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Groundwater
& Environmental
Consultants

Report on

GS23

Lower Darling Alluvium Stage 5

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GS23 – Lower Darling Alluvium

Stage 5 – Assessment through multiple lines of evidence

The Lower Darling Alluvium (GS23) is located within the Darling River catchment in southwestern New South Wales and consists of unconsolidated Quaternary deposits hosting an unconfined alluvial system hydraulically connected to the Darling River (Figure 1; Crosbie et al., 2023). Groundwater entitlements are sparse, concentrated around Menindee, Pooncarie and Burtundy, whereas basic landholder rights (stock and domestic use) are evenly distributed between Menindee and Burtundy (Figure 1). Entitlements also include the Curlwaa Salt Interception Scheme (SIS) (701 ML/year), located upstream of Wentworth. GS23 spans approximately 1,652 km², with a Sustainable Diversion Limit (SDL) of 2.23 GL/year and a long-term average recharge estimate of 2.61 GL/year (Table 1). Between 2013 and 2023, average annual groundwater extraction was 0.79 GL/year, representing 30% of estimated recharge and 35% of the SDL (Figure 2). Groundwater use is underdeveloped and supports mostly stock and domestic supplies along the main alluvial corridor between Menindee and Burtundy, with a weak correlation to supplement surface water supply during years of below-average rainfall (Figure 1, Figure 2). Long-term climate observations show a relatively persistent below-average rainfall signal for the 2000–2010 period, with a partial recovery early 2011 and another substantial period of below-average rainfall between 2011 and 2021, interrupted by a short recovery in 2016 (Figure 3). GS23 shows an arid climate since at least the 1980s based on the precipitation-to-evaporation ratio (Figure 3).

The water table is generally within 10 m of the ground surface, though some areas might reach values deeper than 15 m, particularly around Menindee and Pooncarie (Figure 4a). Closer to the Murray River, water levels are shallow, less than 5 m, and possibly driven by the river head. Groundwater flows from north to south along the main alluvial valley (Figure 4b), with groundwater levels generally mounding near the river (NSW DPIE, 2019). Long-term (1974–2024) and short-term (2012–2024) median groundwater levels show spatial variability across GS23 when defining the long-term groundwater fluctuation zone (Figure 5): around Menindee and closer to the western SDL boundary, a long-term fluctuation zone of around 5 m is observed, around Burtundy the fluctuation zone is limited to approximately 1 m, whereas south, upstream the confluence with the Murray River, the fluctuation zone ranges between 2 and 10 m, being thicker away from the river (Figure 5). In the downstream section of GS23, the bottom of the groundwater fluctuation zone is aligned with recent (short-term) water levels, indicating that current water levels are close to the deepest observed since 1974. Salinity data is concentrated around Menindee and downstream of Pooncarie, and shows values in the range 4,480–20,900 $\mu\text{S}/\text{cm}$ (equivalent to 3,000–14,000 mg/L) (Figure 6), with a few isolated shallow and narrow lenses of relative freshwater (MDBA, 2020). Water level trends generally show stable or not statistically significant trends over both long- and short-term periods (Figure 7; Figure 9; Figure 10), with some localised declining trends downstream of Burtundy, up to 0.2 m/year over the long-term and 0.5 m/year over the short-term. The understanding of temporal salinity trends is limited due to poor data availability (Figure 8).

MDBA (2020) previously reported recharge at 6.75 GL/year for GS23, which is higher than the estimate of 2.61 GL/year used Stage 2 of this assessment (derived from Lee et al., 2024), and higher than that of Crosbie et al. (2025), reported for the MD-SY2 project as 1.35 GL/year for diffuse recharge alone. Table 1 shows a storage-to-recharge ratio (S/R) of 1,149, using the recharge estimate from Lee et al. (2024) and the RRAM storage estimate, suggesting high buffering capacity and limited vulnerability to short-term climate variability (above the “low responsiveness” threshold¹ defined in Rojas et al., 2022). The low extraction-to-recharge (E/R) and high SDL-to-recharge (SDL/R) ratios (Table 1) suggest moderate pressure on the productive base, especially if take up to the full SDL volume materialises.

The productive base shows signs of stress, with long-term water level showing declining trends in about half of eligible bores (Table 1; Figure 9; Figure 10). Statistically significant ($\alpha=0.05$) declines have occurred since 1974 in bores around Burtundy and the downstream section of GS23. Short-term trends (Figure 10) show slightly less favourable conditions, with statistically significant declining trends persisting around Burtundy and Menindee, and a greater rate of decline for the 5th and 10th percentiles of trends (Table 1). The short-term period (2012–2024) is characterised by a persistent below-average rainfall pattern prior to 2020 (Figure 3) and a modest recovery in rainfall post 2021 (Figure 2). River reaches for GS23 transition from ‘mostly losing’ and ‘some losing’ upstream Pooncarie to ‘mostly not losing’ during 2000–2019 (Crosbie et al., 2023). Groundwater-dependent ecosystems (GDEs), such as riparian and floodplain vegetation, may also be impacted in the lower sections of GS23 and in locations proximal to the Darling River if water levels drop below ecologically relevant thresholds.

Stage 4 of this BPR technical groundwater review provided a quantitative assessment of resource condition indicators (RCIs) within a 5 km buffer around extraction points (asset area). Long-term groundwater level declines were observed in 37% of the productive base asset area, 25% of the river connectivity asset area, and 37% of the GDE asset area (Table 2). In the short-term, these percentages decreased to 18%, 14% and 18%, respectively (Table 2). Just 6% to 13% of the ESLT asset areas showed improving water level conditions in the short-term (Table 2), compared to values around 10% to 15% for the long-term, suggesting a shift towards slightly less favourable conditions (Figure 11). Levels of uncertainty, as indicated by areas with insufficient data to inform temporal trends, are substantial, and have increased to above 73% for the short-term analysis (substantial vertical displacement of points in Figure 11). For the water quality (salinity) ESLT value, the short-term asset area classified as having ‘insufficient data’ represents 100% of the asset area.

The NSW state-based risk assessment (NSW DPE, 2023) assigns low risk ratings across ESLT values in GS23. For the productive base, the only risk rated as medium is the potential for growth in basic landholder rights (BLR) to reduce groundwater availability, which is considered a tolerable medium residual risk.

Future projections from the MD-SY2 project suggest that diffuse recharge in GS23 may remain unchanged or slightly decrease by 2050 (Crosbie et al., 2025). In contrast, overbank flood recharge is projected to decrease by 14% to 20% relative to current conditions (Crosbie et al., 2025), potentially reducing (localised) episodic recharge and groundwater availability during dry periods. Stage 6 of this BPR technical groundwater review found that the future area of drawdown (Area of Influence, Aoi²) is projected to remain practically unchanged under median climate change conditions (Figure 12). However, given that diffuse and floodplain recharge are projected to decrease, there is evidence that the SDL/R ratio will increase in future, suggesting that the resource's replenishment rate may change in the future. Stage 6 classified the pressure from future climate change on GS23 groundwater resources as moderate, based on evidence of water level trends (long- and short-term) and projected changes in recharge.

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

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.

Overall, short-term groundwater trends (2012–2024) indicate insufficient data to reliably assess the conditions across ESLT values in GS23, with uncertainty levels significantly higher than in the long-term assessment (1974–2024). Water level trends show a mixture of declining and stable or not statistically significant patterns across the bores, with localised declines around Burtundy and downstream of GS23. Uncertainty regarding salinity trends has increased markedly, with 100% of the short-term asset area now classified as ‘insufficient data’ to inform temporal trends. Current extraction remains below the SDL, while recharge estimates are being refined toward a more conservative figure than early RRAM estimates (MDBA, 2020). The SDL represents 85% of the recharge estimate used in this assessment, but exceeds the most conservative diffuse recharge estimate for GS23 in MD-SY2 (Crosbie et al., 2025). The state-based risk assessment rates most risks to ESLT values as low, with only medium risks identified on the productive base due to potential growth in the BLR. Although there may be growth in groundwater demand in future, there are practical limits on take due to the zones of saline groundwater in the resource unit. Climate projections suggest reduced episodic (localised) recharge from floodplain processes, and overall, climate change pressure is considered moderate. Together, the analysis indicates that there is moderate pressure on the productive base and water quality of GS23, but that there is insufficient data to determine the pressure and sensitivities on ESLT values confidently. Meanwhile, more refined and conservative recharge estimates are approaching current groundwater extraction levels, thus increasing the sensitivity of GS23 to future climate variability.

Productive base (groundwater entitlements) - GS23

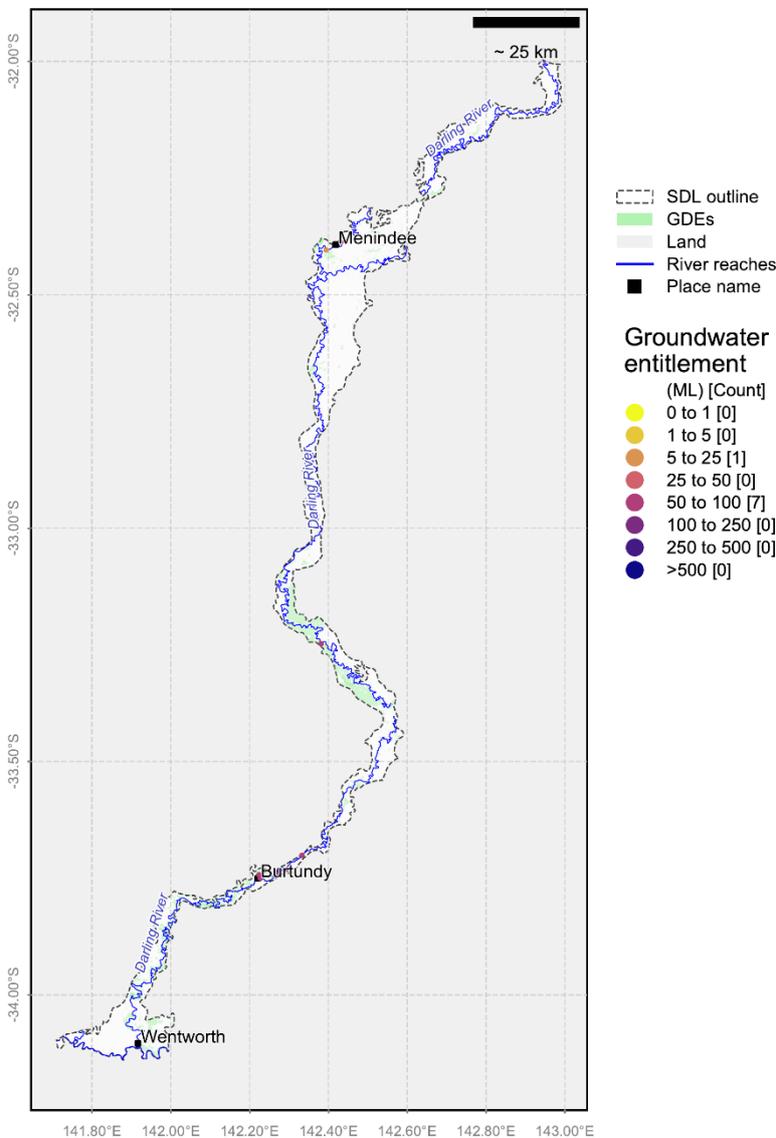


Figure 1 Productive base (groundwater entitlements)

Annual groundwater take and rainfall anomaly for GS23

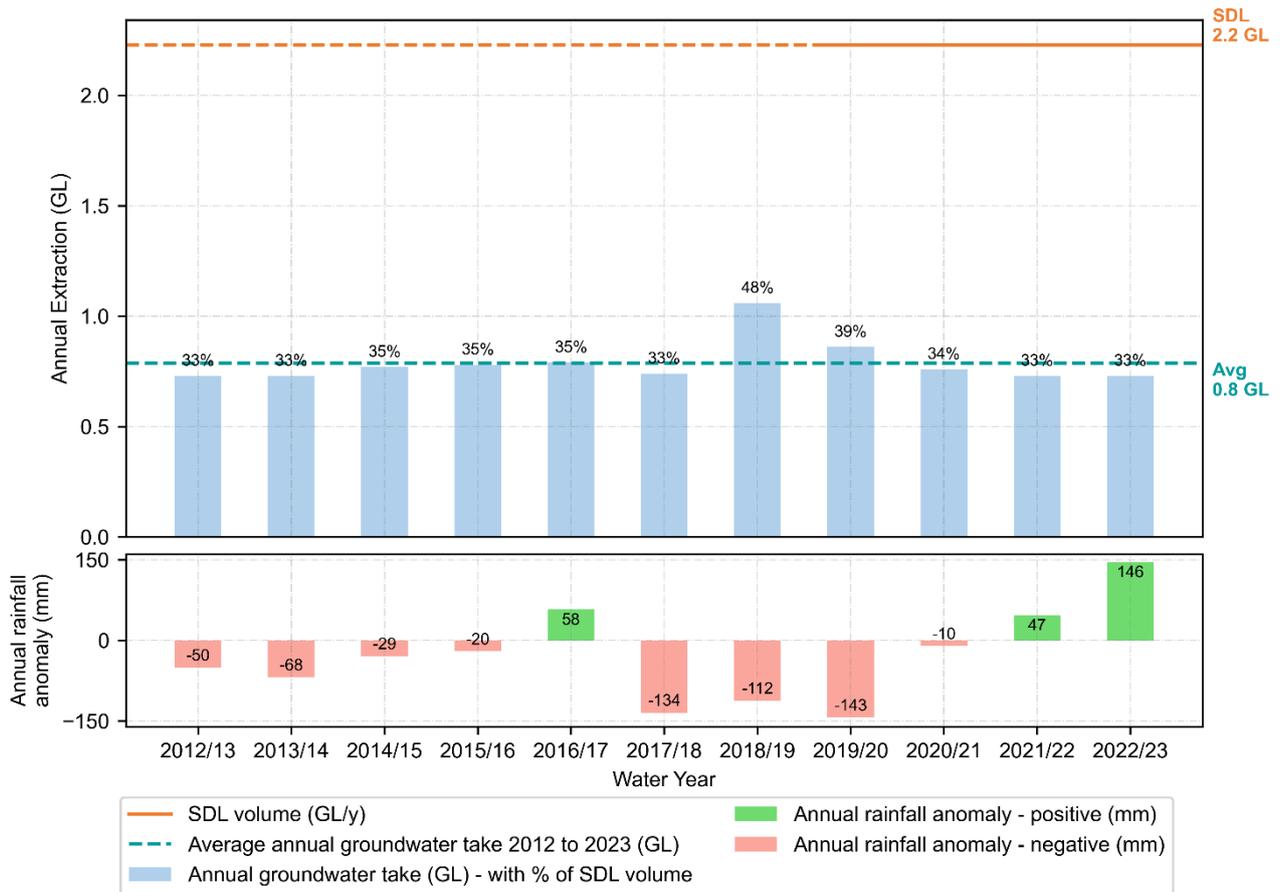


Figure 2 Groundwater take in the SDL since 2012

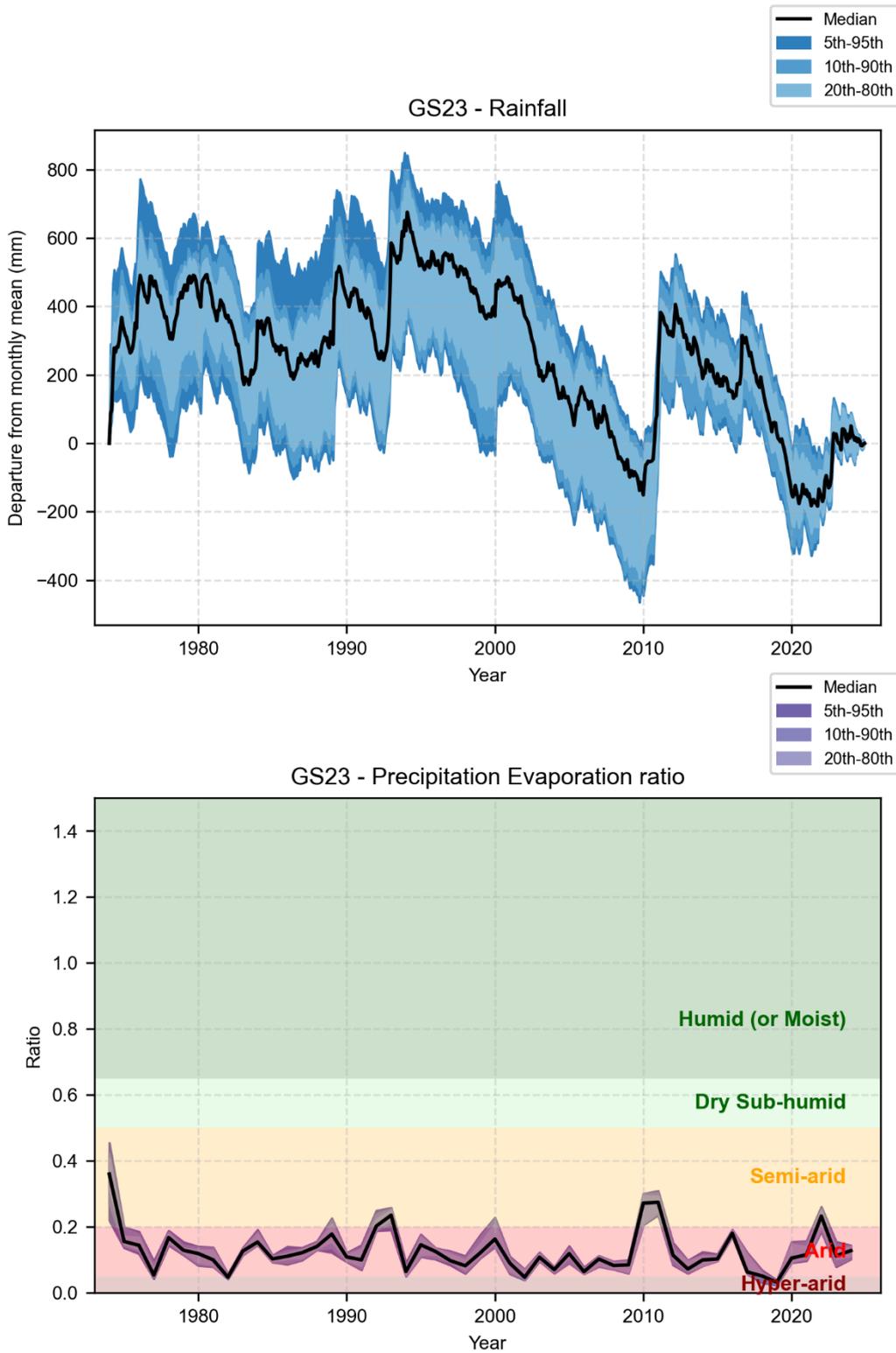
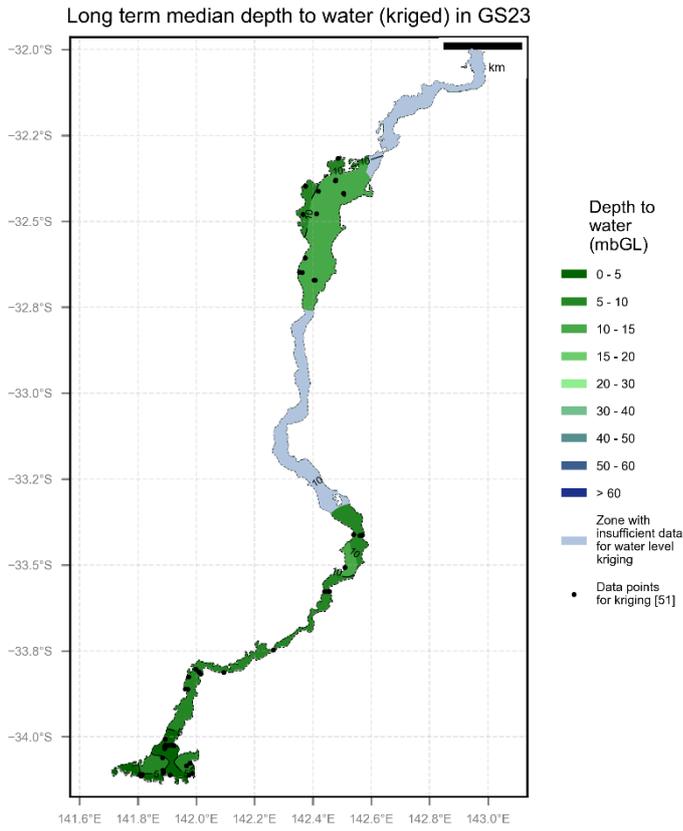
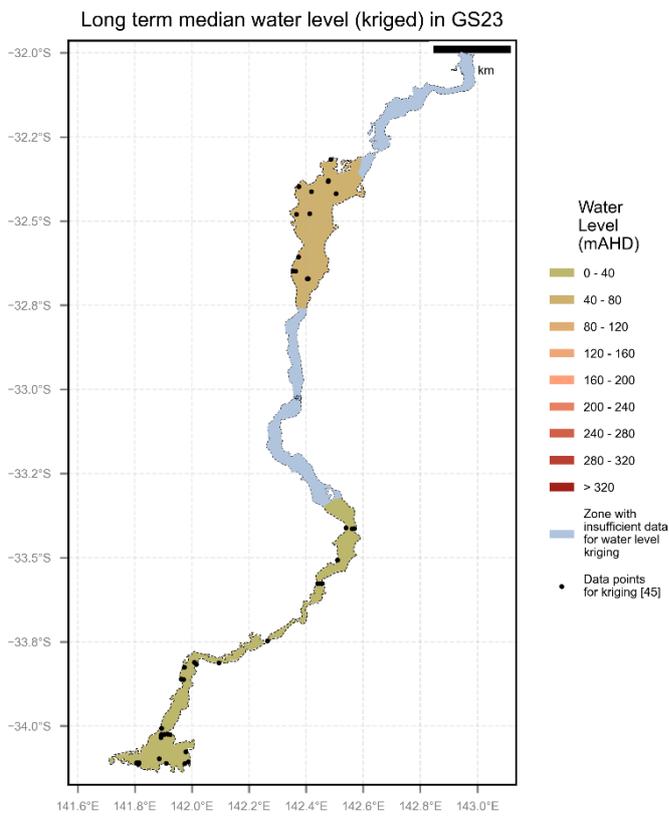


Figure 3 Historical climate trends



Long term - 1974 to 2024; median - 50th percentile water level relative to ground surface

(a)

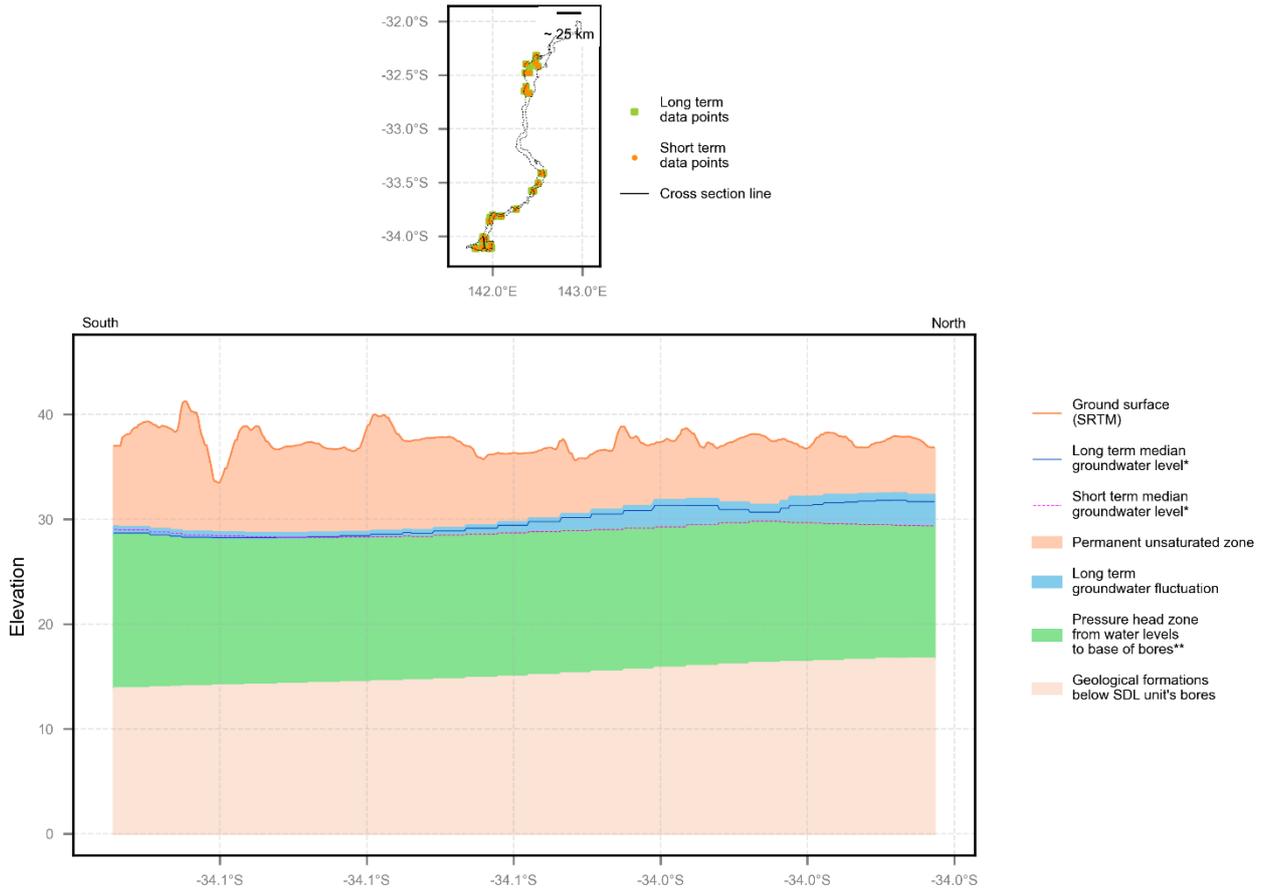


Long term - 1974 to 2024; median - 50th percentile water level relative to Australian Height Datum

(b)

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

Water level elevation cross section for GS23



*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 South to north distribution of water levels in the south of the SDL resource unit

Kriged median salinity values in GS23

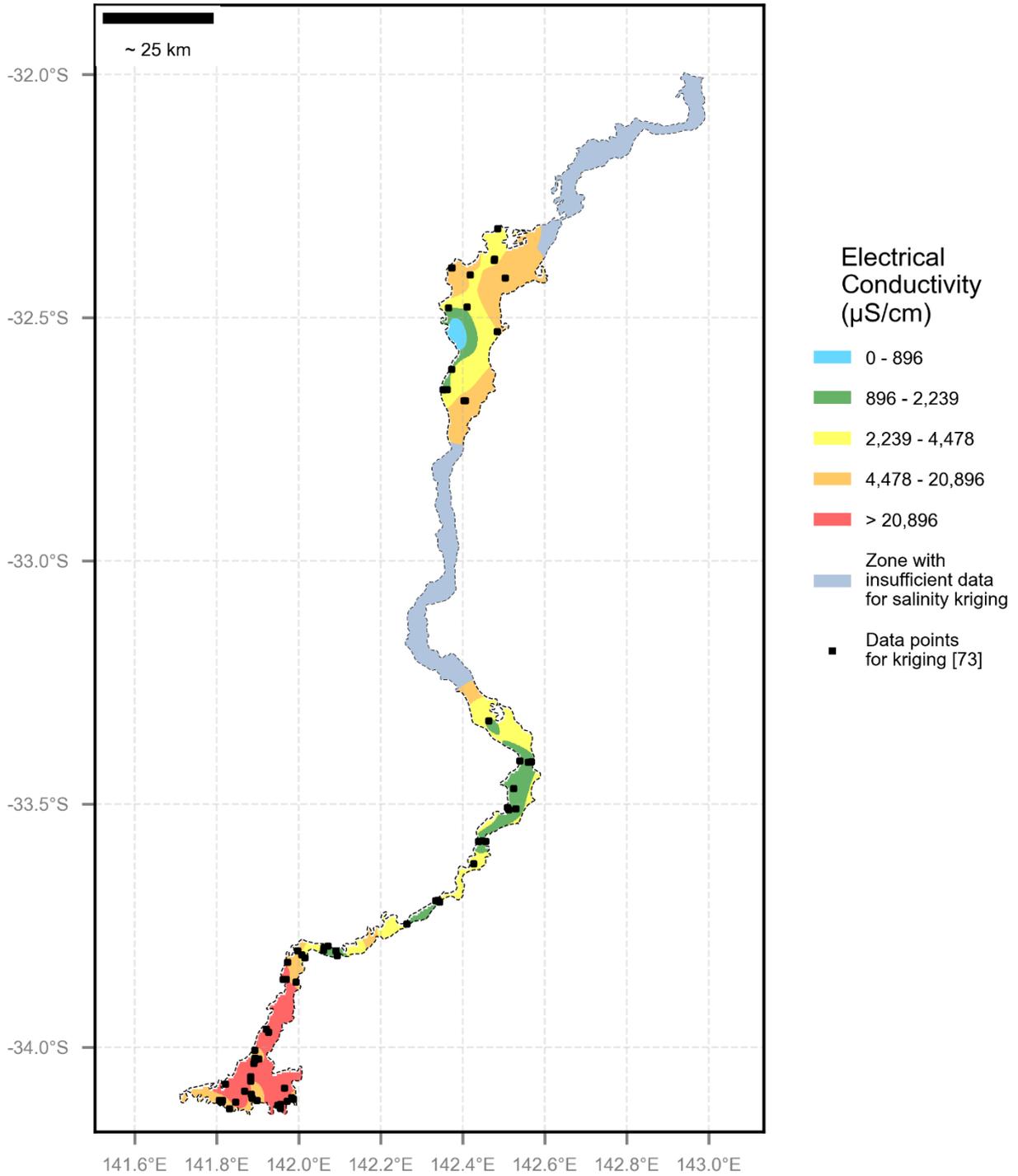


Figure 6 Groundwater salinity distribution

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	-	-	2.23
SDL resource unit area	km ²	-	-	1,652
Average annual take (2013 to 2023)	GL/y	-	-	0.79
Number of groundwater entitlement bores	-	-	-	8
SDL resource unit storage estimate*	GL	-	-	3,000
Recharge estimate (SY1)	GL/y	-	-	6.75
Recharge estimate (Stage 2)	GL/y	-	-	2.61
Diffuse recharge estimate (SY2 - WAVES)	GL/y	-	-	1.35
Extraction/SDL (E/SDL) (Stage 2 result)	-	-	-	0.35
SDL/Recharge (SDL/R) (Stage 2 result)	-	-	-	0.85
SDL/Recharge (SDL/R) (SY2 or modelled recharge)	-	-	-	1.65
Storage/Stage 2 Recharge (S/R)	-	-	-	1,149
Storage/SY2 or modelled Recharge (S/R)	-	-	-	2,222
Number of bores in the SDL unit	-	511	511	-
Number of bores for water level trend analysis	-	51	45	-
Number of bores for water level trend with sufficient data	-	45	26	-
Number of bores with decreasing water level trend	-	24	13	-
Number of bores with increasing water level trend	-	7	0	-
Number of bores with no statistically significant water level trend	-	14	13	-
Mean water level trend magnitude	m/y	-0.02	-0.08	-
Minimum water level trend magnitude	m/y	-0.15	-0.22	-
5%ile water level trend magnitude	m/y	-0.12	-0.2	-
10%ile water level trend magnitude	m/y	-0.08	-0.17	-
50%ile water level trend magnitude	m/y	-0.02	-0.06	-
90%ile water level trend magnitude	m/y	0.03	-0.03	-
95%ile water level trend magnitude	m/y	0.05	-0.03	-
Maximum water level trend magnitude	m/y	0.06	0.06	-
Number of bores for salinity trend analysis	-	79	53	-
Number of bores for salinity trend with sufficient data	-	35	2	-
Number of bores with decreasing salinity trend	-	1	0	-
Number of bores with increasing salinity trend	-	2	0	-
Number of bores with no statistically significant salinity trend	-	32	2	-
Mean salinity trend magnitude	µS/cm/y	6	-6	-
Minimum salinity trend magnitude	µS/cm/y	-398	-8	-
5%ile salinity trend magnitude	µS/cm/y	-308	-8	-
10%ile salinity trend magnitude	µS/cm/y	-107	-8	-
50%ile salinity trend magnitude	µS/cm/y	5	-6	-
90%ile salinity trend magnitude	µS/cm/y	82	-5	-
95%ile salinity trend magnitude	µS/cm/y	220	-5	-
Maximum salinity trend magnitude	µS/cm/y	660	-5	-

Note: *Groundwater resource storage estimate source: RRAM.

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	388,338,391	10%	37%	53%	Insufficient data	6%	18%	76%	Insufficient data
GDEs	388,338,391	10%	37%	53%	Insufficient data	6%	18%	76%	Insufficient data
River connectivity	778,647,790	15%	25%	60%	Insufficient data	13%	14%	73%	Insufficient data
Water quality	366,008,556	47%	16%	37%	Variable trends	0%	0%	100%	Insufficient data

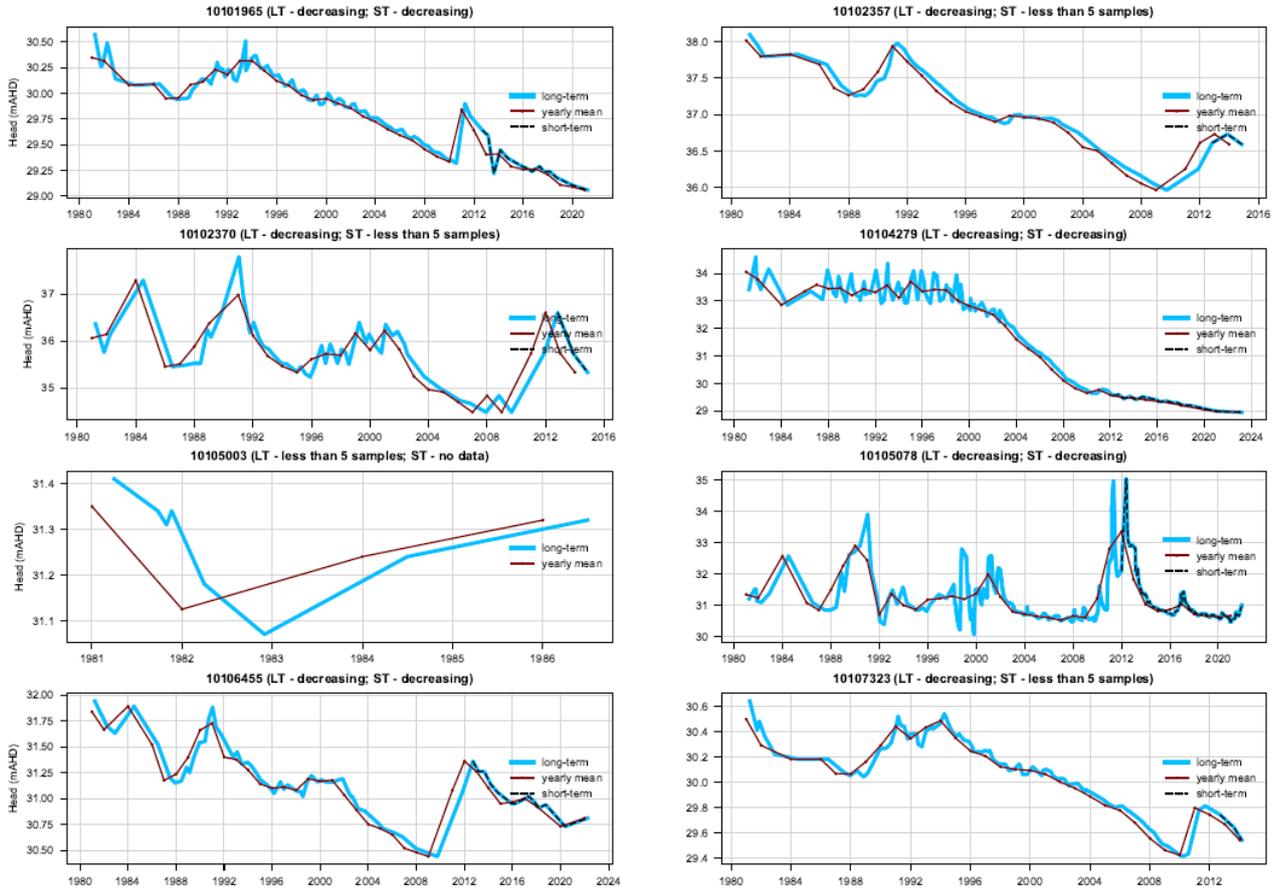


Figure 7 Representative groundwater hydrographs for the SDL resource unit

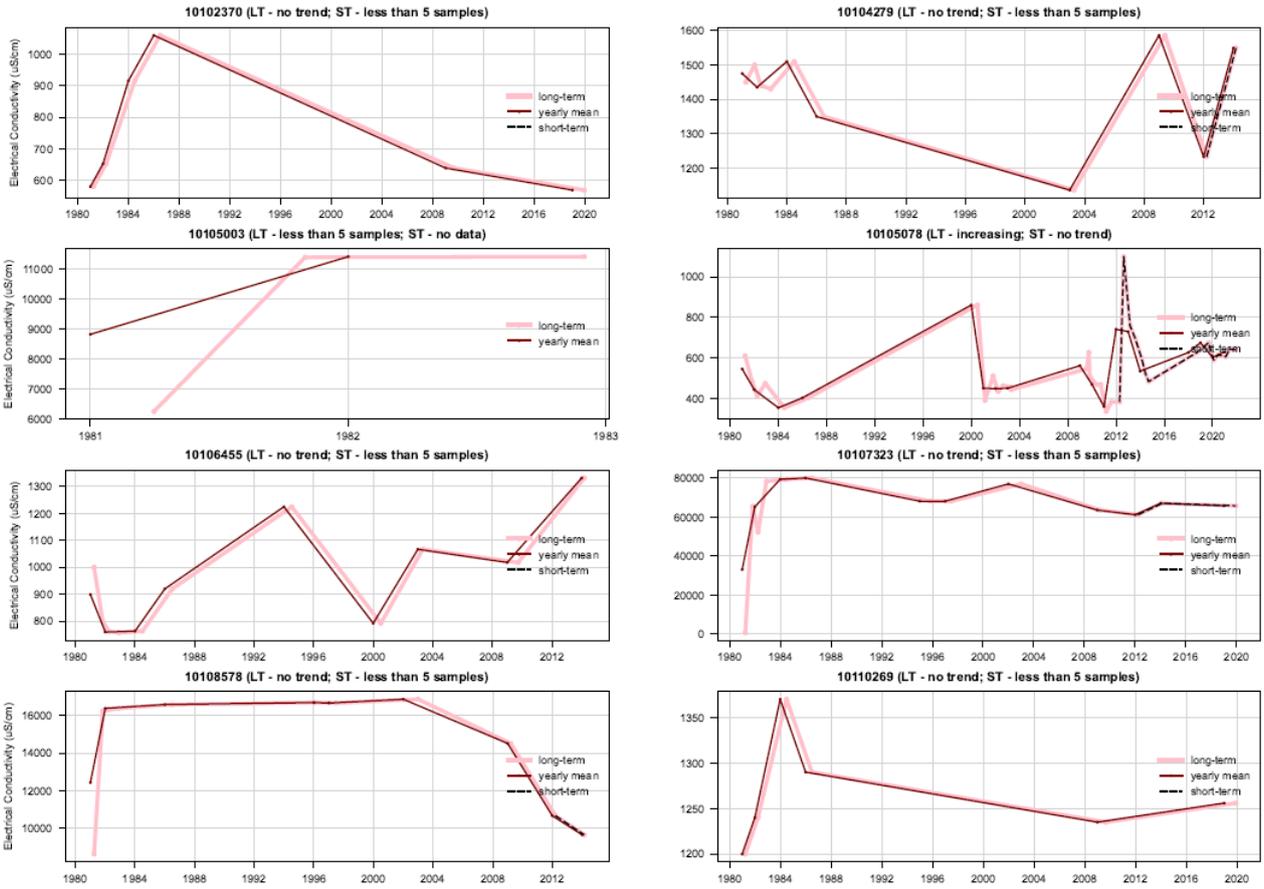
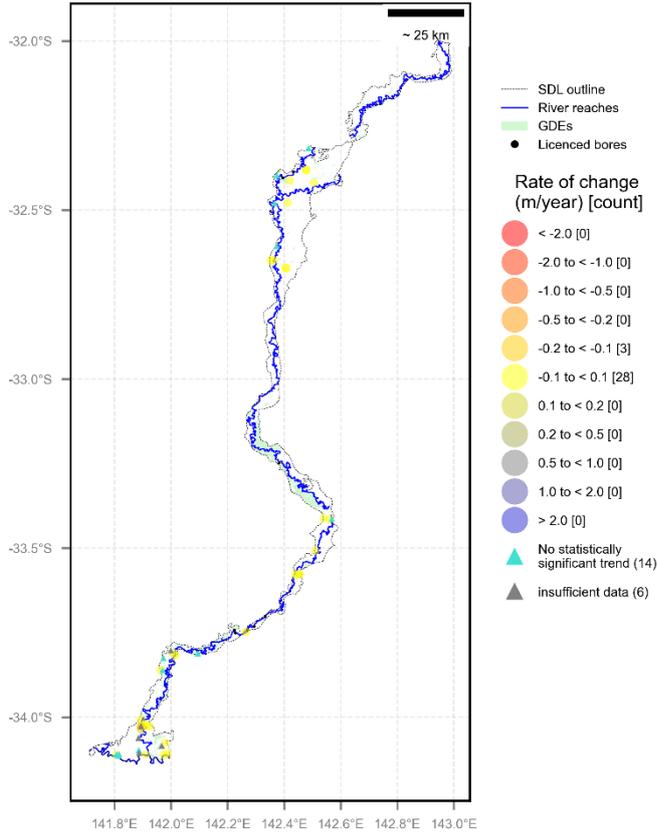


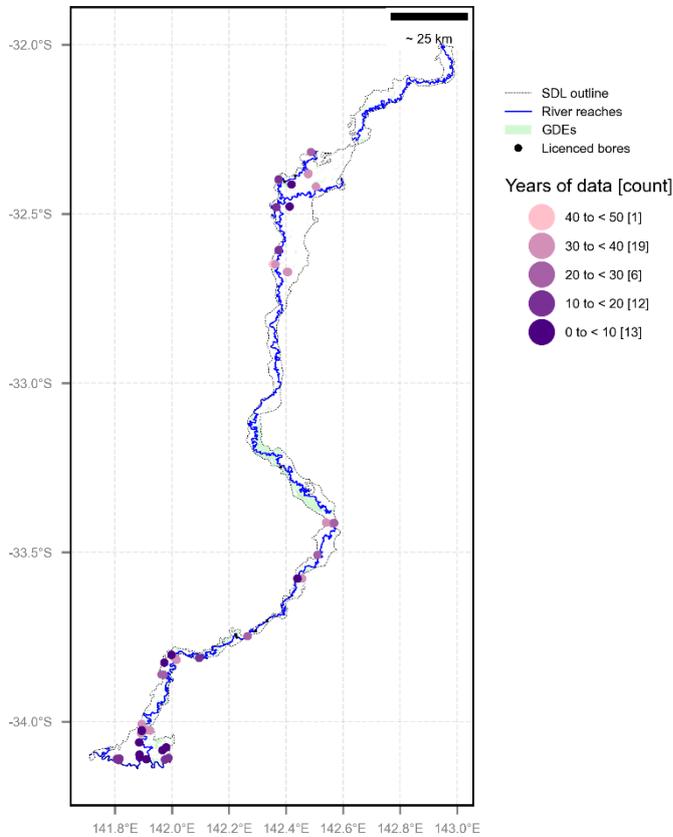
Figure 8 Representative groundwater salinity time series for the SDL resource unit

Long-term water level trends in GS23



a)

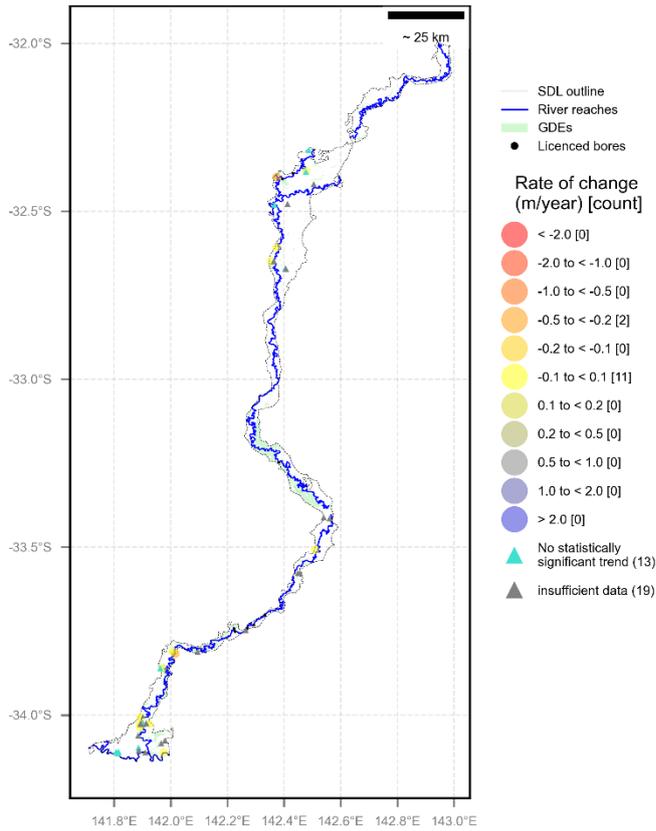
Long-term water level data density in GS23



b)

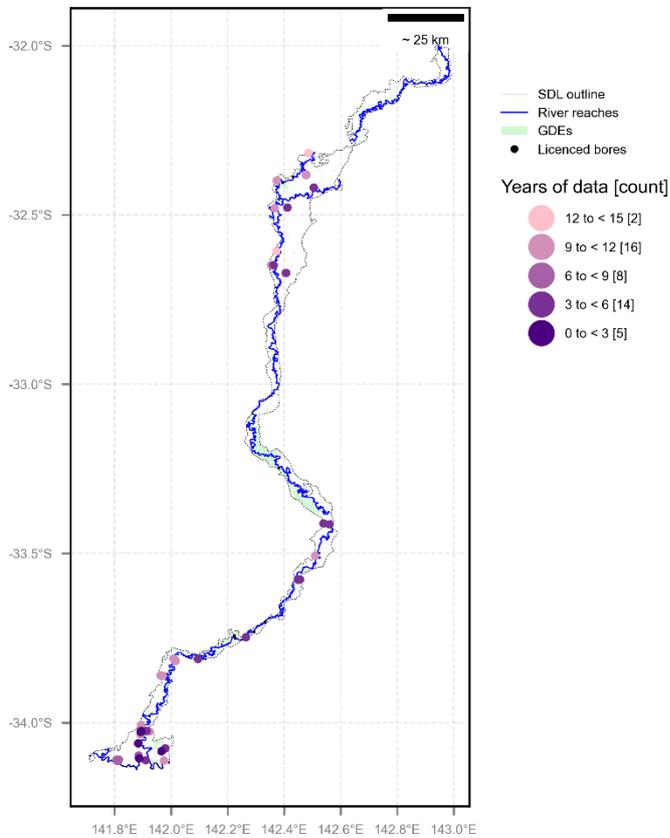
Figure 9 Long-term (1974 to 2024) (a) groundwater level trends and (b) data availability

Short-term water level trends in GS23



a)

Short-term water level data density in GS23



b)

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

Ternary plot for GS23

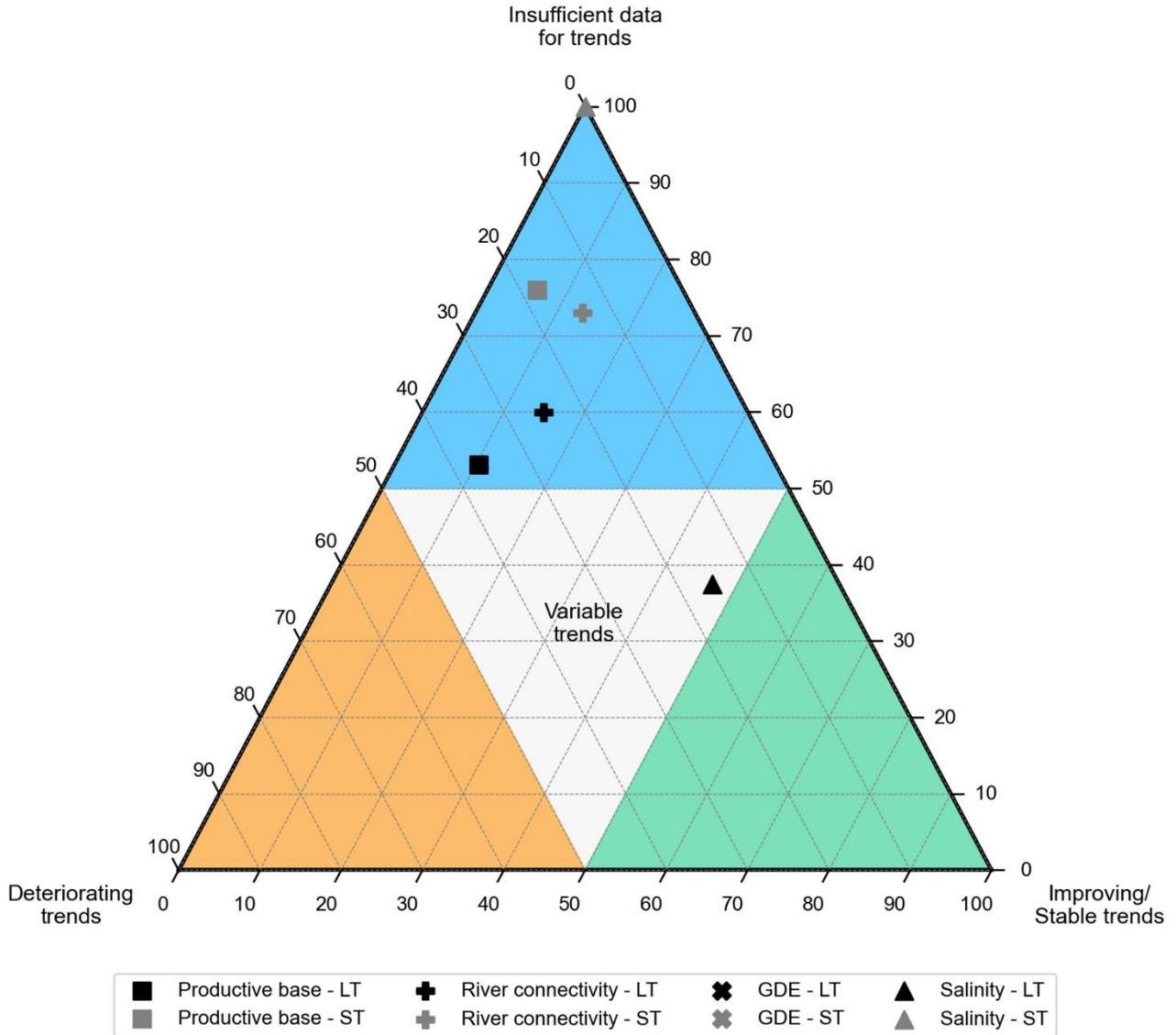


Figure 11 Stage 4 assessment outcome: trends in resource condition indicators for ESLT values

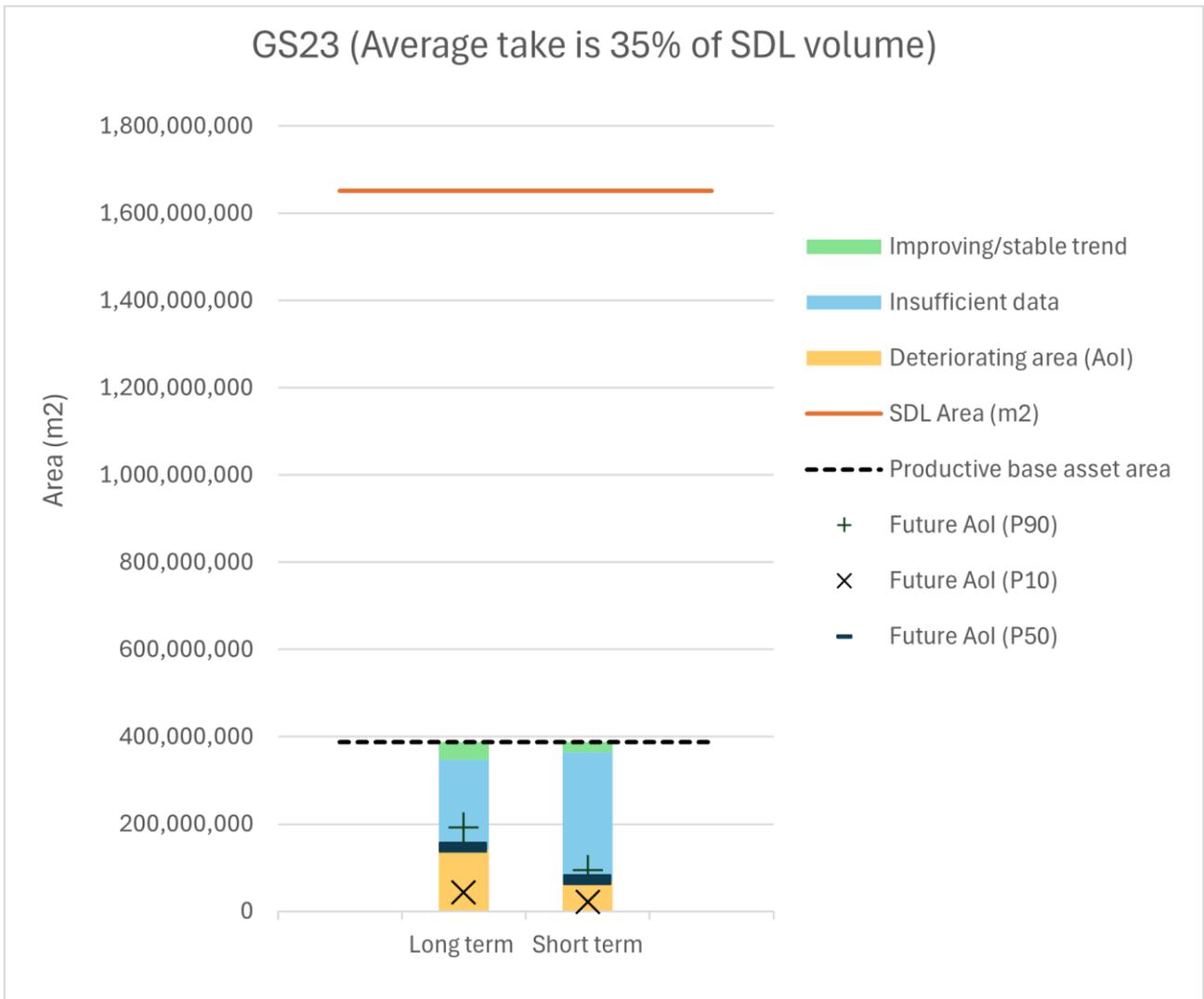


Figure 12 Estimates for change in area of influence (AoI) due to climate change

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