Australasian Groundwater & Environmental Consultants

Report on

GS45 Upper Macquarie Alluvium Stage 5

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GS45 – Upper Macquarie Alluvium

Stage 5 – Assessment through multiple lines of evidence

The Upper Macquarie Alluvium (GS45) is located within the Macquarie catchment in central-western New South Wales and comprises a narrow alluvial aquifer system associated with the Macquarie River floodplain (Figure 1). Groundwater entitlements are concentrated along the main alluvial corridor, particularly downstream of Wellington and around Dubbo (Figure 1). GS45 spans approximately 285 km², with a Sustainable Diversion Limit (SDL) of 17.90 GL/year and a long-term average recharge estimate of 20.60 GL/year (Table 1). Between 2013 and 2023, average annual groundwater extraction was 15.59 GL/year, representing 76% of estimated recharge and 87% of the SDL (Figure 2). Groundwater supplements the surface water supply in years of below-average rainfall, supporting irrigation, stock and domestic use, and providing a critical reserve for local water utilities in Dubbo (Figure 1 and Figure 2). Rainfall patterns show mixed below- and above-average conditions for the 2011-2018 period, leading into a 2018–2020 drought, followed by substantial rainfall recovery post-2020 (Figure 3).

The aquifer is generally shallow, with water levels within 10 m to 15 m of the ground surface across most of the SDL area (Figure 4a). Groundwater flows from southeast to northwest along the main river valley, with the last section (downstream of Dubbo) flowing in an east-to-west direction (Figure 4b). The long-term (1974–2024) and short-term (2012–2024) groundwater level surfaces are broadly consistent, with an observed depression around Dubbo (Figure 5). Water levels at the bottom of the long-term groundwater fluctuation zone are aligned with recent short-term water levels, indicating that current levels are close to the deepest observed since 1974 (Figure 5). Water quality is generally fresh, with salinity below 1,500 mg/L (~2,239 µS/cm) (Figure 6). No dominant declining or increasing tendency is observed in the water level timeseries trends (Figure 7). Spatially, long-term water level trends show stable conditions (30 bores), with five bores showing a statistically significant declining trend (-0.2 to -0.1 m/year) around the Dubbo area (Figure 9). In the short-term (2012-2024), a slight declining trend is observed in three bores downstream of Dubbo, whereas a large number of bores (38) have no statistically significant trend (Figure 10). Salinity trend analysis is constrained by limited data availability (Figure 8).

Recharge for GS45 is estimated at 20.60 GL/year (MDBA, 2020). It has been derived from a groundwater model covering 96% of the SDL area, which includes diffuse recharge, groundwater throughflows and river leakage. A recent reassessment by Crosbie et al. (2025) estimated diffuse recharge alone at 5.97 GL/year for GS45. Table 1 shows a storage-to-recharge ratio (S/R) of 72 using the WERP estimate of storage (Rojas et al., 2022). This suggests low buffering capacity and high vulnerability to short-term climate variability (“high responsiveness” threshold[1] defined in Rojas et al., 2022). Both the extraction-to-recharge (E/R = 0.76) and SDL-to-recharge (SDL/R = 0.87) ratios remain above the critical value of 0.5, indicating high pressure on the productive base.

Long-term (1974-2024) groundwater level trends show signs of stress and indicate statistically significant ($\alpha = 0.05$) declines in a localised area around Dubbo. Elsewhere, long-term water level trends are stable or slightly fluctuating (Figure 9). In contrast, short-term (2012-2024) water levels often show no statistically significant trend and a reduced number of bores (3) with a slightly declining trend in the lower section of GS45 (Figure 10). With stable or slightly fluctuating trends, the impacts on surface water connectivity are expected to be moderate. Crosbie et al. (2023) classified the reaches of the Macquarie River in GS45 as ‘mostly losing’ for the period 2000-2019, thus highlighting the variable connectivity between river and aquifer.

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

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). The analysis reveals that 43% of the productive base asset area, 38% of the river connectivity asset area, and more than 43% of the GDE asset area exhibit long-term declining trends (Table 2). Short-term trends are more favourable, with all ESLT asset areas showing declining trends in 10% or less of the area. In the short-term, between 60% and 68% of the ESLT asset areas showed stable or improving conditions (Table 2). Figure 11 illustrates this improvement as a horizontal displacement from variable trends towards the improving/stable trend conditions, while marginally increasing the uncertainty (insufficient data, represented by the vertical displacement) for the productive base, river connectivity, and GDEs. Salinity data availability remains a significant limitation: only one bore had sufficient long-term data, and no bores were available for short-term analysis, resulting in the salinity ESLT assert area being fully classified as 'insufficient data' in the short-term analysis (2012-2024).

The NSW state-based risk assessment (NSW DPE, 2022) assigns variable risk ratings across ESLT values in GS45. Productive base risks are rated high for aquifer structural integrity, local drawdown reducing access to groundwater users, and reductions in recharge due to improved irrigation efficiencies and water conveyance. River connectivity risks are predominantly low for the impacts of groundwater use on (surface) water users and for impacts on instream ecological values. This is aligned with the observed river connectivity behaviour (mostly losing) and the historical depth-to-water values observed. Risks to GDEs are variable, with some risks rated as medium, particularly where deeper water tables may affect ecological thresholds. Other risks are classified as low/nil, such as climate change reducing groundwater availability for GDEs and the risk of poor water quality impacting GDEs. The NSW state-based risk assessment rated water quality risks as high, primarily associated with groundwater extraction, which can induce connections with poor-quality groundwater. The residual risk to water quality is high but classified as tolerable (NSW DPE, 2022). Overall, water level data coverage is good; however, salinity monitoring remains limited in both the long- and short-term, contributing to substantial residual uncertainty in water quality risk assessment.

Climate change is expected to affect GS45 via a shift in recharge dynamics. Projections from the MD-SY2 project suggest that while diffuse recharge may increase due to intense rainfall events, overbank and in-stream recharge are likely to decline by 7–18% by 2050 (Crosbie et al., 2025). These changes are expected to reduce episodic recharge and groundwater replenishment during dry years, although these opposing trends introduce uncertainty regarding net future recharge in GS45. Stage 6 of this BPR review shows that the median future Area of Influence (AoI[2]) exceeds the current AoI, and deteriorating areas are projected to expand under future climate scenarios (Figure 12). Despite the uncertainty surrounding net future recharge, overbank and in-stream recharge are likely the dominant recharge processes for GS45, and thus, the SDL/R ratio is likely to increase under future climate conditions. The Stage 6 assessment classifies climate change pressure on GS45 as high for both long- and short-term timeframes based on modelled drawdown projections.

In summary, GS45 shows widespread improvement or stabilisation of water levels in the short-term (2012–2024), particularly following the post-2020 rainfall recovery. However, long-term trends indicate localised declines and legacy drawdown around Dubbo that may still affect the productive base. Salinity trends cannot be robustly evaluated due to the limited data available, and this remains a critical information gap. Current extraction is below both the SDL and the MD-SY1 recharge estimate. However the SDL is similar to MD-SY1 recharge, and exceeds the MD-SY2 estimate of recharge. Therefore, future increases in take could place the productive base under stress. Risk assessments highlight high risks to the productive base, and low to moderate risks for river connectivity and GDEs, which reflects the variable connectivity of the aquifer with the Macquarie River in GS45. Water quality risks are rated high, and they may be exacerbated by reduced in-stream and floodplain recharges. Climate projections suggest an increasing risk of localised groundwater level decline due to changes in episodic recharge patterns, and overall, the pressure from climate change is assessed as high. Collectively, the analysis also suggests high pressure on the productive base of GS45, with current conditions generally stable; however, future risks are emerging under full SDL use and climate pressure.

[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.

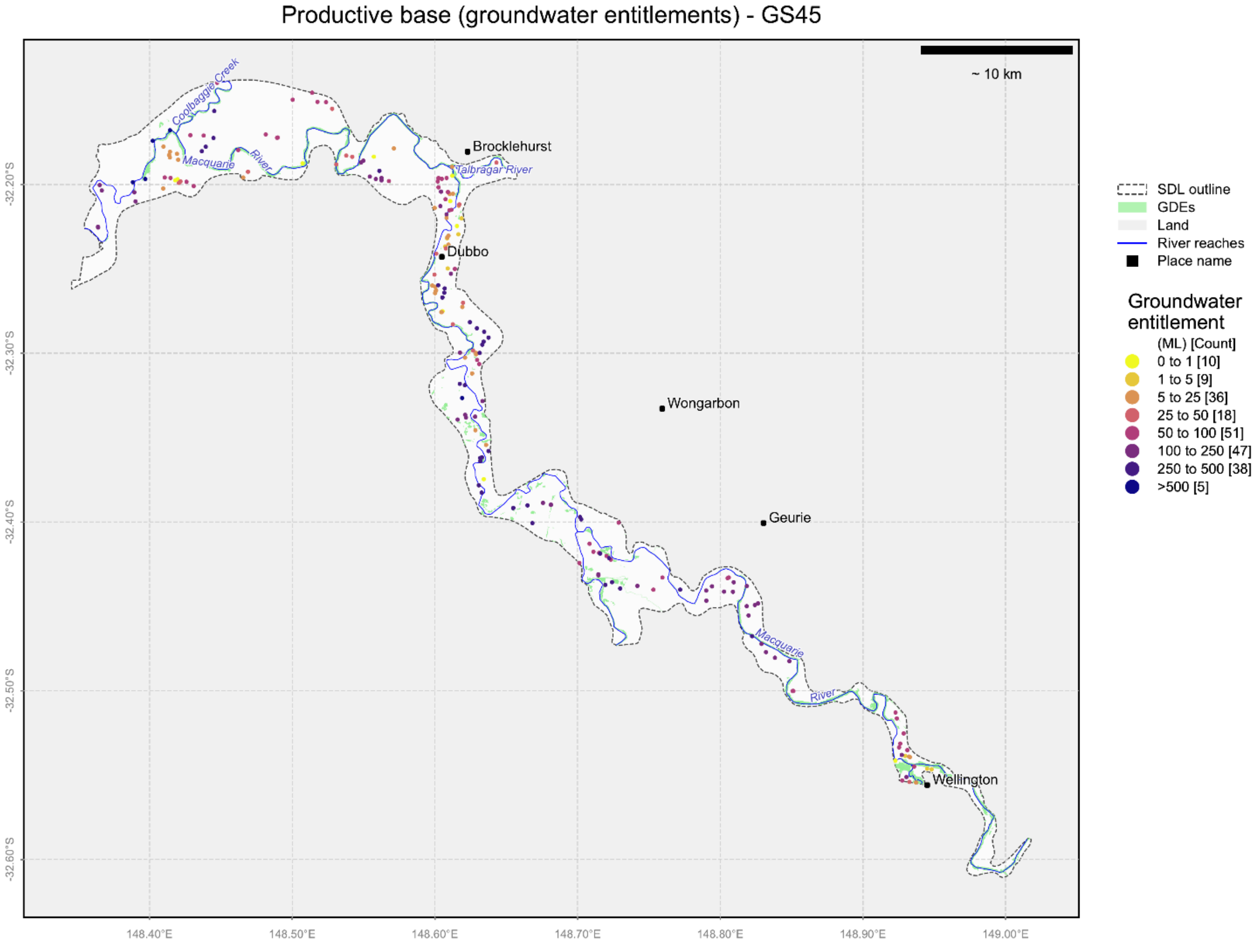


Figure 1 Productive base (groundwater entitlements)

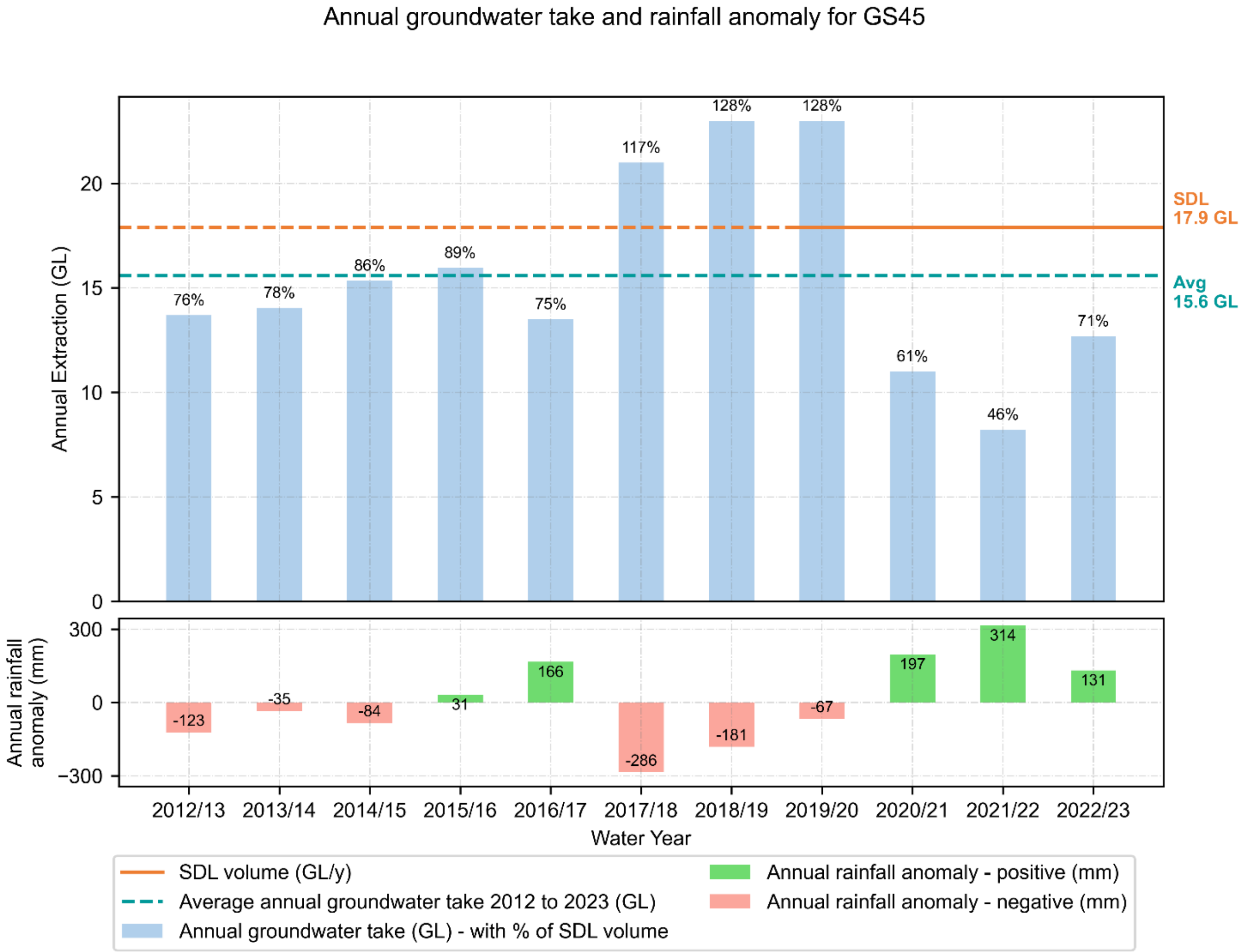


Figure 2 Groundwater take in the SDL since 2012

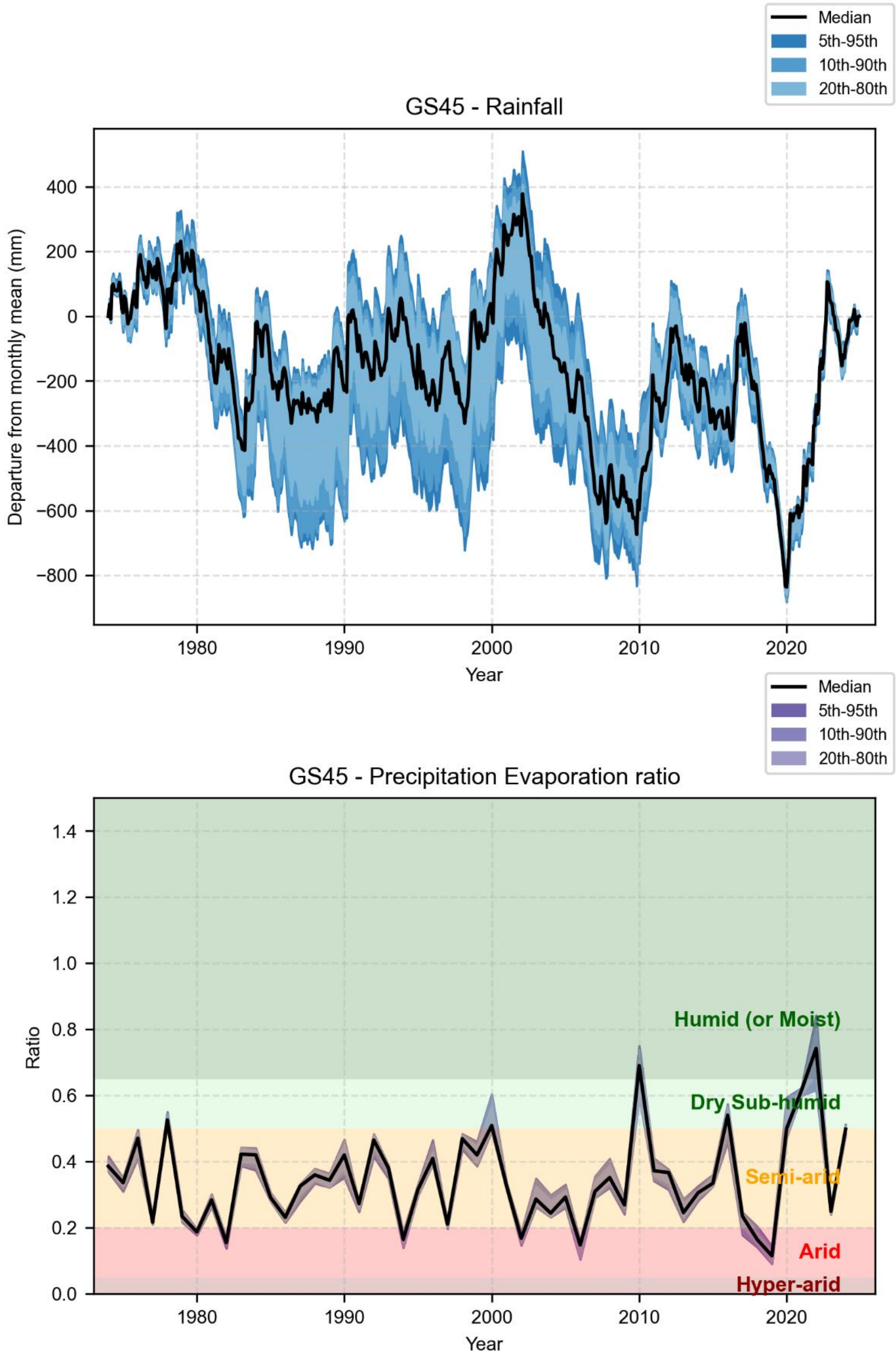
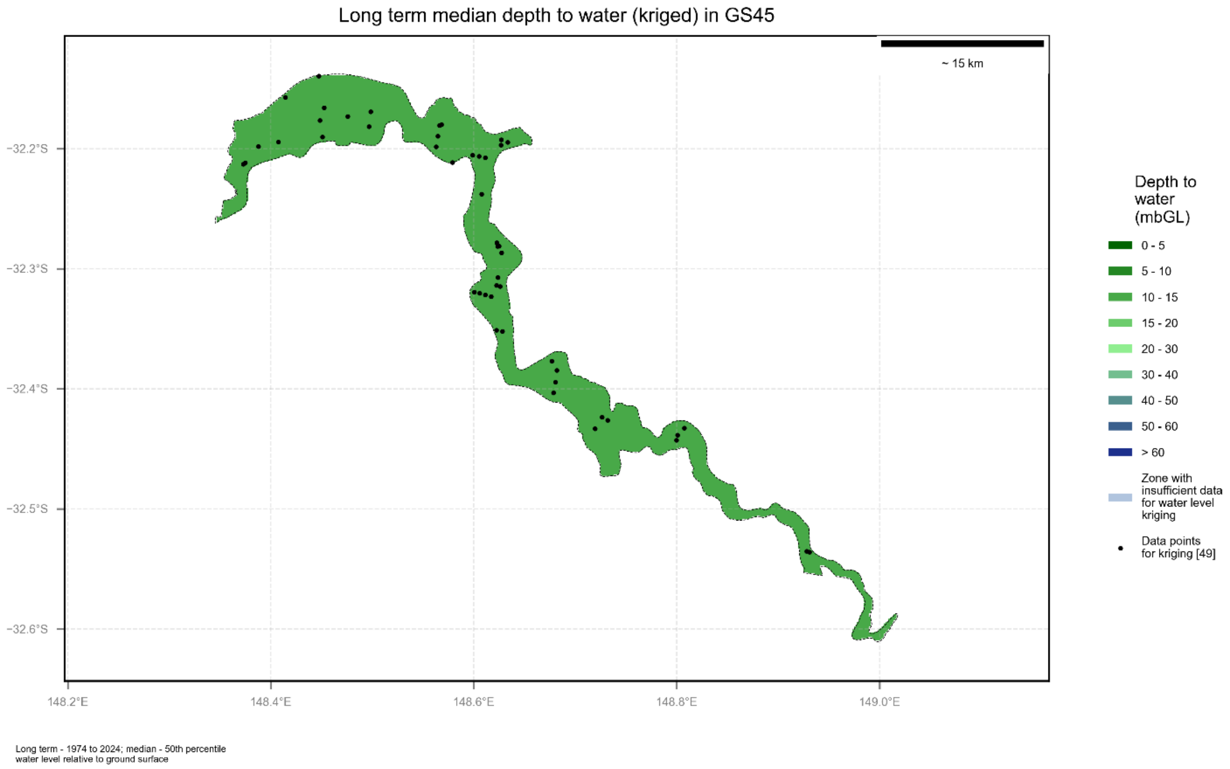
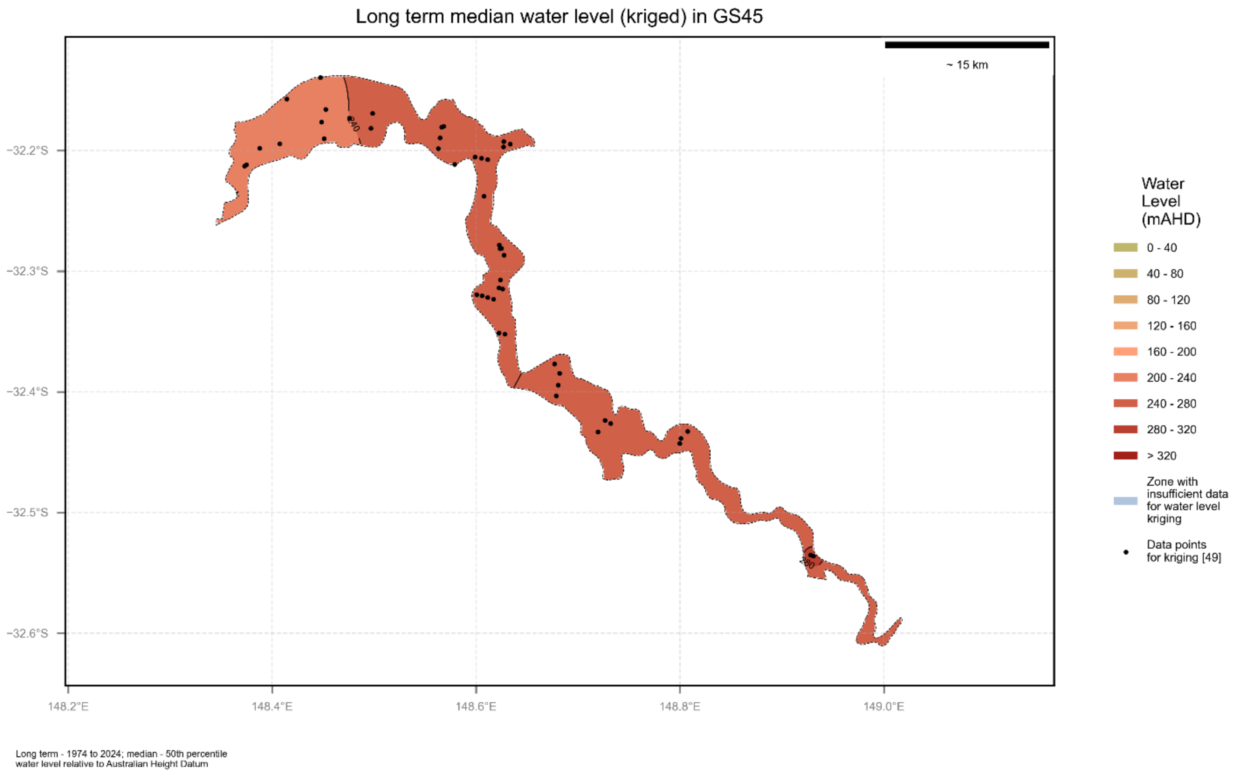


Figure 3 Historical climate trends

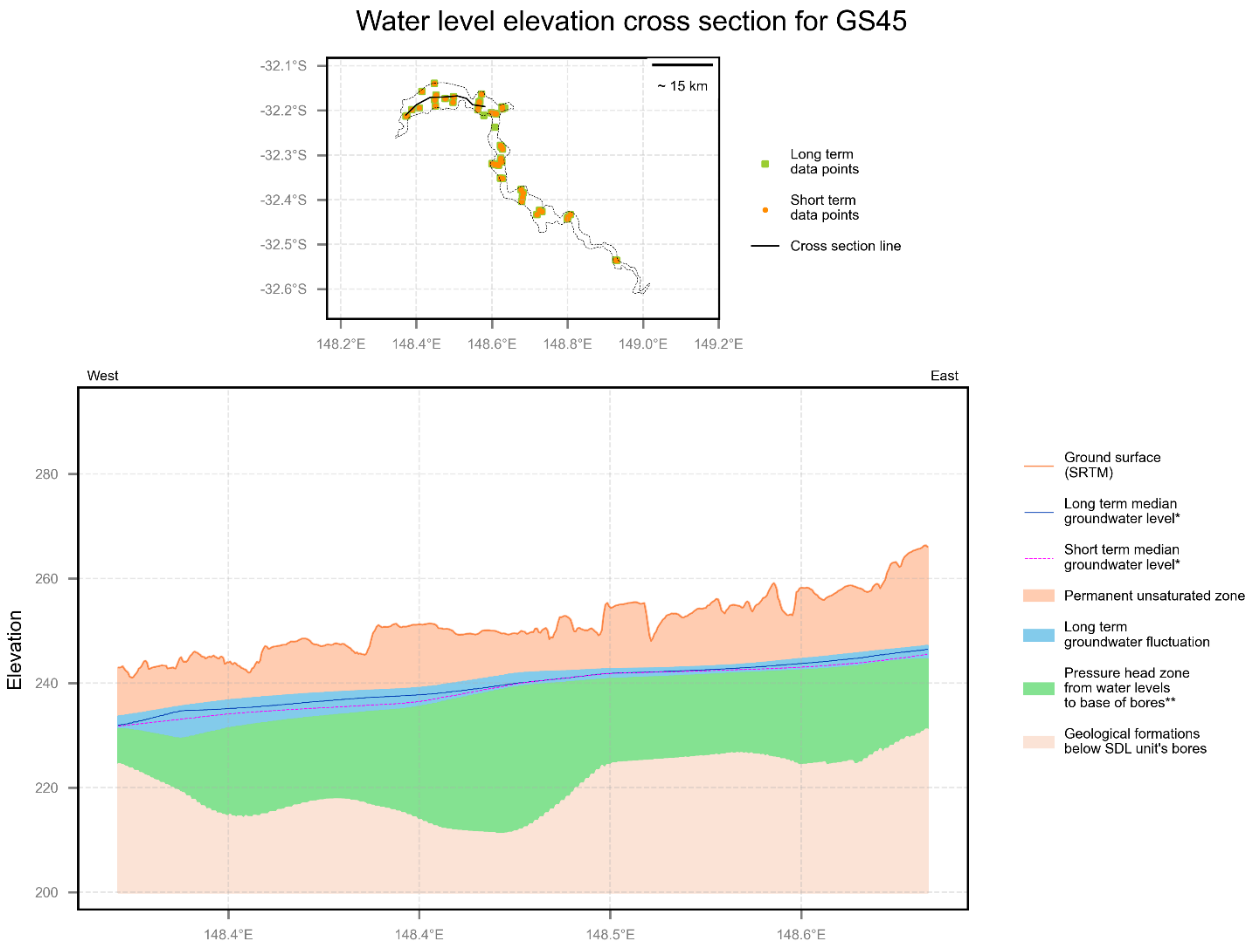


a)



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

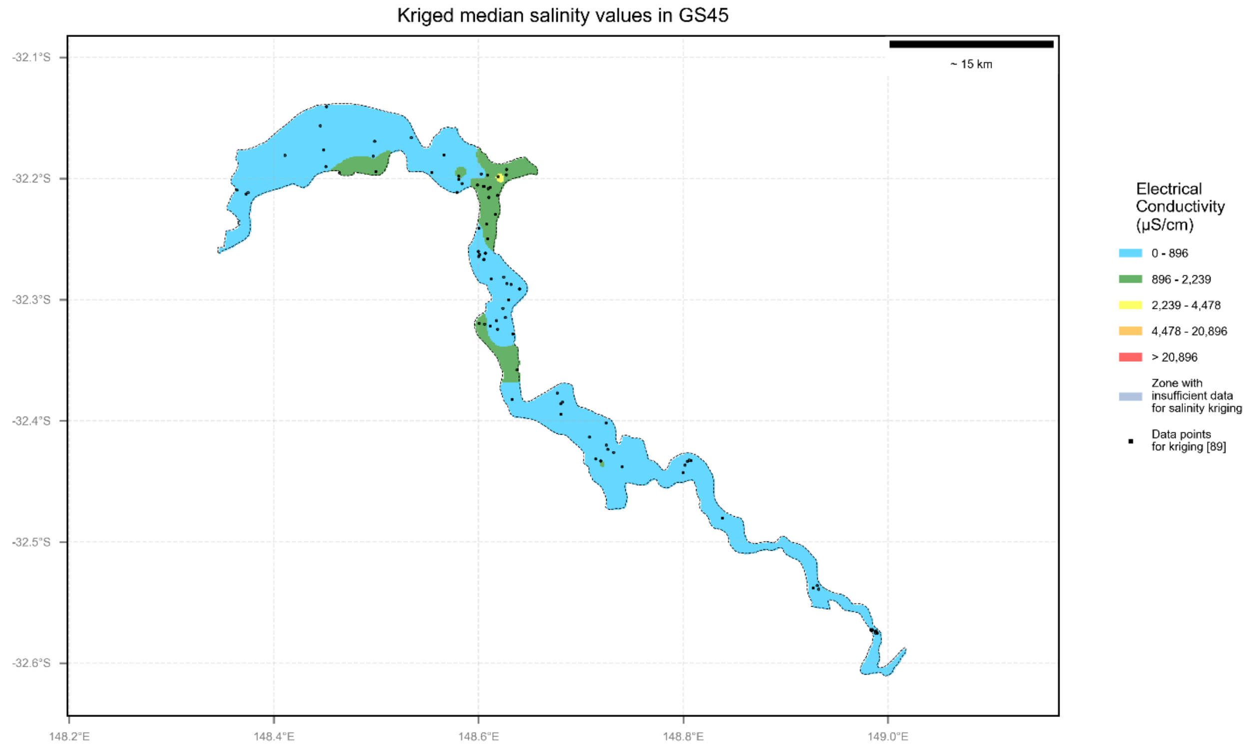


Figure 6 Groundwater salinity distribution

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	-	-	17.90
SDL resource unit area	km²	-	-	285
Average annual take (2013 to 2023)	GL/y	-	-	15.59
Number of groundwater entitlement bores	-	-	-	214
SDL resource unit storage estimate*	GL	-	-	1,478
Recharge estimate (SY1)	GL/y	-	-	20.60
Recharge estimate (Stage 2)	GL/y	-	-	20.60
Diffuse recharge estimate (SY2 - WAVES)	GL/y	-	-	5.97
Extraction/SDL (E/SDL) (Stage 2 result)	-	-	-	0.87
SDL/Recharge (SDL/R) (Stage 2 result)	-	-	-	0.87
SDL/Recharge (SDL/R) (SY2 or modelled recharge)	-	-	-	0.87
Storage/Stage 2 Recharge (S/R)	-	-	-	72
Storage/SY2 or modelled Recharge (S/R)	-	-	-	72
Number of bores in the SDL unit	-	1,144	1,144	-
Number of bores for water level trend analysis	-	50	46	-
Number of bores for water level trend with sufficient data	-	49	44	-
Number of bores with decreasing water level trend	-	34	6	-
Number of bores with increasing water level trend	-	1	0	-
Number of bores with no statistically significant water level trend	-	14	38	-
Mean water level trend magnitude	m/y	-0.03	0.05	-
Minimum water level trend magnitude	m/y	-0.17	-0.22	-
5%ile water level trend magnitude	m/y	-0.17	-0.12	-
10%ile water level trend magnitude	m/y	-0.1	-0.09	-
50%ile water level trend magnitude	m/y	-0.02	0.05	-
90%ile water level trend magnitude	m/y	0.03	0.19	-
95%ile water level trend magnitude	m/y	0.07	0.23	-
Maximum water level trend magnitude	m/y	0.08	0.47	-
Number of bores for salinity trend analysis	-	93	2	-
Number of bores for salinity trend with sufficient data	-	1	0	-
Number of bores with decreasing salinity trend	-	0	0	-
Number of bores with increasing salinity trend	-	0	0	-
Number of bores with no statistically significant salinity trend	-	1	0	-
Mean salinity trend magnitude	µS/cm/y	-4	N/A	-
Minimum salinity trend magnitude	µS/cm/y	-4	N/A	-
5%ile salinity trend magnitude	µS/cm/y	-4	N/A	-
10%ile salinity trend magnitude	µS/cm/y	-4	N/A	-
50%ile salinity trend magnitude	µS/cm/y	-4	N/A	-
90%ile salinity trend magnitude	µS/cm/y	-4	N/A	-
95%ile salinity trend magnitude	µS/cm/y	-4	N/A	-
Maximum salinity trend magnitude	µS/cm/y	-4	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	1,101,735,559	35%	43%	22%	Variable trends	66%	10%	23%	Improving / stable trends
GDEs	1,061,270,133	36%	43%	21%	Variable trends	68%	10%	22%	Improving / stable trends
River connectivity	1,237,941,542	31%	38%	31%	Variable trends	59%	9%	32%	Improving / stable trends
Water quality	1,023,377,281	8%	0%	92%	Insufficient data	0%	0%	100%	Insufficient data

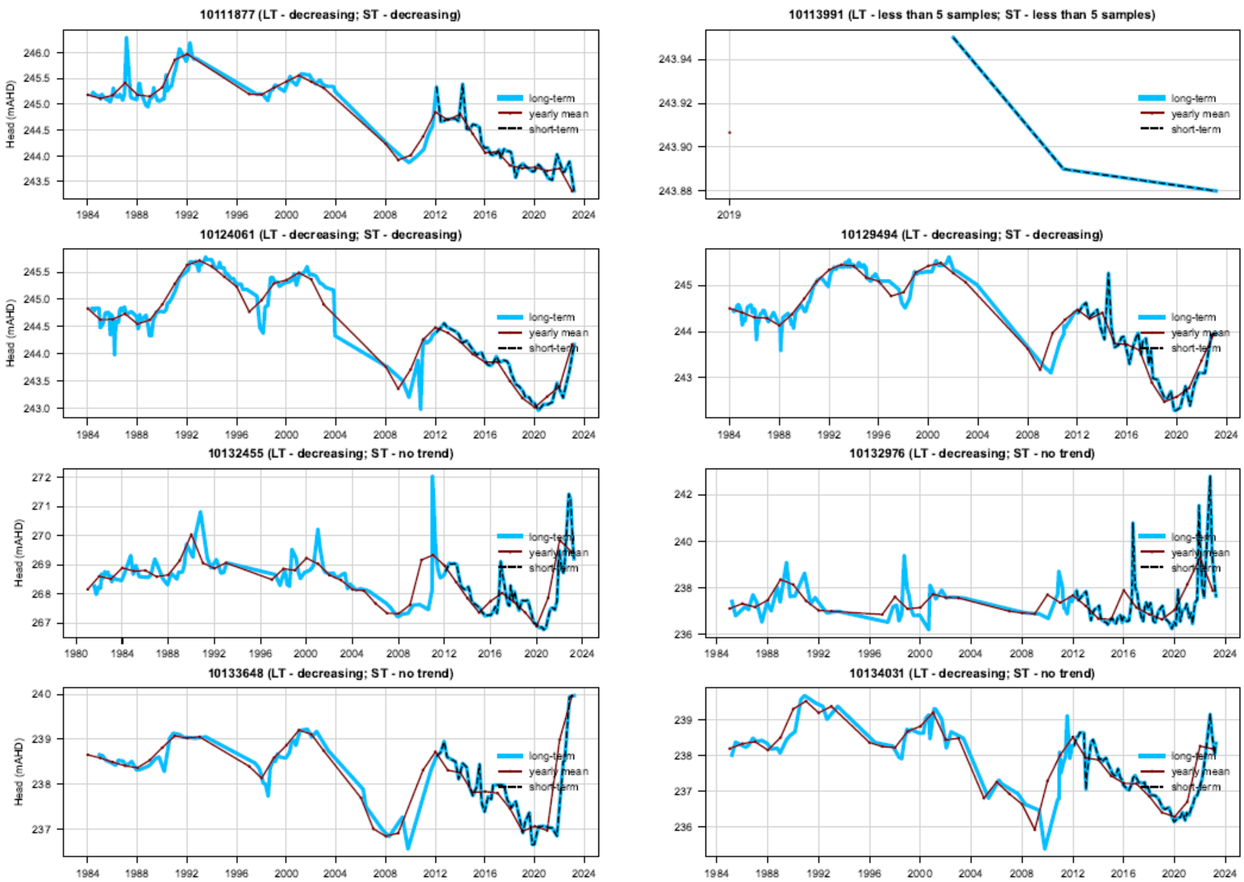


Figure 7 Representative groundwater hydrographs for the SDL resource unit

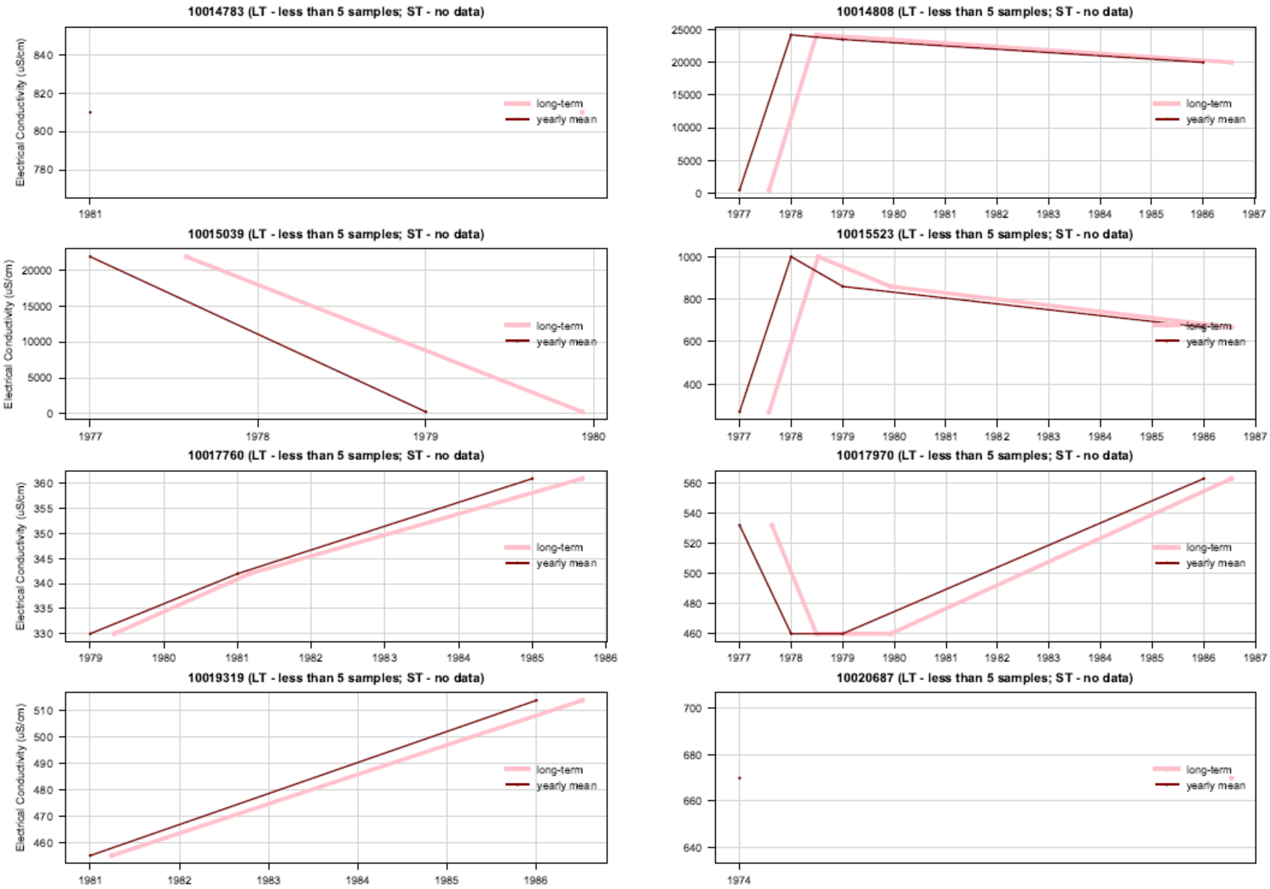
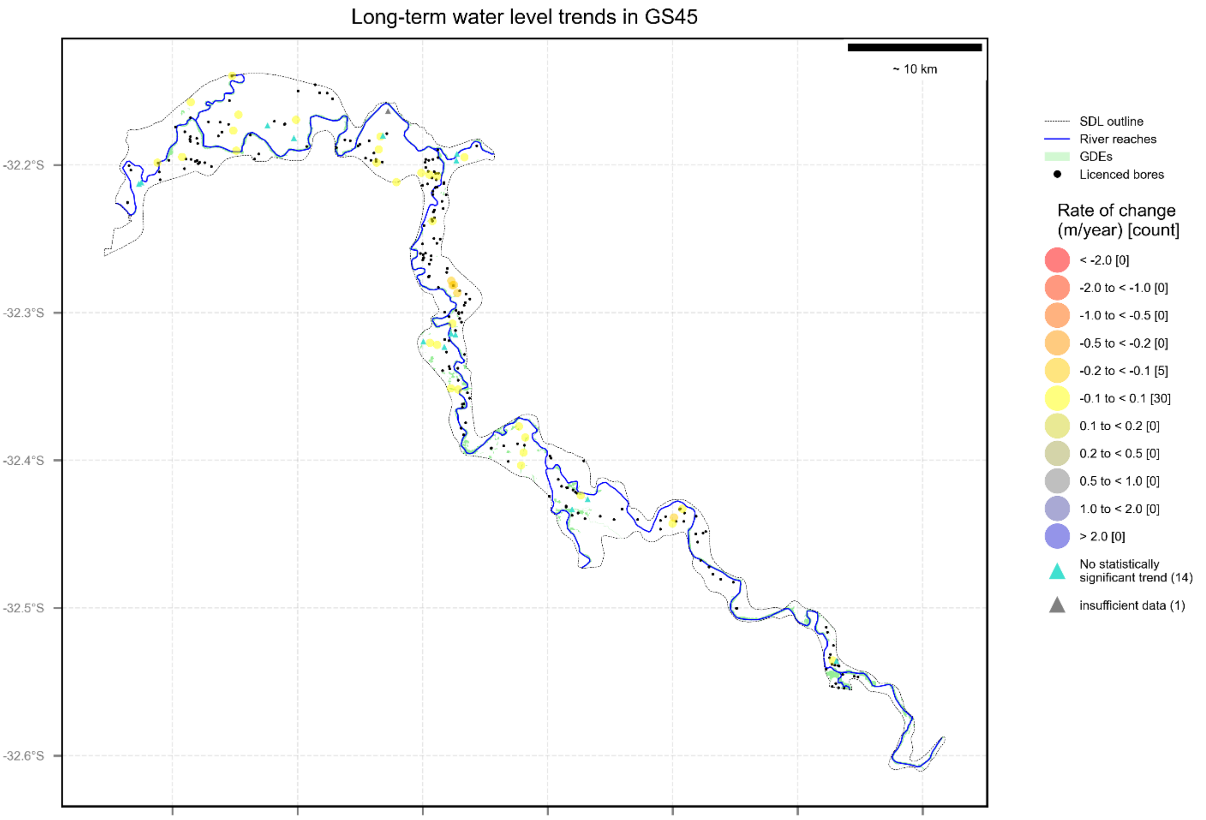


Figure 8 Representative groundwater salinity time series for the SDL resource unit



a)

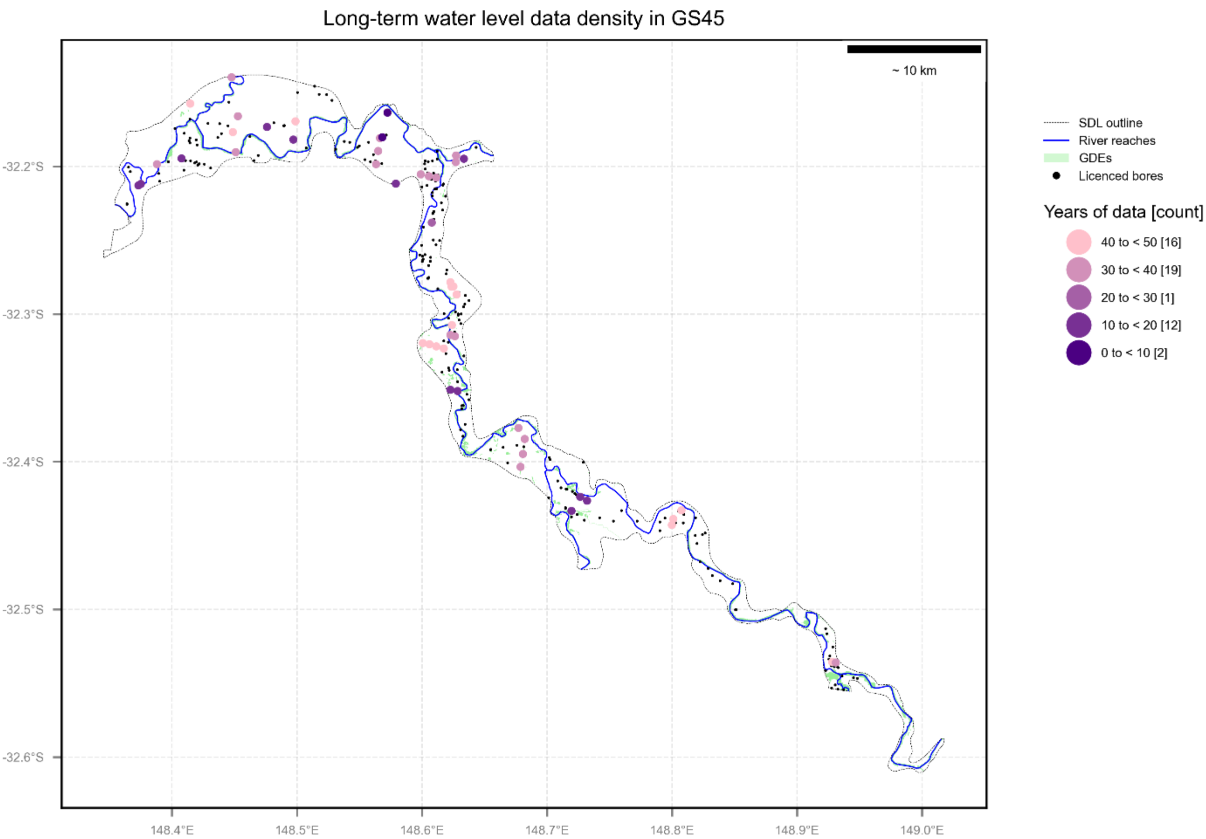


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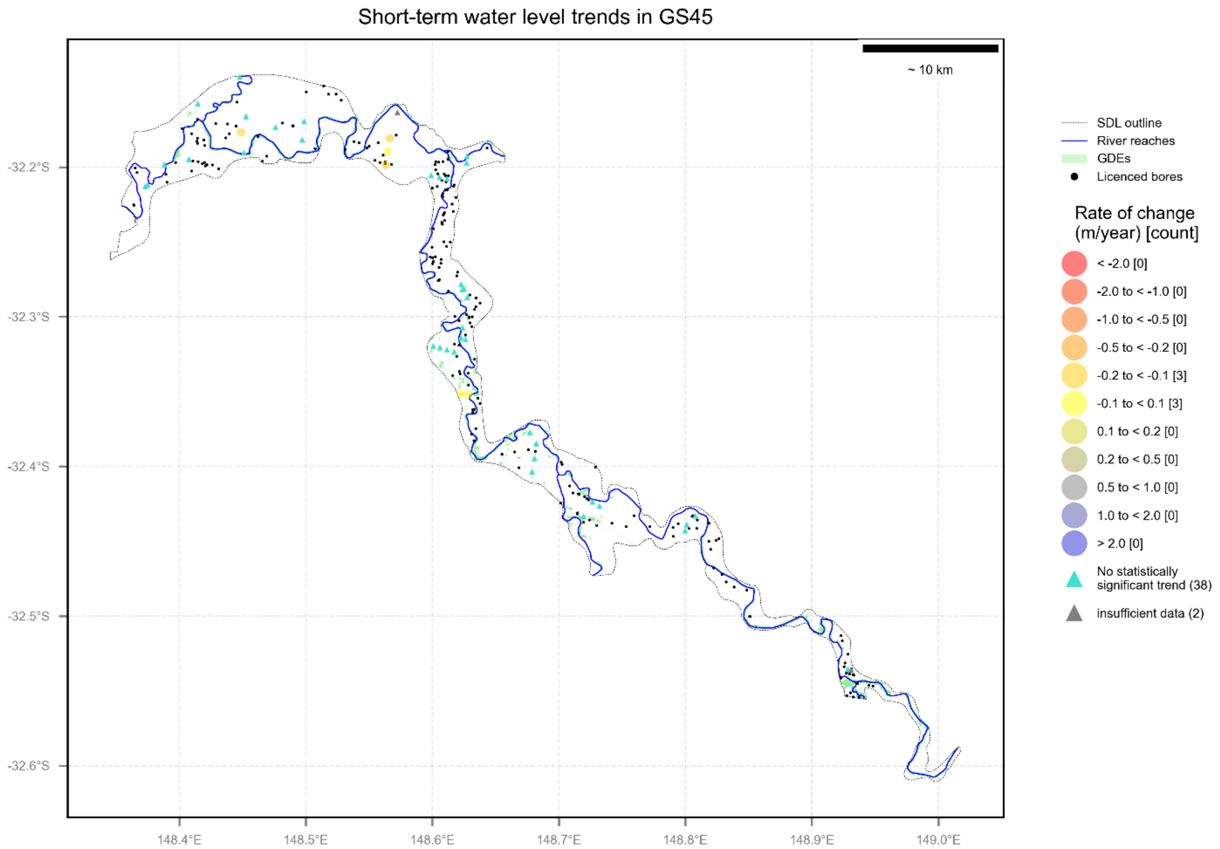
Figure 9 Long-term (1974 to 2024) (a) groundwater level trends and (b) data availability



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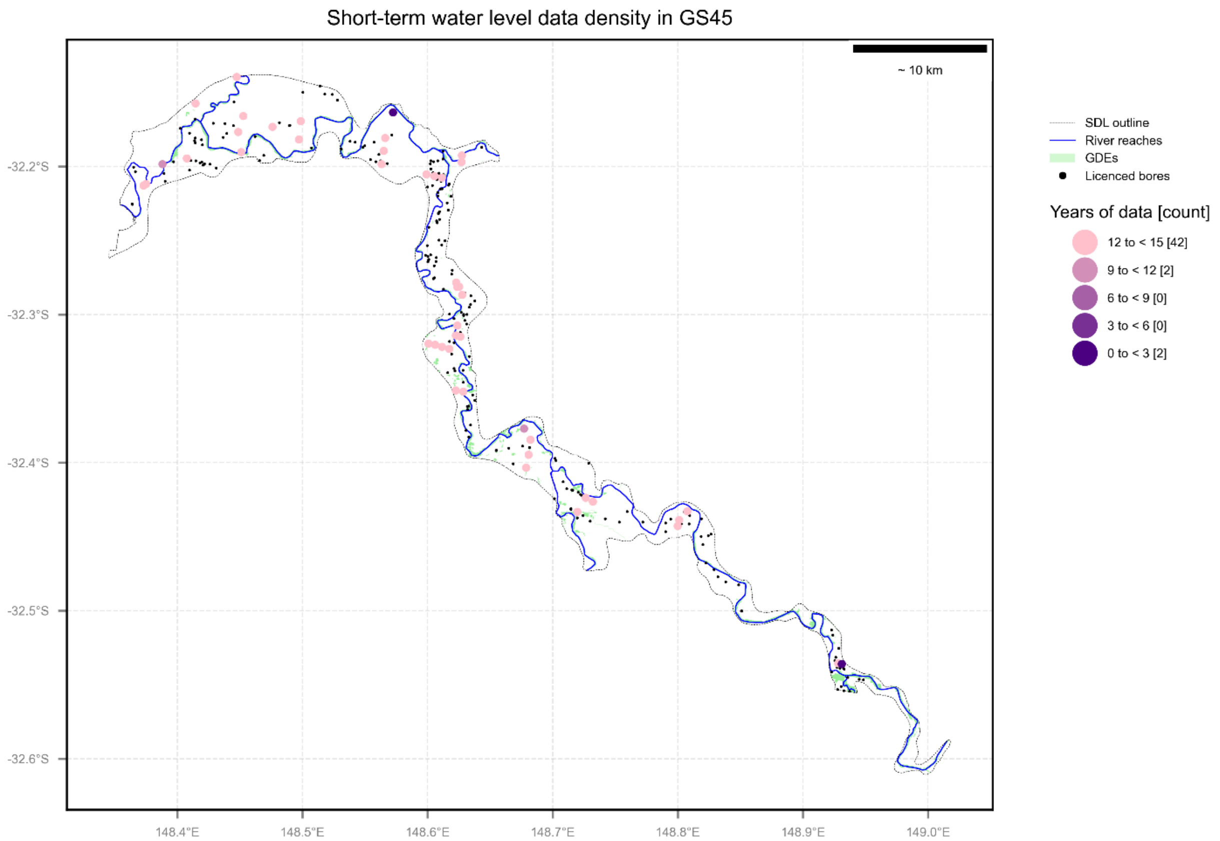

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Figure 10 Short-term (2012 to 2024) (a) groundwater level trends and (b) data availability

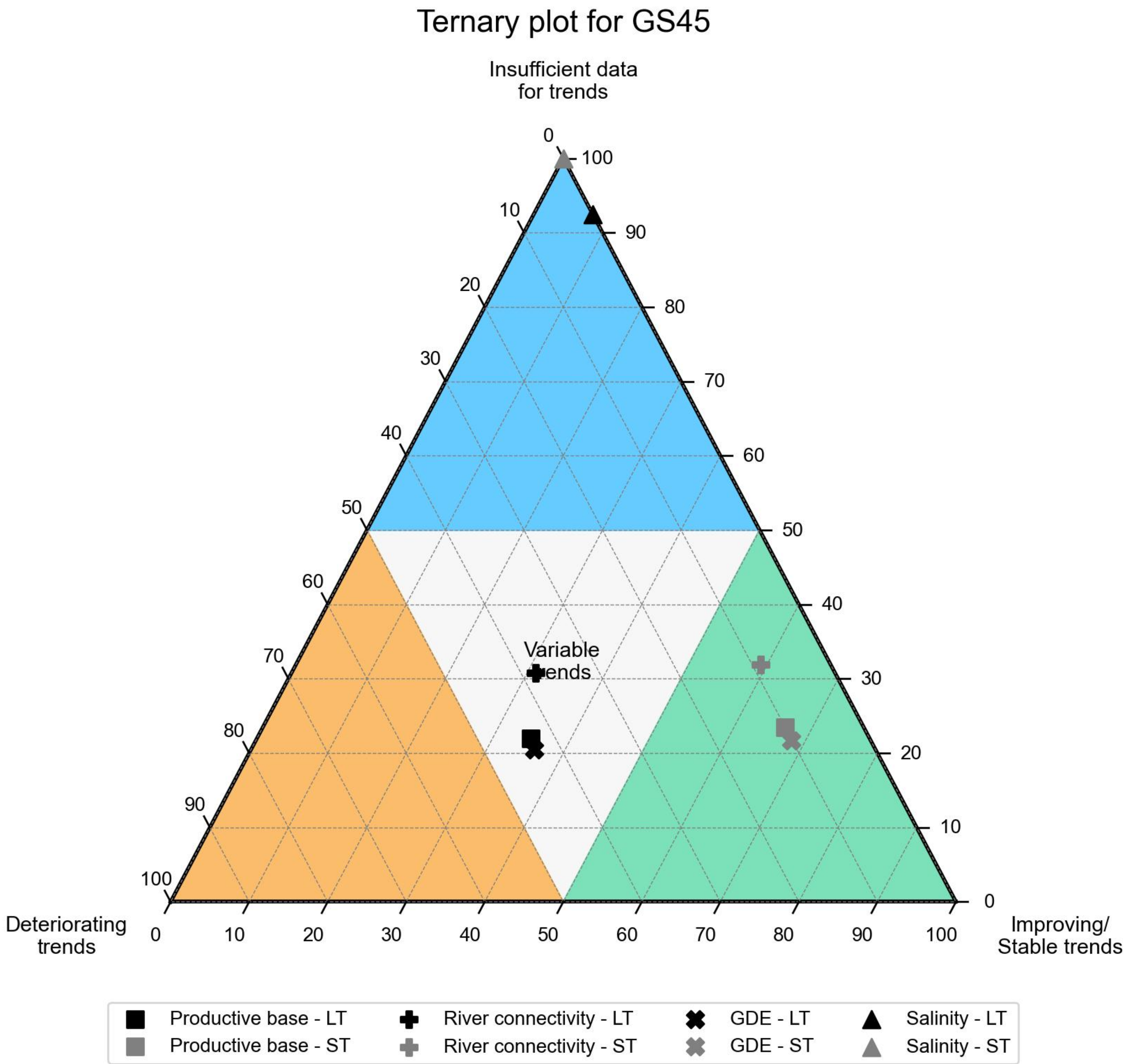

Figure 11 Stage 4 assessment outcome: trends in resource condition indicators for ESLT values

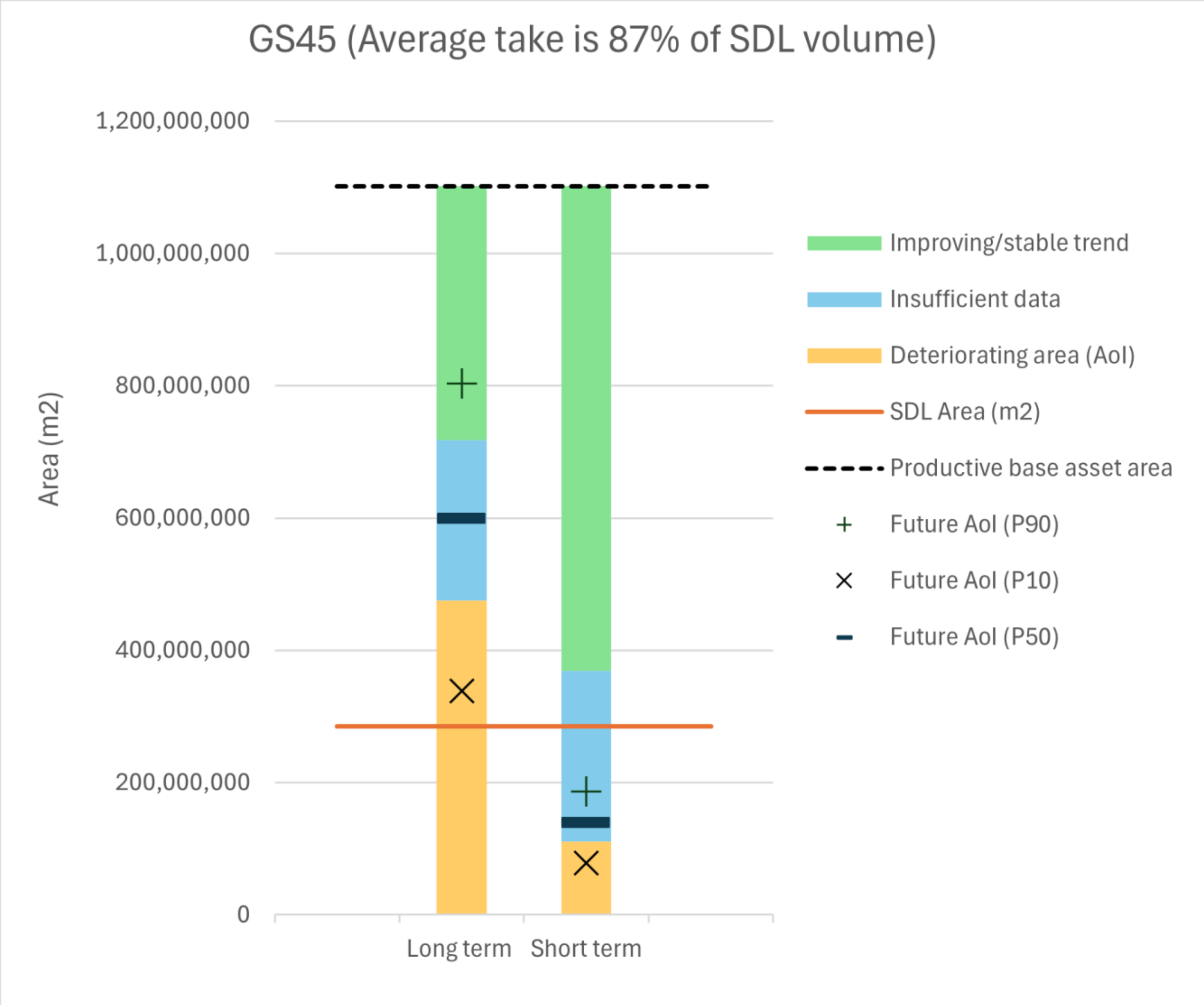

Figure 12 Estimates for change in area of influence (AoI) due to climate change

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