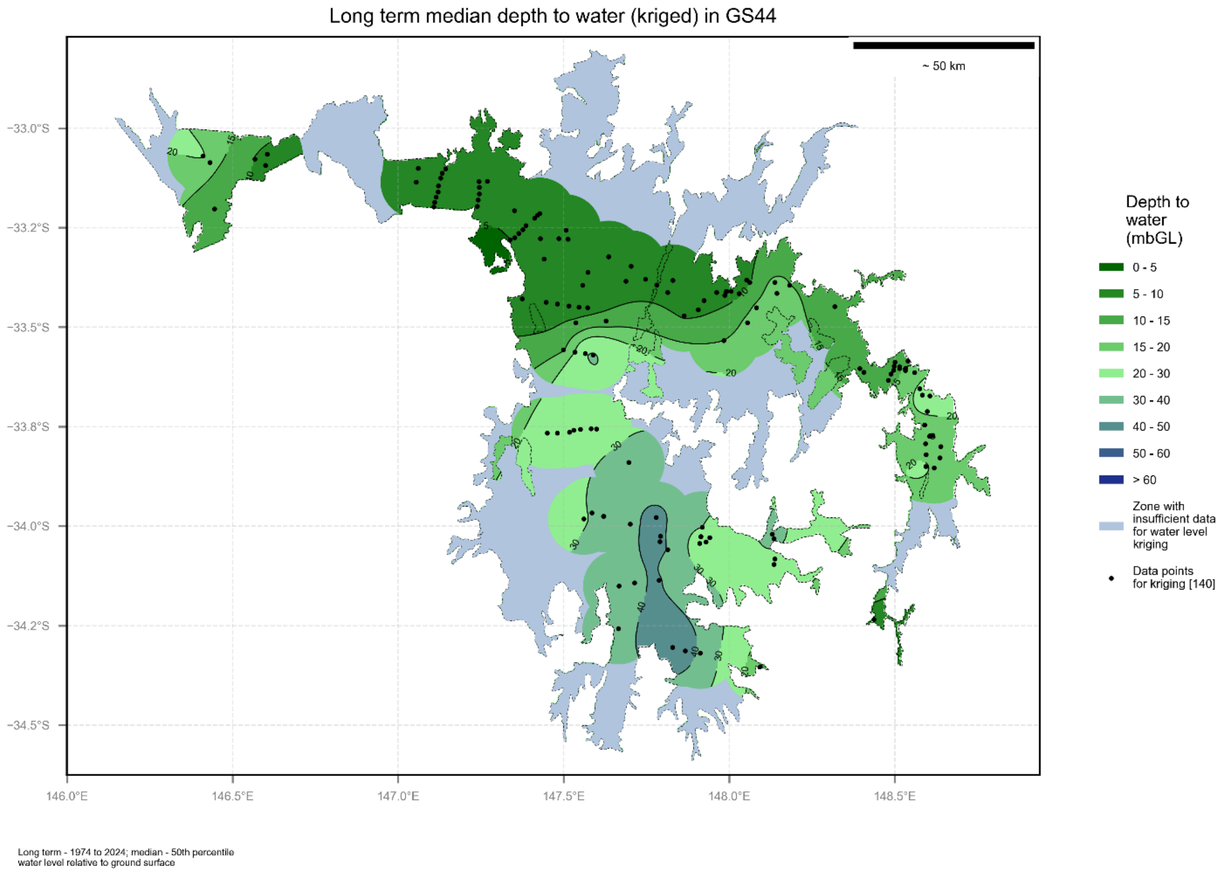
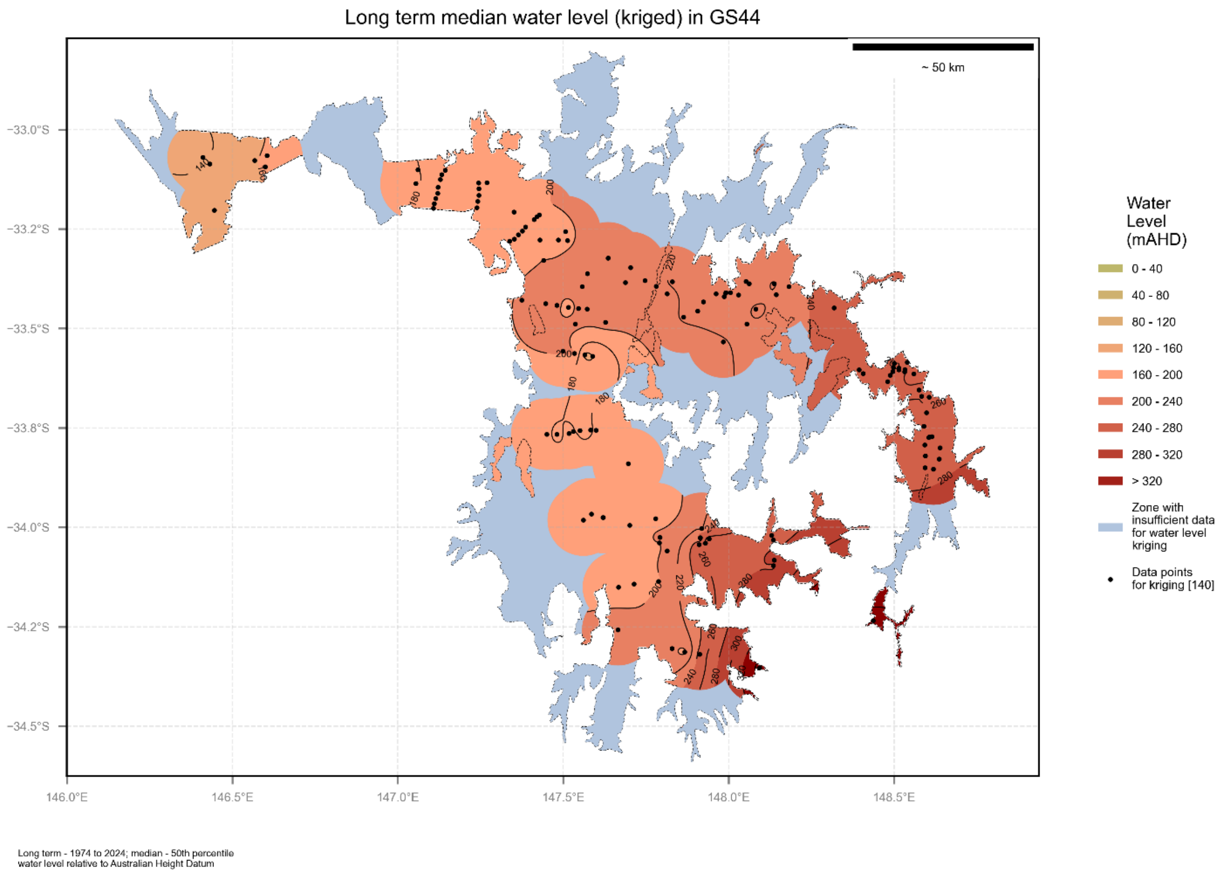


Figure 3 Historical climate trends

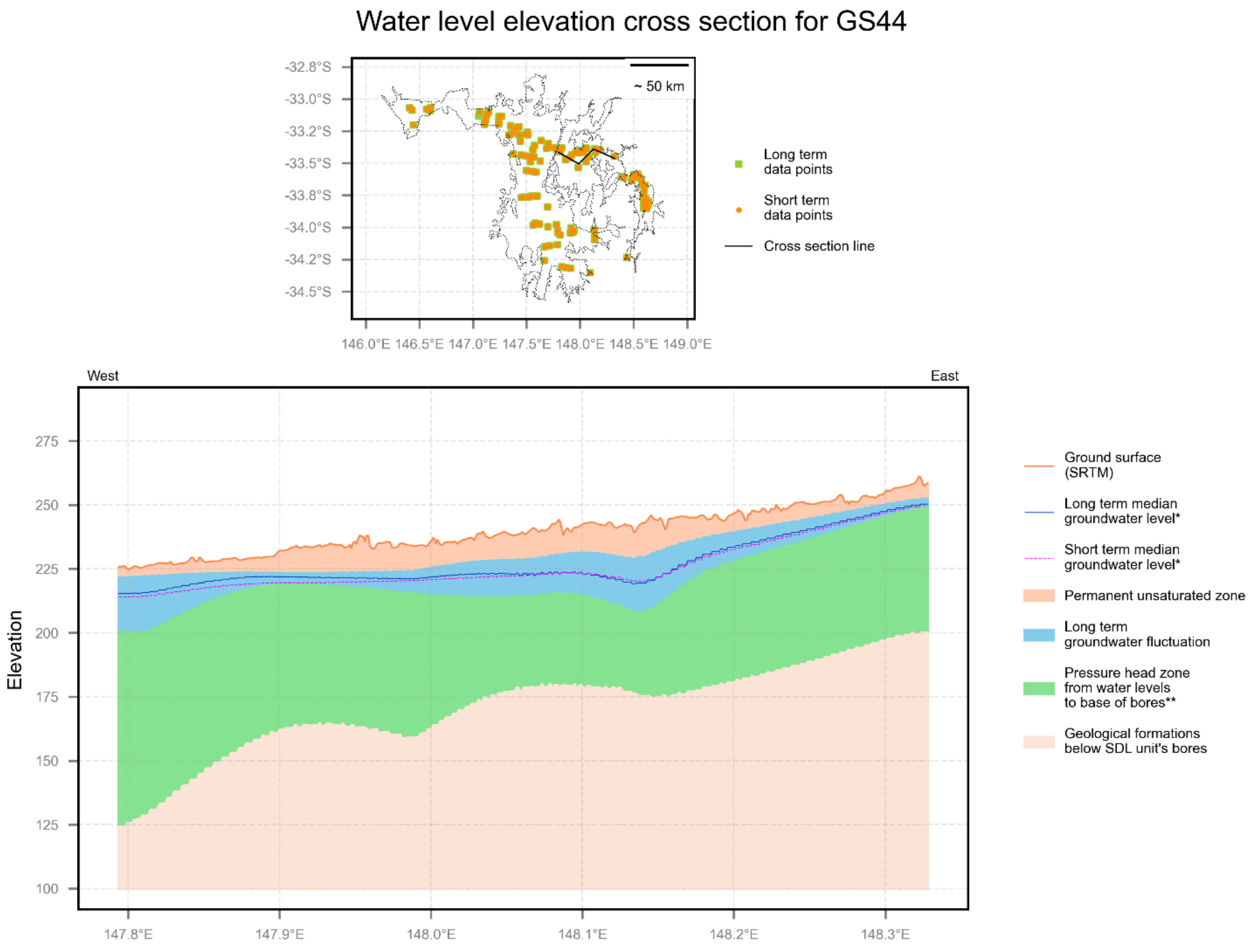


a)



b)

Figure 4 Long-term median (a) depth to water and (b) water level elevation



*Long term - 1974 to 2024; Short term - 2012 to 2024; median - 50th percentile

***This cross-section is a scaled representation of bore data specific to the SDL resource unit.*
The data are temporally and spatially aggregated, resulting in some smoothing of the representation of water levels and aquifer formations that is different from the detail of reality.
The blue zone represents the long term fluctuation in groundwater levels, as indicated by the 5th and 95th percentiles of groundwater levels from 1974 to 2024.
The green pressure head zone may be representative of the total available drawdown (TAD), as it shows the water column in bores of the SDL resource unit
(measured as the difference between the long-term 5th percentile groundwater level and the base of the bores of the SDL resource unit).
This cross-section is for interpretation purposes only and should not be used for planning or compliance purposes.

Figure 5 West to east distribution of water levels in the SDL resource unit

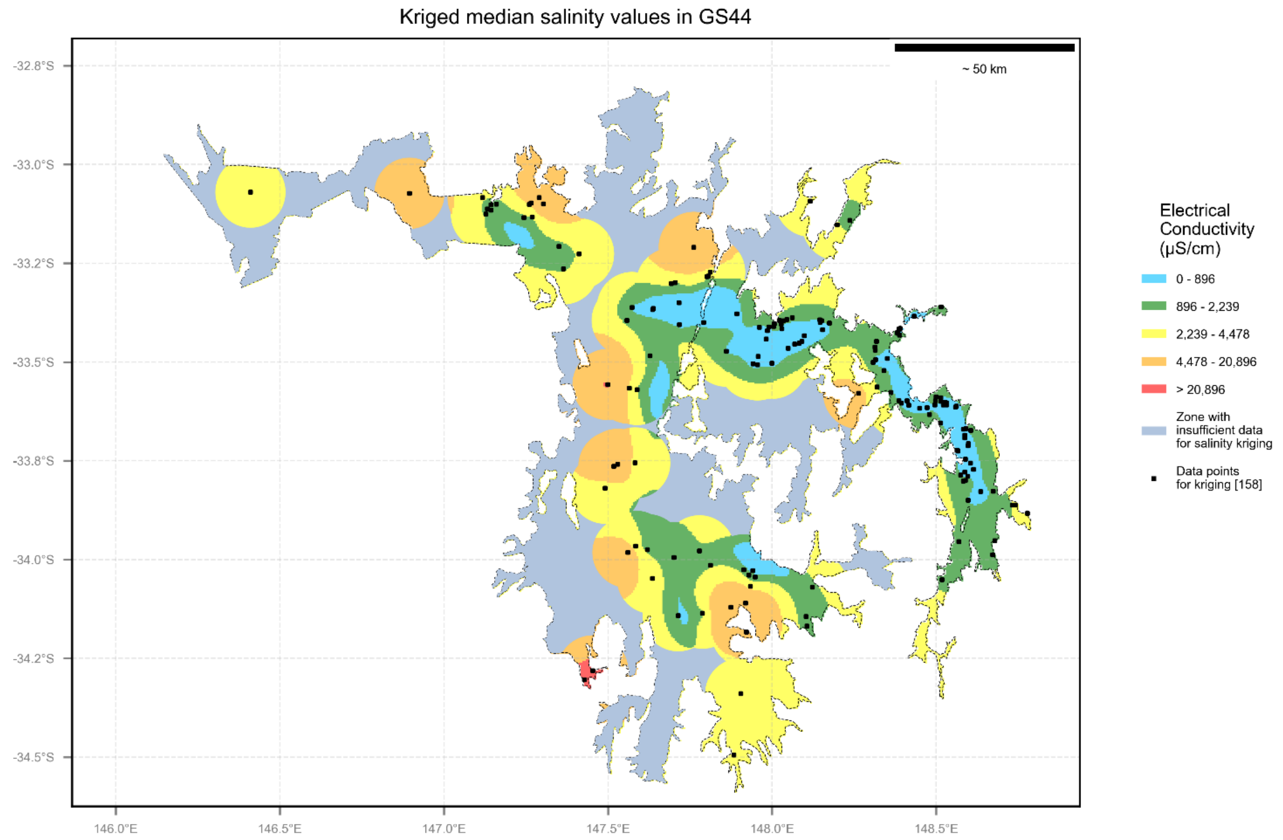


Figure 6 Groundwater salinity distribution

Table 1 Table of groundwater metadata for the SDL resource unit

Parameter	Unit	Long-term (1974 to 2024)	Short-term (2012 to 2024)	SDL resource unit data
SDL volume	GL/y	-	-	94.20
SDL resource unit area	km²	-	-	13,341
Average annual take (2013 to 2023)	GL/y	-	-	55.54
Number of groundwater entitlement bores	-	-	-	553
SDL resource unit storage estimate*	GL	-	-	138,833
Recharge estimate (SY1)	GL/y	-	-	186.50
Recharge estimate (Stage 2)	GL/y	-	-	186.50
Diffuse recharge estimate (SY2 - WAVES)	GL/y	-	-	195.41
Extraction/SDL (E/SDL) (Stage 2 result)	-	-	-	0.59
SDL/Recharge (SDL/R) (Stage 2 result)	-	-	-	0.51
SDL/Recharge (SDL/R) (SY2 or modelled recharge)	-	-	-	0.51
Storage/Stage 2 Recharge (S/R)	-	-	-	744
Storage/SY2 or modelled Recharge (S/R)	-	-	-	744
Number of bores in the SDL unit	-	4,660	4,660	-
Number of bores for water level trend analysis	-	141	139	-
Number of bores for water level trend with sufficient data	-	140	136	-
Number of bores with decreasing water level trend	-	105	34	-
Number of bores with increasing water level trend	-	23	30	-
Number of bores with no statistically significant water level trend	-	12	72	-
Mean water level trend magnitude	m/y	-0.13	0.03	-
Minimum water level trend magnitude	m/y	-1.67	-0.85	-
5%ile water level trend magnitude	m/y	-0.55	-0.39	-
10%ile water level trend magnitude	m/y	-0.38	-0.26	-
50%ile water level trend magnitude	m/y	-0.07	0.06	-
90%ile water level trend magnitude	m/y	0.09	0.26	-
95%ile water level trend magnitude	m/y	0.19	0.32	-
Maximum water level trend magnitude	m/y	0.42	0.44	-
Number of bores for salinity trend analysis	-	166	N/A	-
Number of bores for salinity trend with sufficient data	-	0	N/A	-
Number of bores with decreasing salinity trend	-	0	N/A	-
Number of bores with increasing salinity trend	-	0	N/A	-
Number of bores with no statistically significant salinity trend	-	0	N/A	-
Mean salinity trend magnitude	µS/cm/y	N/A	N/A	-
Minimum salinity trend magnitude	µS/cm/y	N/A	N/A	-
5%ile salinity trend magnitude	µS/cm/y	N/A	N/A	-
10%ile salinity trend magnitude	µS/cm/y	N/A	N/A	-
50%ile salinity trend magnitude	µS/cm/y	N/A	N/A	-
90%ile salinity trend magnitude	µS/cm/y	N/A	N/A	-
95%ile salinity trend magnitude	µS/cm/y	N/A	N/A	-
Maximum salinity trend magnitude	µS/cm/y	N/A	N/A	-

Note: *Groundwater resource storage estimate source: WERP (RQ8b).

Table 2 Table of results from spatial analysis of RCI trends in ESLT asset areas

ESLT Value	Asset area (m2)	Long-term				Short term			
		Proportion of asset area with improving/ stable RCI trends	Proportion of asset area with deteriorating RCI trends	Proportion of asset area with uncertain RCI trends	Trend grouping	Proportion of asset area with improving/ stable RCI trends	Proportion of asset area with deteriorating RCI trends	Proportion of asset area with uncertain RCI trends	Trend grouping
Productive base	5,714,308,493	8%	46%	46%	Variable trends	43%	11%	46%	Variable trends
GDEs	5,283,167,894	7%	45%	48%	Variable trends	43%	9%	48%	Variable trends
River connectivity	4,213,447,458	4%	47%	50%	Variable trends	42%	8%	50%	Variable trends
Water quality	5,678,070,297	0%	0%	100%	Insufficient data	0%	0%	100%	Insufficient data

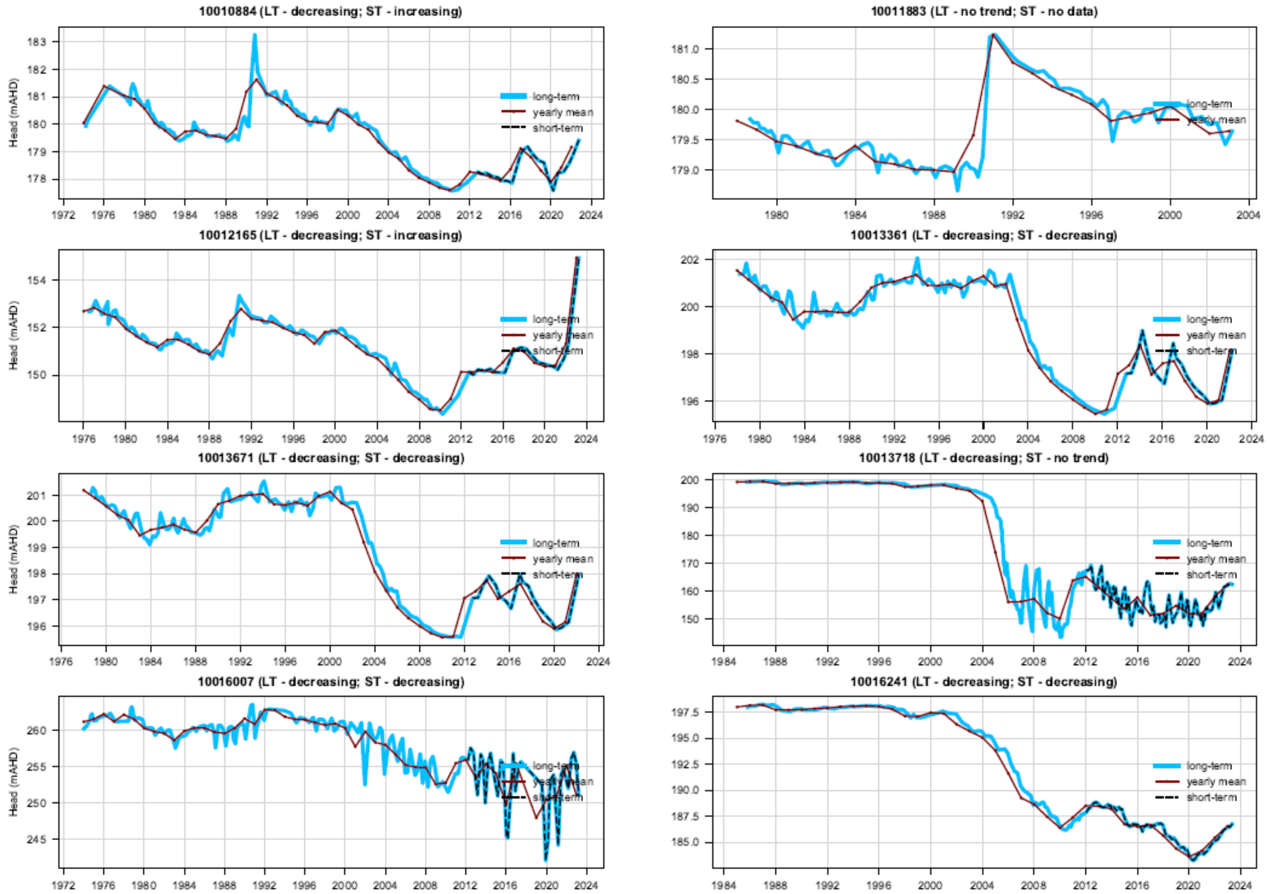


Figure 7 Representative groundwater hydrographs for the SDL resource unit

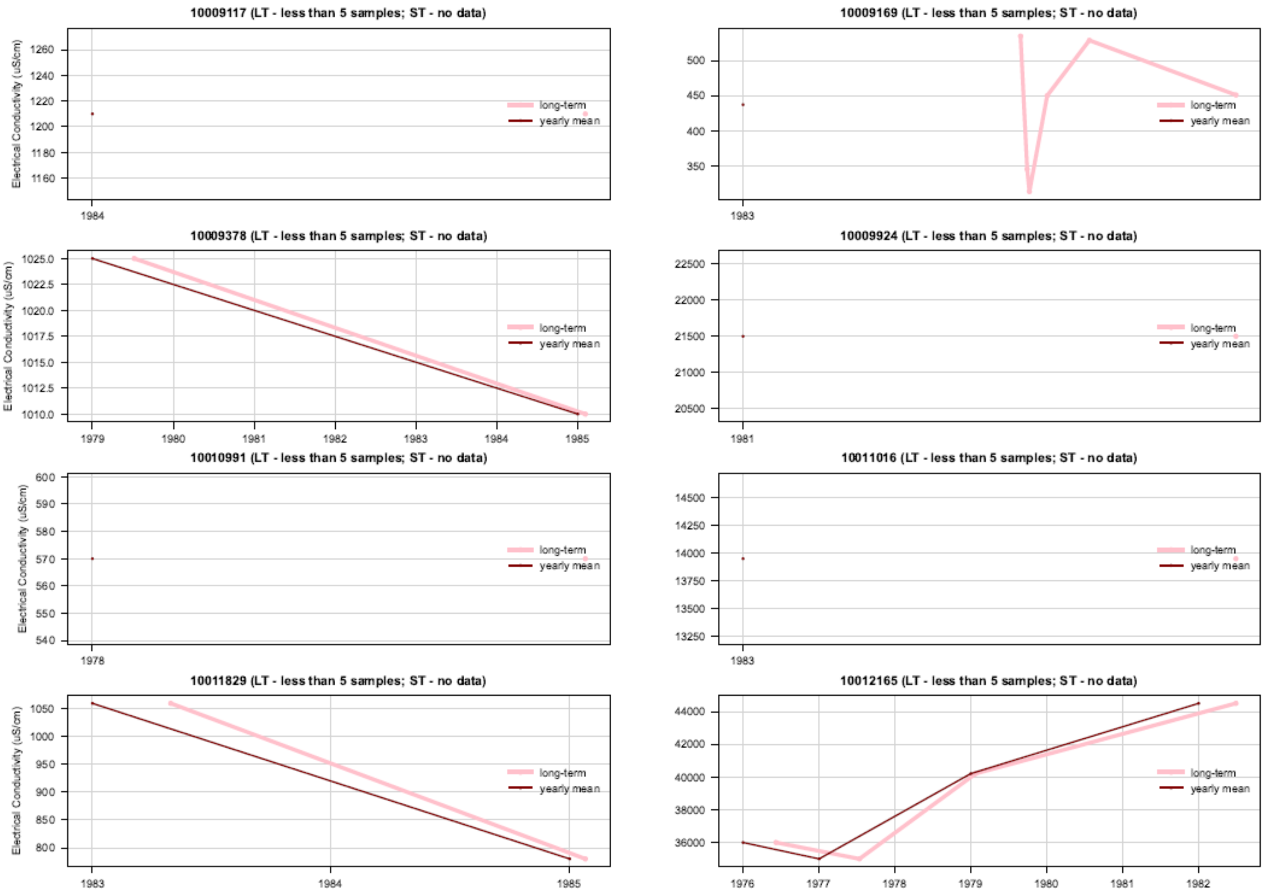
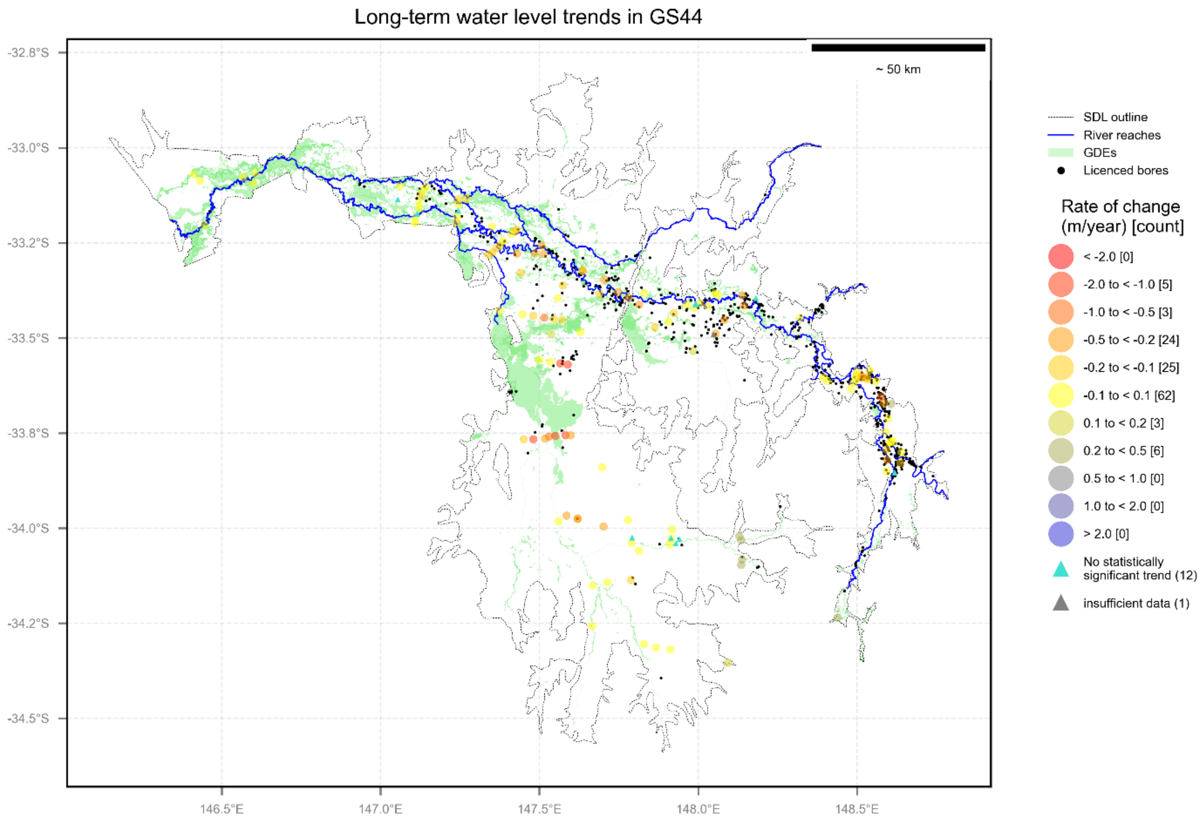


Figure 8 Representative groundwater salinity time series for the SDL resource unit



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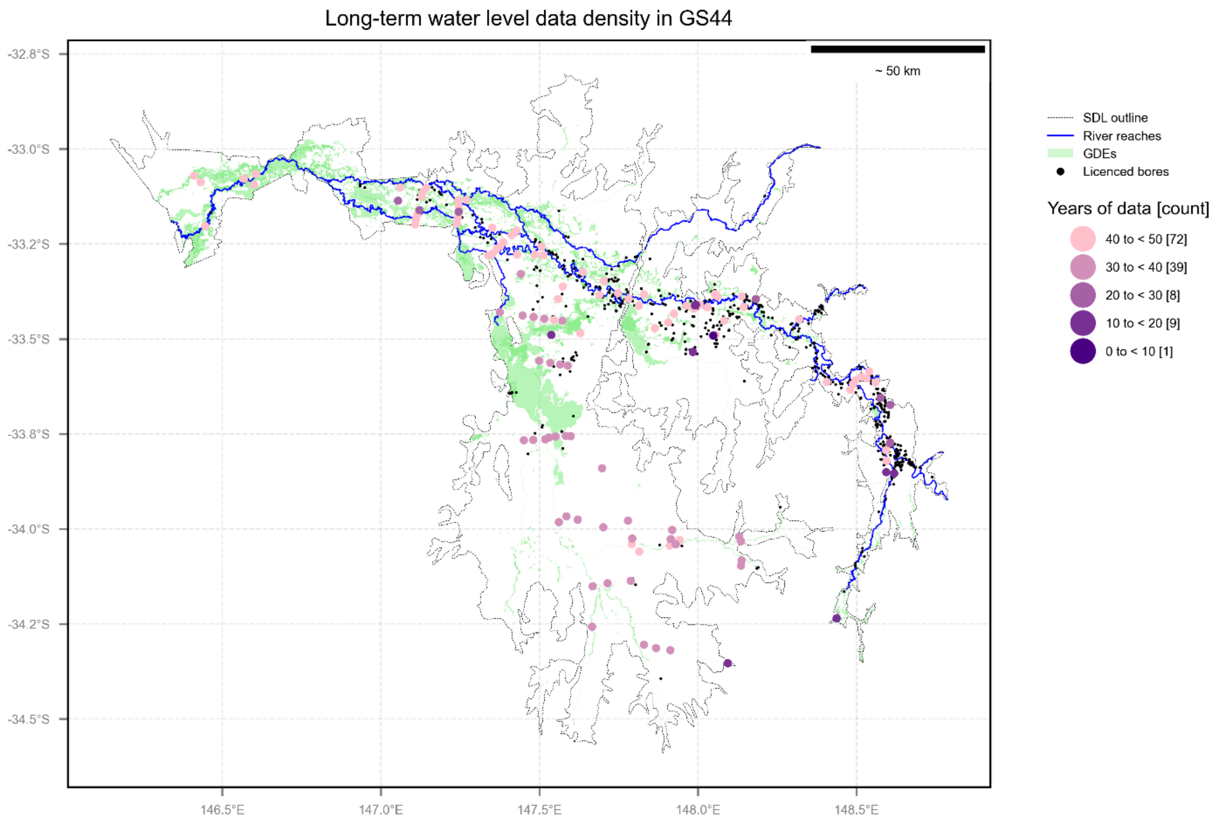

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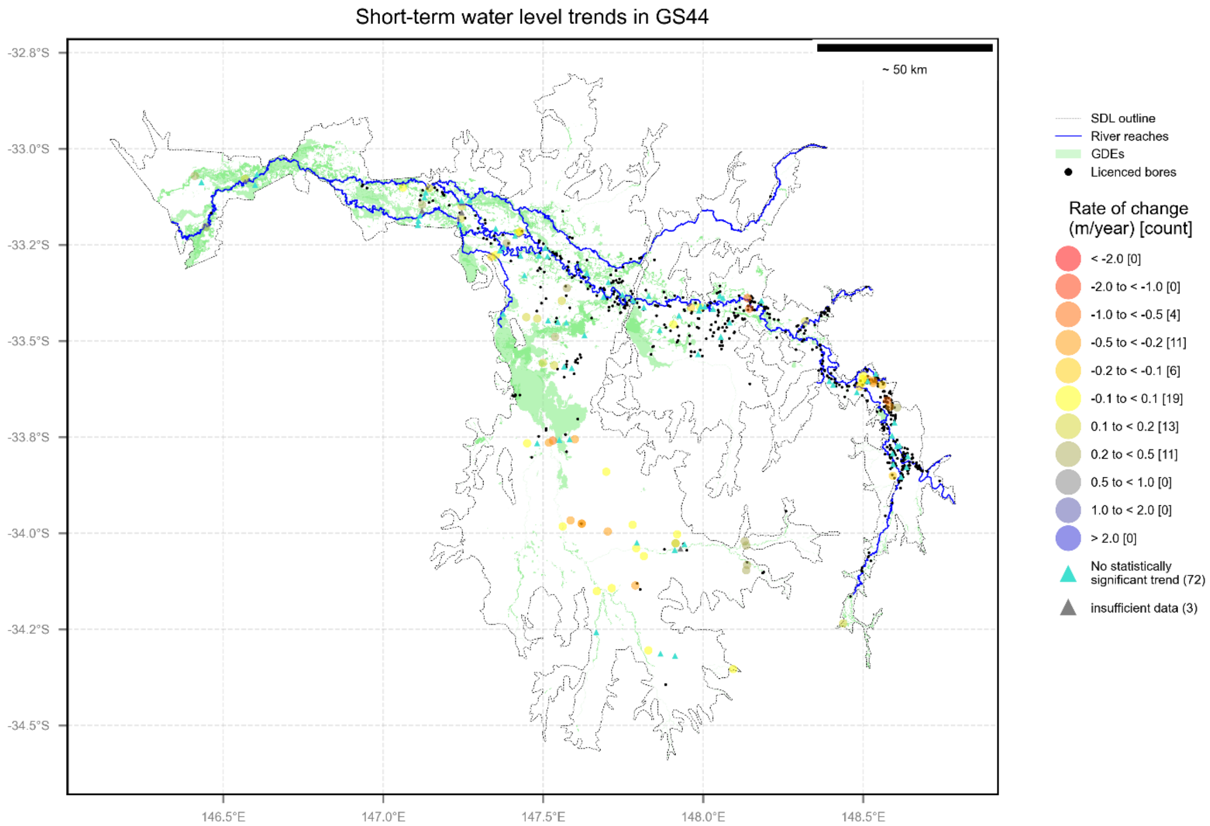
Figure 9 Long-term (1974 to 2024) groundwater level trends (a) and data availability (b)



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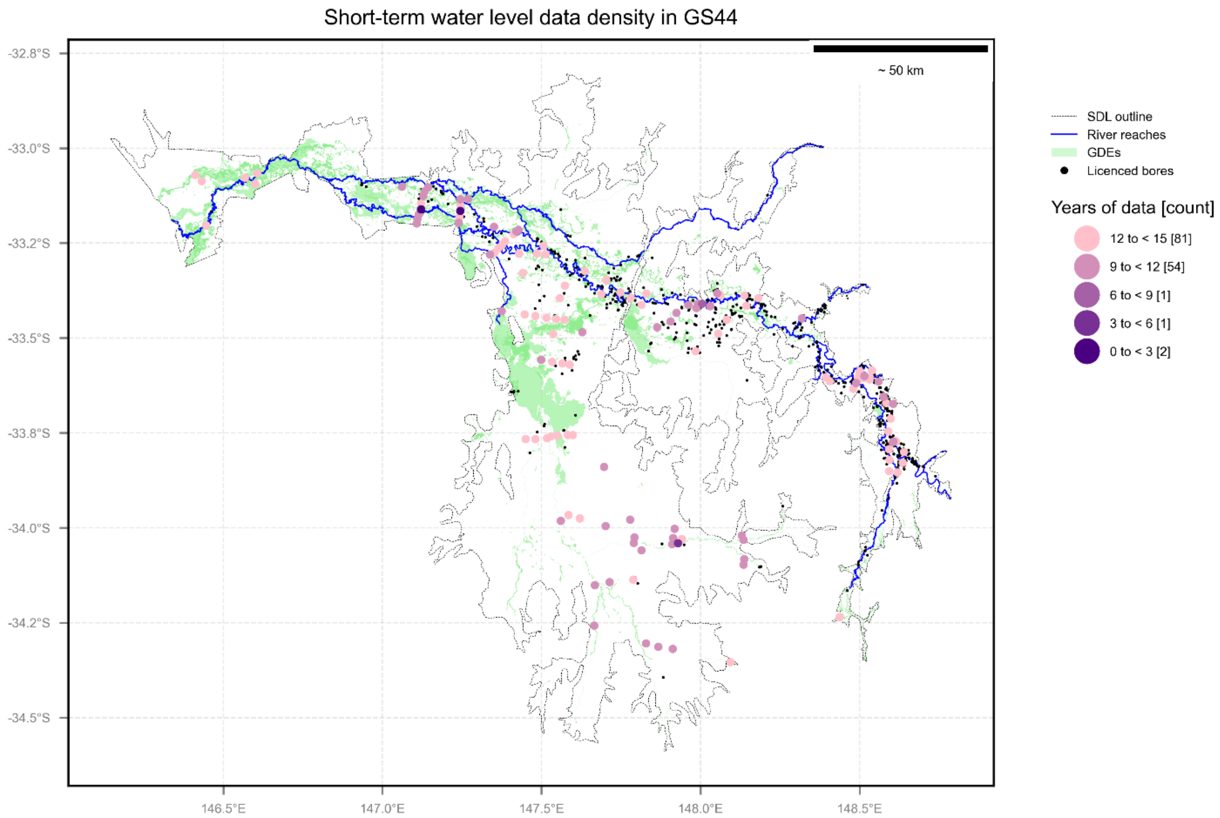

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Figure 10 Short-term (2012 to 2024) groundwater level trends (a) and data availability (b)

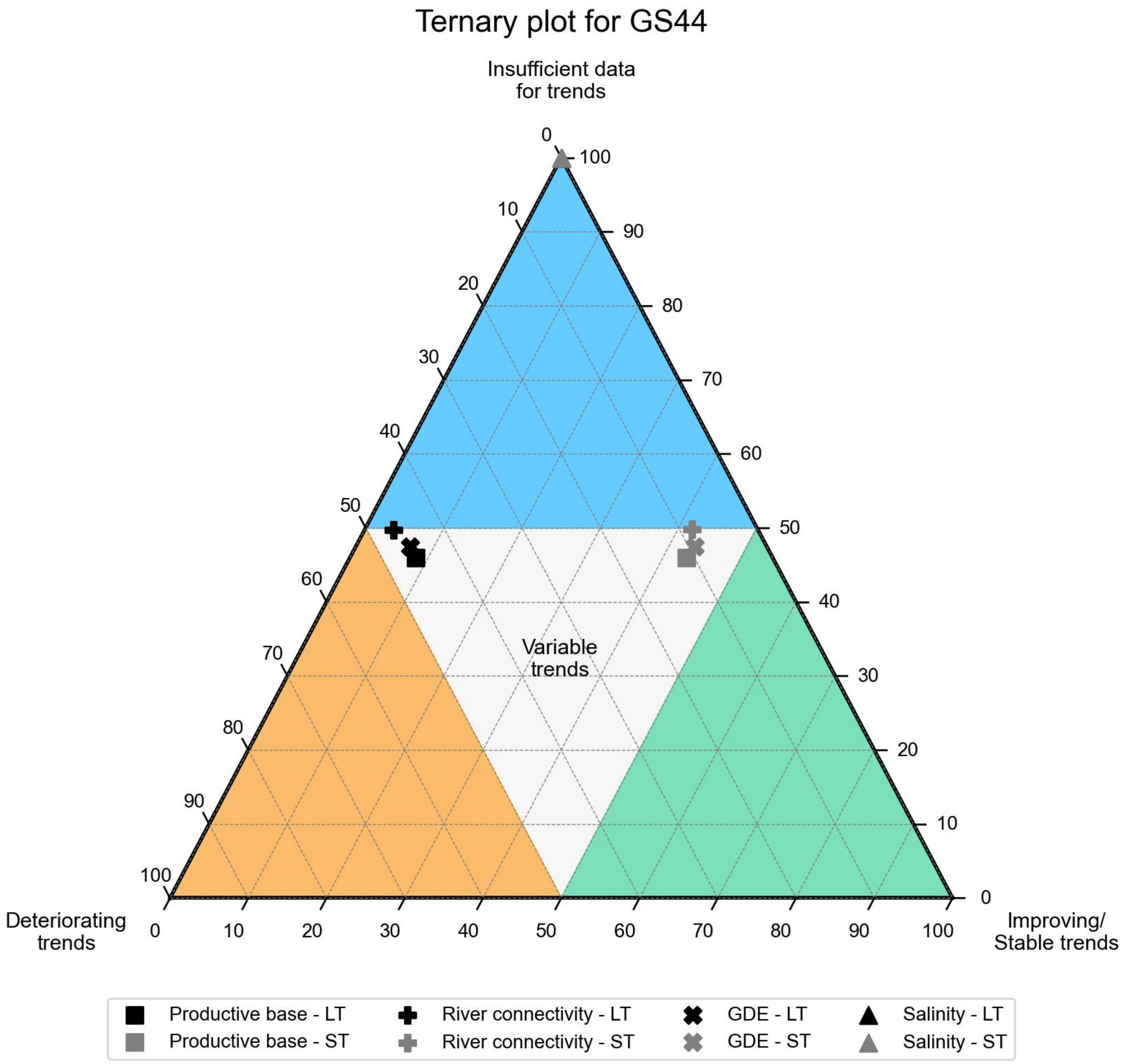

Figure 11 Stage 4 assessment outcome: trends in resource condition indicators for ESLT values

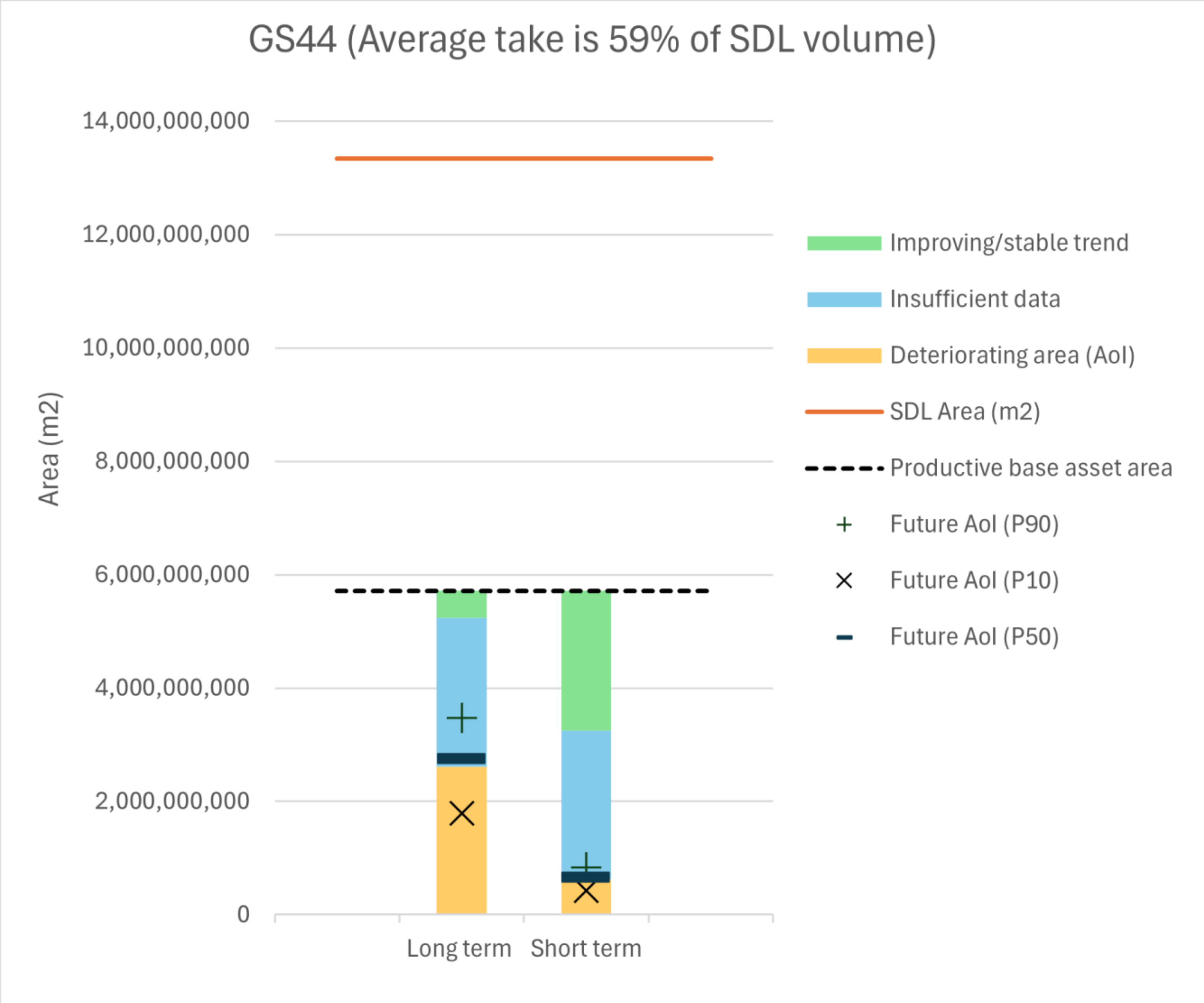

Figure 12 Estimates for change in area of influence (AoI) due to climate change

References

Crosbie R, Wang B, Kim S, Mateo C, and J Vaze (2023) Changes in the surface water – Groundwater interactions of the Murray-Darling basin (Australia) over the past half a century. Journal of Hydrology, 622, doi:10.1016/j.jhydrol.2023.129683.

Crosbie R, Doble R, Fu G, Campos Teixeira P, Pickett T, Devanand A, Ticehurst C, Gibbs M, Gunner W, Gonzalez D, Post D. (2025) "Groundwater recharge modelling of the Murray-Darling Basin under historical and future climate conditions". MDB Sustainable Yields 2, Module 3a. CSIRO Report, 2025.

MDBA (2020) Groundwater report cards For Sustainable Diversion Limit Resource Units under the Murray–Darling Basin Plan. Canberra, Australia. https://www.mdba.gov.au/sites/default/files/publications/mdba-groundwater-report-cards-november-2020.pdf.

NSW DPE (2022a), Schedule D: Lachlan Alluvium Water Resource Plan Risk assessment, NSW Department of Planning and Environment, Available from https://www.mdba.gov.au/publications-and-data/publications/lachlan-alluvium-water-resource-plan, accessed 18 February 2025.

NSW DPE, (2022b), Schedule F: Lachlan Alluvium Water Quality Management Plan, NSW Department of Planning and Environment. Available from https://www.mdba.gov.au/publications-and-data/publications/lachlan-alluvium-water-resource-plan, accessed 18 February 2025.

NSW DPE, (2022c), Lachlan Alluvium Groundwater Resource Description - GW10 Water Resource Plan Area, NSW Department of Planning and Environment. Available from https://www.mdba.gov.au/publications-and-data/publications/lachlan-alluvium-water-resource-plan, accessed on 18 February 2025.

Rojas R., Fu G. and González D. (2022) "*Groundwater level trends and aquifer prioritisation in the Murray-Darling Basin*". Project RQ8b: Groundwater as an adaptation option to current water resources management. Deliverable T.8b.2 - 31 May 2022. https://www.mdba.gov.au/sites/default/files/publications/groundwater-level-trends-and-aquifer-prioritisation-in-the-murray-darling-basin.pdf.