



Australasian
Groundwater
& Environmental
Consultants

Report on

GS65

Upper Condamine Basalts Alluvium Stage 5

Prepared for
Murray Darling Basin Authority

Project No. MDB5000.001
December 2025

ageconsultants.com.au

ABN 64 080 238 642



Document details and history

Document details

Project number	MDB5000.001
Document title	GS65 – Upper Condamine Basalts – Stage 5
Site address	Murray Darling Basin Authority, Canberra
File name	MDB5000.001 Stage 5 GS65 Upper Condamine Basalts v04.01.docx

Document status and review

Edition	Comments	Author	Authorised by	Date
v01.01	First draft for internal review	RR	AB	12/09/2025
v03.01	Draft delivered to client	RR/AB	AB	15/09/2025
v04.01	Final report	RR/AB	AB	18/12/2025

This document is and remains the property of AGE and may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

Australasian Groundwater and Environmental Consultants Pty Ltd

Brisbane Head Office
Level 2, 15 Mallon Street
Bowen Hills QLD 4006
t: (07) 3257 2055

Newcastle
4 Hudson Street
Hamilton NSW 2303
t: (02) 4962 2091

Perth
46B Angove Street
North Perth WA 6006
t: (08) 6383 9970

Townsville
Unit 1, 60 Ingham Road
West End QLD 4810
t: (07) 4413 2020

GS65 – Upper Condamine Basalts

Stage 5 – Assessment through multiple lines of evidence

The Upper Condamine Basalts (GS65) SDL unit is situated in southern Queensland and consists of a fractured volcanic aquifer formed from Tertiary basalt flows of the Main Range Volcanics (MRV) (Figure 1). Groundwater entitlements are clustered densely in the central part of the unit around the population centres of Toowoomba, Oakey, and Pittsworth (where fracture permeability and water quality are favourable) and are sparse to the north (where the aquifer is less extensive) and south (where the primary land use is conservation and nature reserves; Figure 1). The SDL unit spans approximately 4,537 km², with a sustainable diversion limit (SDL) of 79.00 GL/year and a long-term average recharge of 151.16 GL/year (Table 1, Stage 2 estimate derived from Lee *et al.*, 2024). The average extraction between 2013 and 2023 was 62.24 GL/year, representing 41% of estimated recharge and 79% of the SDL. This aquifer underlies much of the Condamine catchment and serves as a critical groundwater resource for irrigation, town water supply, and stock and domestic use. Long-term climate observations show a relatively persistent below-average rainfall signal for the 2011–2024 period but a highly anomalous rainfall year in 2021–22 (Figure 2; Figure 3). Groundwater take has generally declined since 2017, although dry conditions in 2022/23 resulted in a renewed uptake (Figure 2).

The water table is deeper than 10 m below surface, and is typically between 15 m and 20 m below the ground surface for most of the SDL resource unit area (with smaller extents of slightly deeper or shallower conditions (Figure 4a). The deeper zones of the watertable are generally located in the high use areas near Toowoomba. Groundwater flows from east to west, or northeast to southwest, in different zones of GS65, with the high topographic relief of this region driving strong lateral hydraulic gradients (Figure 4b). Long-term (1974–2024) and short-term (2012–2024) median groundwater levels show spatial agreement and are contained within a thick multi-decadal fluctuation zone ranging from about 5 m to 15 m (Figure 5; only nine of 128 bores have a fluctuation range greater than 15 m in the short-term). This variability is greater than many other regions and is due to low storativity of the fractured rocks (DNRME, 2019) and rapid responses to recharge. The productive part of this fractured rock aquifer, as defined by the depth of production bores, is generally 50 m to 75 m thick in the central area (Figure 5). In some parts of GS65, the recent (short-term) median water level sits above that of the long-term (Figure 5), indicating that during recent wet years current levels remain, or have recovered, higher than those of the past (Figure 7). Long-term water level trends (Figure 7) show both high-frequency signals (seasonal take and recharge) and slower oscillations, which represent depletion or replenishment of aquifer storage depending on year-on-year take and rainfall conditions. These oscillations are often present despite an overall stable water level trend on a decadal scale, marked by an absence of a statistically significant trend, which is the case for about 50 bores in the long-term and short-term (Table 1). Alternatively, the oscillations can be overprinted by decadal-scale statistically significant trends, which mainly have decreasing magnitudes in both the long-term (Figure 9; 74 bores) and short-term (Figure 10; 50 bores). Water quality is generally fresh across GS65 (salinity below 1,500 mg/L; equivalent to 2,239 $\mu\text{S}/\text{cm}$; Figure 6), reflecting the high rainfall in this humid to sub-humid climate (Figure 3) and short groundwater residence times. The understanding of temporal salinity trends is limited due to poor data availability (Figure 8).

MDBA (2020) previously reported recharge at 115.00 GL/year based on WAVES modelling results of MD-SY1, incorporating diffuse recharge only. This estimate compares favourably to the WAVES modelling estimate for diffuse recharge from the MD-SY2 project (Crosbie et al., 2025) of 111.46 GL/year. The Stage 2 estimate of recharge is relatively higher at 151.16 GL/year, and provides the SDL:recharge ratio (SDL/R) of 0.52. Table 1 shows a storage-to-recharge ratio (S/R) of 72 using the Stage 2 estimate of recharge and the RRAM estimate of storage, suggesting low buffering capacity and vulnerability to short-term climate variability (S/R sits in the “high responsiveness” bracket¹ defined in Rojas et al., 2022). Groundwater in GS65 is stored primarily in weathered zones and fracture networks rather than in pore spaces, which limits its buffering capacity compared to alluvial systems. In addition, the high extraction-to-SDL (E/SDL) ratio of 0.79 (Table 1) suggests high pressure on the productive base. Recent recovery of water levels to elevations similar to the long-term median is positive, especially as the 1970s (the beginning of the long-term period) represented an anomalously high rainfall period accompanied by higher water tables.

The productive base shows significant signs of stress, particularly in zones with high extraction and limited recharge access. Local drawdown, unmetered take, and inconsistent enforcement have contributed to declining groundwater levels in parts of the SDL resource unit. Aquifer compartmentalisation and local heterogeneity mean that pressures may be unevenly distributed, which is the reason that signs of over-extraction have emerged in high-demand zones. Long-term water level declines affect about 22% of the productive base asset area of GS65 and short-term declines affect 21% (Table 2), with resource condition indications similar for GDEs, but showing a greater area of decline for river connectivity (Figure 11). Statistically significant ($\alpha=0.05$) declines have occurred since 1974 in the central area, with magnitudes typically slower than -0.5 m/y (Figure 9). Short-term trends (Figure 10) show a similar pattern, although with fewer bores having declining trends (Table 1), and an intermingling of bores with declines and bores with no statistically significant trend represents localised improvements within the fractured aquifer. The short-term period (2012-2024) is characterised by mainly below-average or close-to-average rainfall, with a single anomalous rainfall year in 2021/22 (Figure 2, Figure 3). Analysis of the hydrographs (Figure 7) indicates that short-term declining trends are due to the rainfall change from 2012 to 2020, and are only statistically significant if the recovery post-2020 does not reach 2012 levels.

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 22% of the productive base asset area, 33% of the river connectivity asset area, and 21% of the GDE asset area (Table 2). In the short-term, these percentages marginally decreased to 21%, 28% and 19%, respectively (Table 2). Approximately 20% of each ESLT asset area showed improving or stable water level conditions in the short-term (Table 2). This proportion appears low compared to the number of stable trend bores present in GS65; however, the result reflects the precautionary approach of the spatial analysis of Stage 4 that weighted a declining trend higher than a stable trend within 5 km. Overall, there is not a large change in the resource condition between the long-term and the short-term (Figure 11), and levels of uncertainty, as indicated by areas with insufficient data to inform temporal trends, have remained relatively consistent (between 53% to 61%; Table 2). Uncertainty is higher for the water quality (salinity) ESLT value, where the zones with ‘insufficient data’ to determine temporal trends increased from 94% of the asset area to 100% in the short-term.

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

The Queensland state-based risk assessment (DNRME, 2019) assigns variable risk ratings across ESLT values. For productive base, the risk to continued groundwater supply from an increase in utilisation of all licenses or activation of unallocated water was identified as medium, with an unlikely likelihood, but a major potential consequence. Localised risks are further elevated in areas with dense bore development or limited recovery. Metering of groundwater take in GS65 is not extensive, although where records are available, take is generally below the entitlement (DNRME, 2019). The risk to productive base is managed through announced entitlements, in a setting where there is expanding water demand from agriculture and resource development. Connectivity to surface water is limited but present in some areas where springs or shallow flow zones intersect with streambeds; this impact is rated as a low risk (i.e. groundwater level changes are not expected to impact surface water flows; DNRME, 2019). Groundwater-dependent ecosystems (GDEs) include spring-fed vegetation and minor wetlands in low-lying areas, but their extent and sensitivity to groundwater decline remain poorly understood. These assets are considered at high risk due to limited data, uncertain ecological thresholds, and likely vulnerability to drawdown. While nutrients and pesticides are currently considered low risk, salinity remains a concern and water quality risk is ranked as high by the state.

Future projections from the MD-SY2 project suggest that diffuse recharge in GS65 may increase by 2050 due to more intense rainfall events (Crosbie et al., 2025); however, predictions under different hydroclimates remain variable. The aquifer does not receive floodplain or in-stream recharge, making it highly reliant on local vertical infiltration. This recharge mechanism is sensitive to surface conditions, and any reduction in infiltration capacity resulting from land use changes could impact long-term resilience. Stage 6 of this BPR technical groundwater review found that the future area of drawdown (Area of Influence, AoI²) is projected to expand under climate change scenarios, with the median future AoI (P50) exceeding the present AoI, indicating likely increases in deteriorating areas (Figure 12). However, the SDL/R ratio is also projected to decrease slightly, indicating overall uncertainty from climate change impacts. The Stage 6 assessment classified the pressure from future climate change on GS65 groundwater resources as very high (based on long-term and short-term water level evidence).

Overall, short-term groundwater level trends (2012–2024) suggest a similar resource condition in GS65 to that observed over the long-term (1974–2024). This shallow fractured basalt aquifer displays localised impacts, as heterogeneity means that signs of over-extraction are not regional, but are present in high-use areas. Long-term water level trends show year-on-year oscillations, which represent depletion or replenishment of the aquifer storage depending on demand and transient recharge fluxes. Periodic recovery of aquifer storage (represented by water levels returning to historical norms) occurs on a decadal scale in some sites, and in other areas a slow reduction in recovered heads has occurred (i.e. residual drawdown). This reflects the low buffering capacity of this resource and a very high pressure from climate change, despite uncertainty around future recharge variability. Recent take has declined (possibly in response to changes in management and availability of surface water), but there is a projected increase in water demand in GS65, and only a fraction of entitled take is metered. The state-based risk assessment highlights the medium to high risk to the productive base, GDEs, and salinity ESLT values from current take or additional demand on groundwater leading to drawdown. Considering that there are significant knowledge and data gaps for these ESLT values, there is an active focus on adaptive management. Collectively, the analysis suggests GS65 exhibits a challenging setting, with the presence of sensitive GDEs, high quality water, high pressure from groundwater users, and very high pressure from climate change in a system where storage levels are susceptible to depletion during dry periods.

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.

Productive base (groundwater entitlements) - GS65

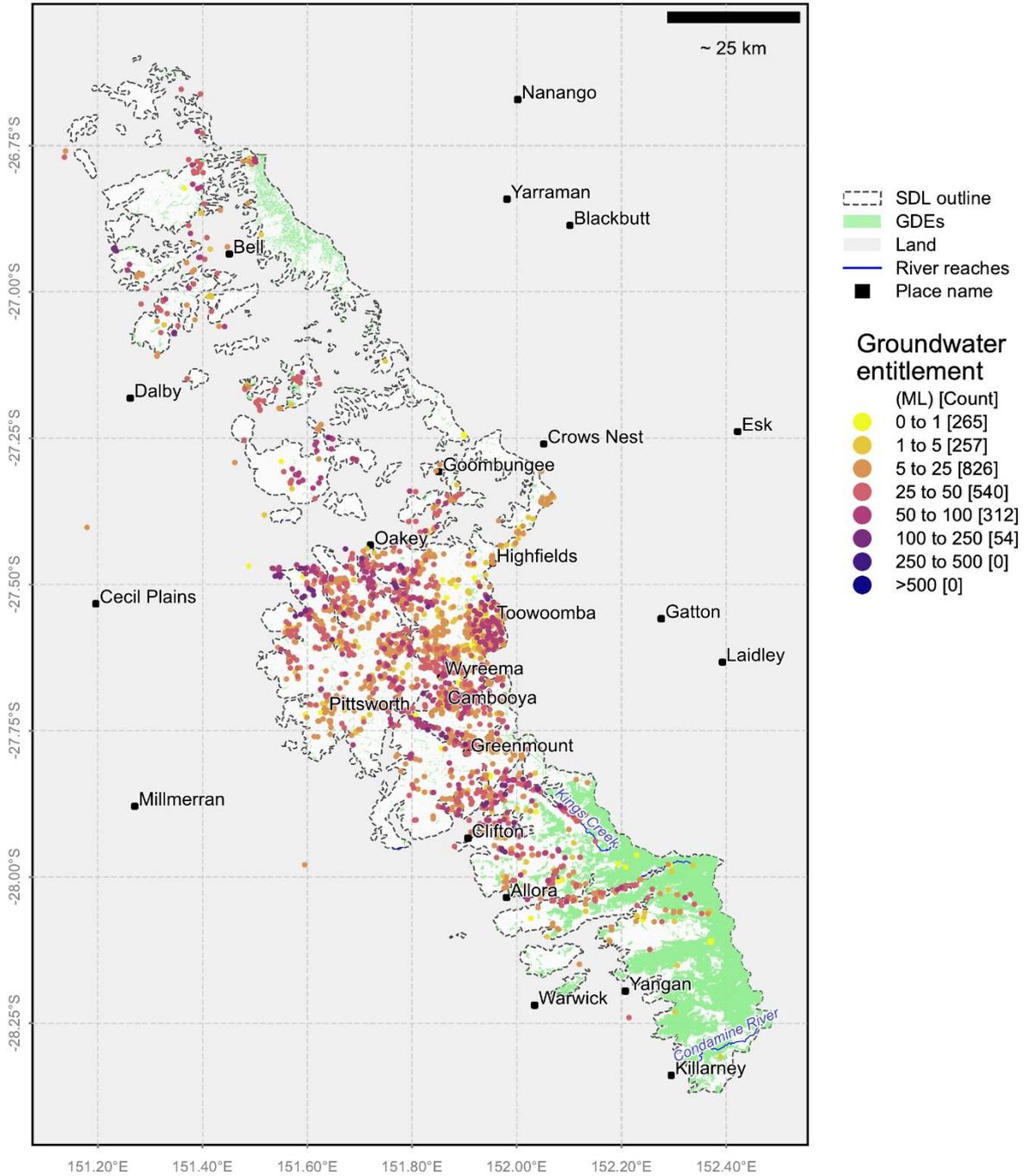


Figure 1 Productive base (groundwater entitlements)

Annual groundwater take and rainfall anomaly for GS65

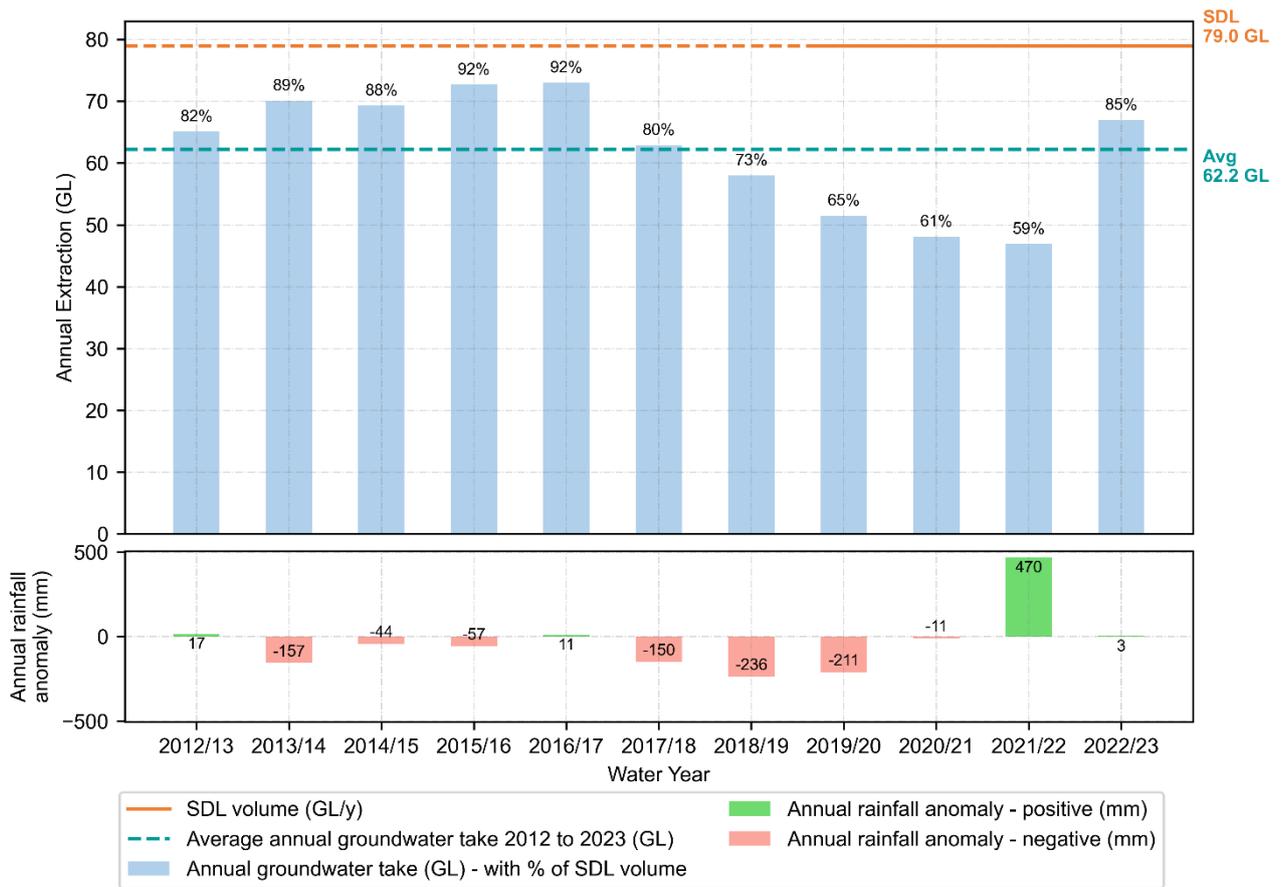


Figure 2 Groundwater take in the SDL since 2012

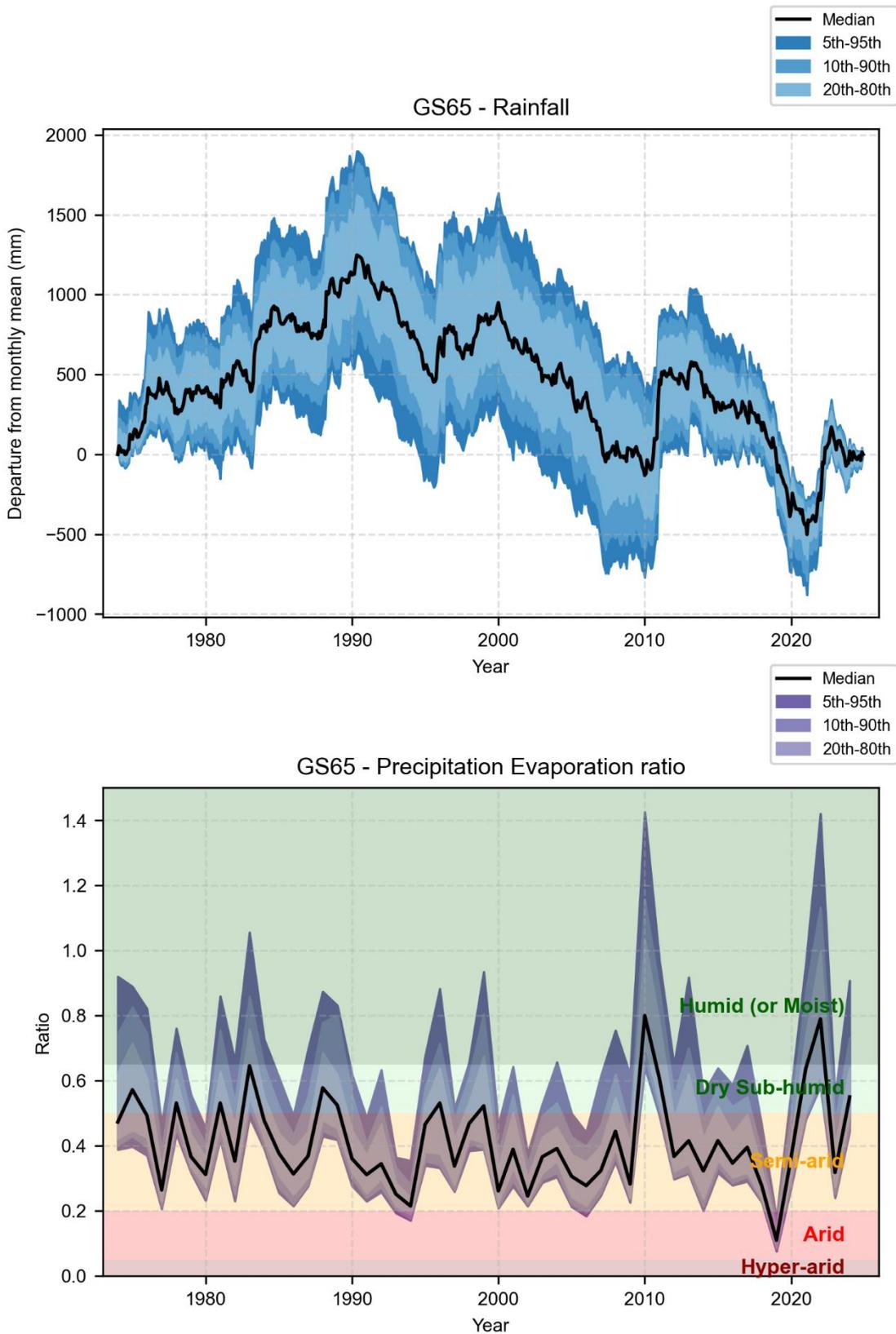
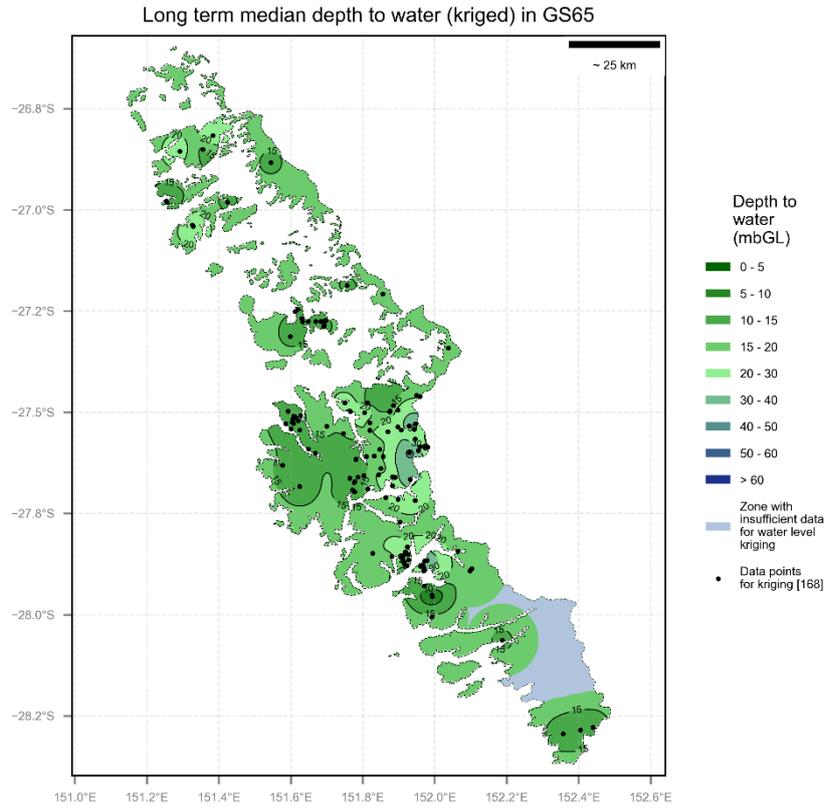
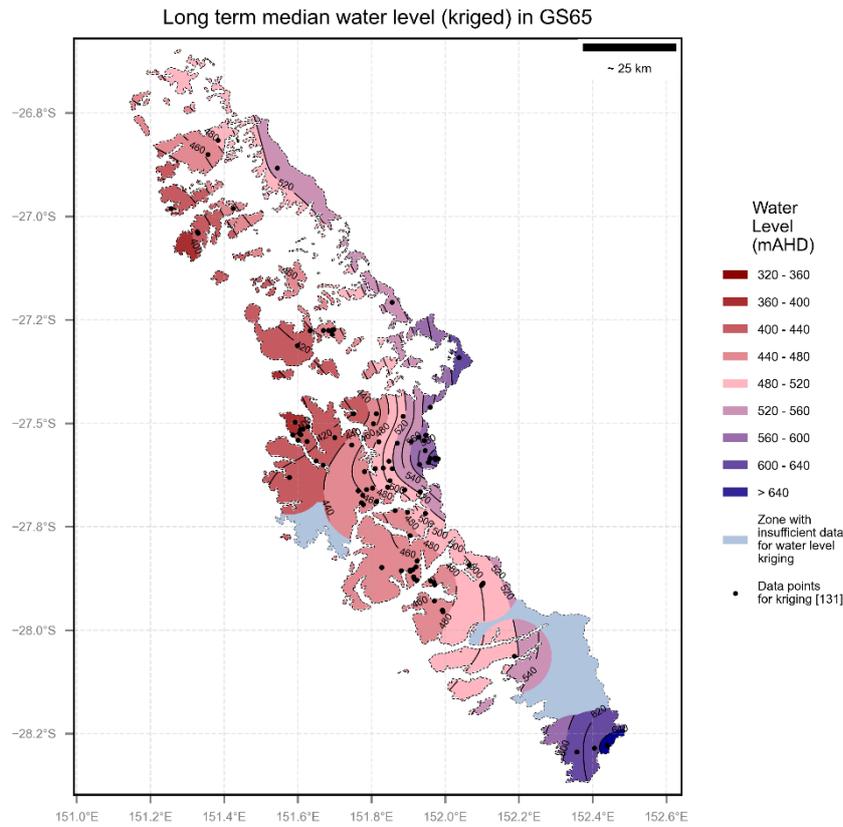


Figure 3 Historical climate trends



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

a)

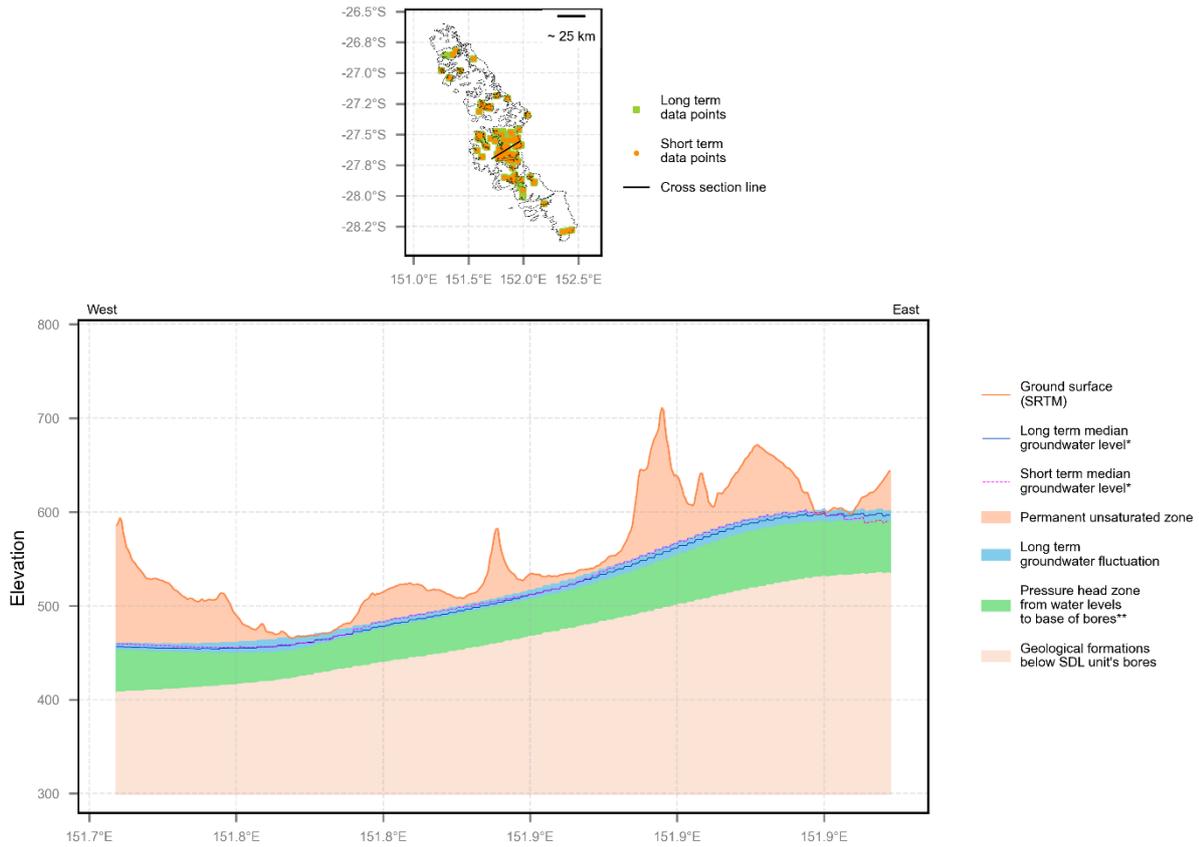


Long term - 1974 to 2024; median - 50th percentile water level relative to Australian Height Datum

b)

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

Water level elevation cross section for GS65



*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

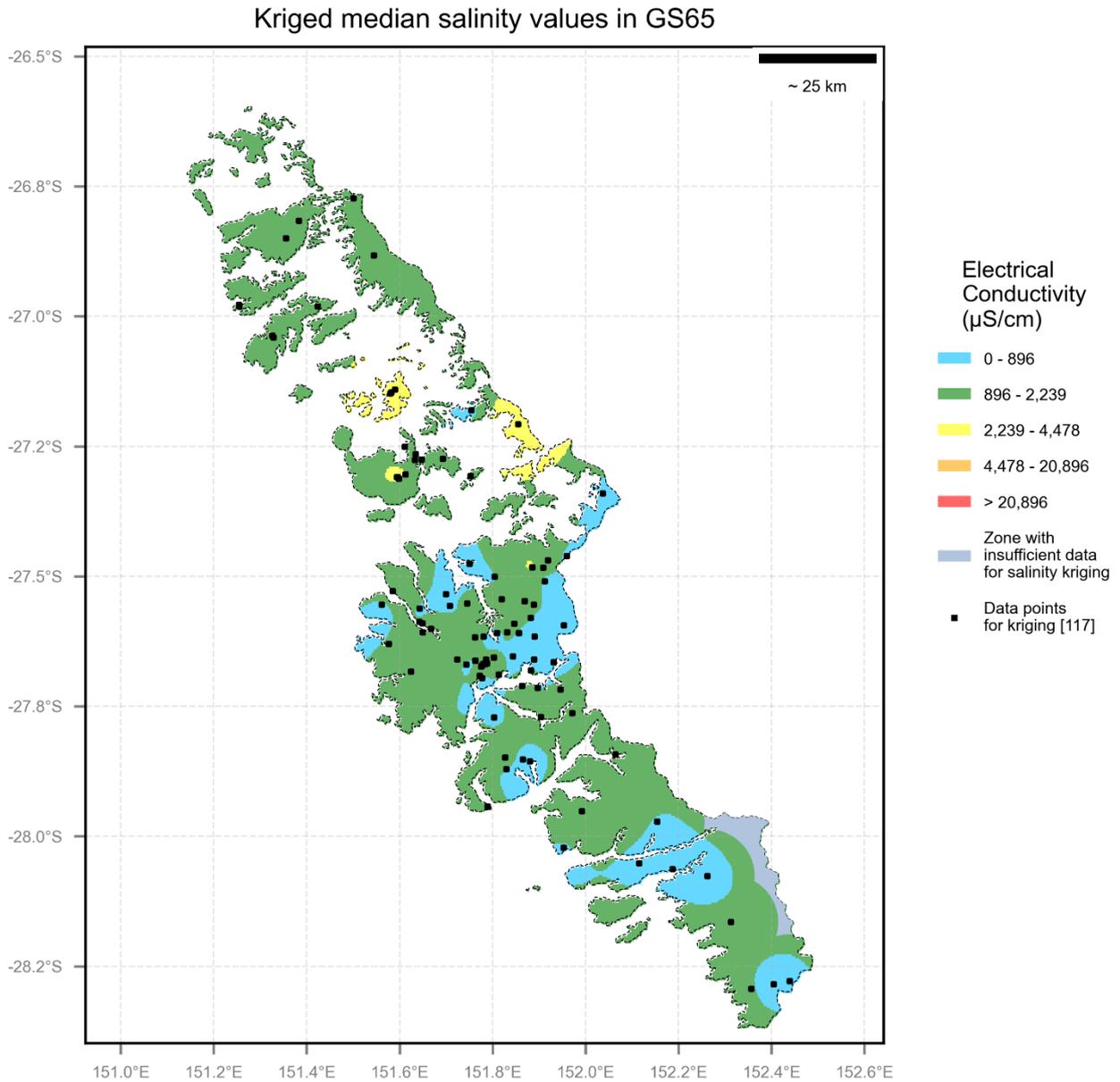


Figure 6 Groundwater salinity distribution

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	-	-	79.00
SDL resource unit area	km ²	-	-	4,537
Average annual take (2013 to 2023)	GL/y	-	-	62.24
Number of groundwater entitlement bores	-	-	-	2,254
SDL resource unit storage estimate*	GL	-	-	10,894
Recharge estimate (SY1)	GL/y	-	-	115.00
Recharge estimate (Stage 2)	GL/y	-	-	151.16
Diffuse recharge estimate (SY2 - WAVES)	GL/y	-	-	111.46
Extraction/SDL (E/SDL) (Stage 2 result)	-	-	-	0.79
SDL/Recharge (SDL/R) (Stage 2 result)	-	-	-	0.52
SDL/Recharge (SDL/R) (SY2 or modelled recharge)	-	-	-	0.71
Storage/Stage 2 Recharge (S/R)	-	-	-	72
Storage/SY2 or modelled Recharge (S/R)	-	-	-	98
Number of bores in the SDL unit	-	9,736	9,736	-
Number of bores for water level trend analysis	-	285	128	-
Number of bores for water level trend with sufficient data	-	132	100	-
Number of bores with decreasing water level trend	-	74	50	-
Number of bores with increasing water level trend	-	9	2	-
Number of bores with no statistically significant water level trend	-	49	48	-
Mean water level trend magnitude	m/y	-0.24	-0.21	-
Minimum water level trend magnitude	m/y	-4.87	-1.92	-
5%ile water level trend magnitude	m/y	-2.08	-0.99	-
10%ile water level trend magnitude	m/y	-0.5	-0.69	-
50%ile water level trend magnitude	m/y	-0.07	-0.16	-
90%ile water level trend magnitude	m/y	0.23	0.13	-
95%ile water level trend magnitude	m/y	0.39	0.32	-
Maximum water level trend magnitude	m/y	0.99	1.99	-
Number of bores for salinity trend analysis	-	123	64	-
Number of bores for salinity trend with sufficient data	-	12	0	-
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	-	9	0	-
Mean salinity trend magnitude	µS/cm/y	7	N/A	-
Minimum salinity trend magnitude	µS/cm/y	-81	N/A	-
5%ile salinity trend magnitude	µS/cm/y	-70	N/A	-
10%ile salinity trend magnitude	µS/cm/y	-57	N/A	-
50%ile salinity trend magnitude	µS/cm/y	4	N/A	-
90%ile salinity trend magnitude	µS/cm/y	55	N/A	-
95%ile salinity trend magnitude	µS/cm/y	96	N/A	-
Maximum salinity trend magnitude	µS/cm/y	140	N/A	-

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	6,041,270,386	21%	22%	57%	Insufficient data	20%	21%	59%	Insufficient data
GDEs	5,768,852,486	19%	21%	59%	Insufficient data	20%	19%	61%	Insufficient data
River connectivity	977,069,391	14%	33%	53%	Insufficient data	17%	28%	55%	Insufficient data
Water quality	6,041,270,386	6%	0%	94%	Insufficient data	0%	0%	100%	Insufficient data

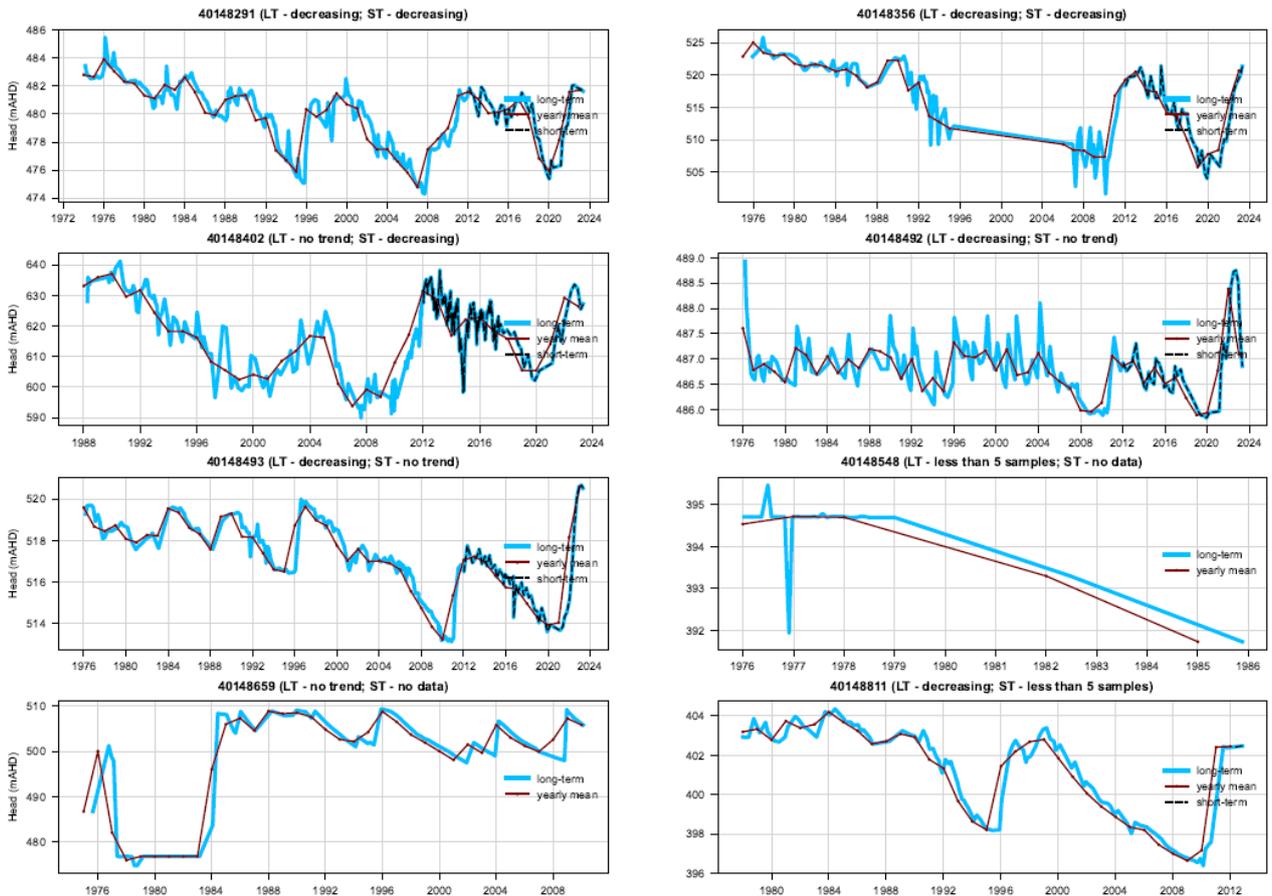


Figure 7 Representative groundwater hydrographs for the SDL resource unit

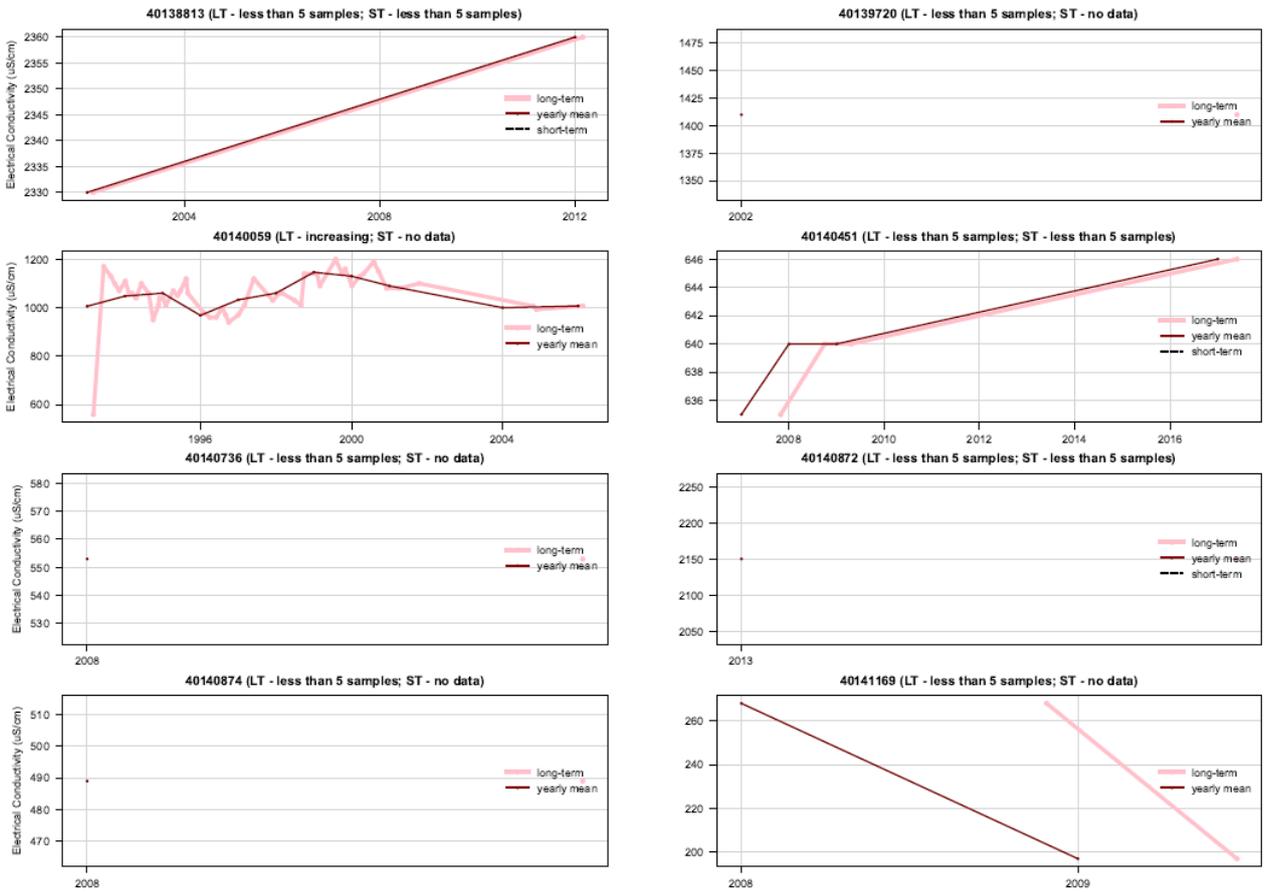


Figure 8 Representative groundwater salinity time series for the SDL resource unit

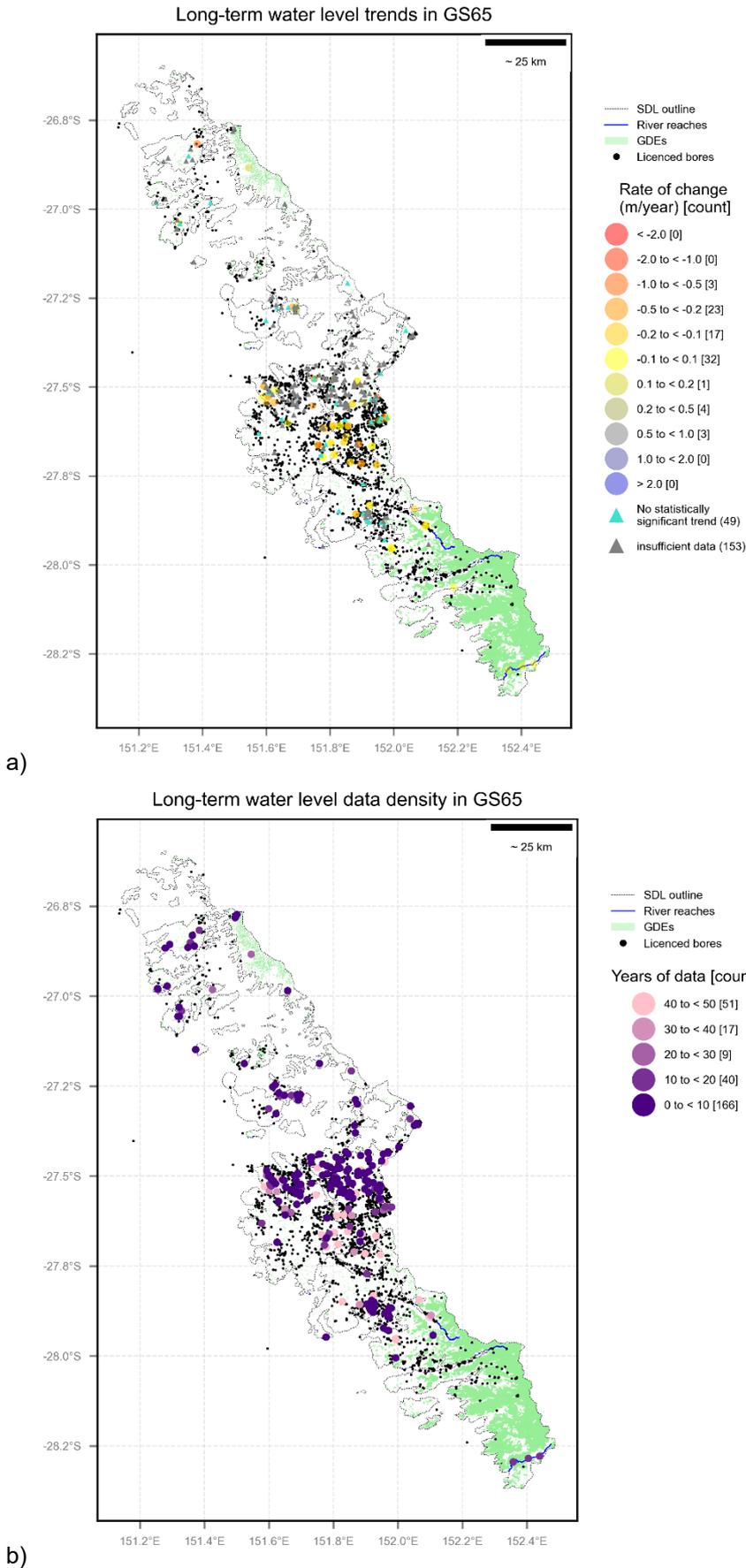


Figure 9 Long-term (1974 to 2024) groundwater level trends (a) and data availability (b)

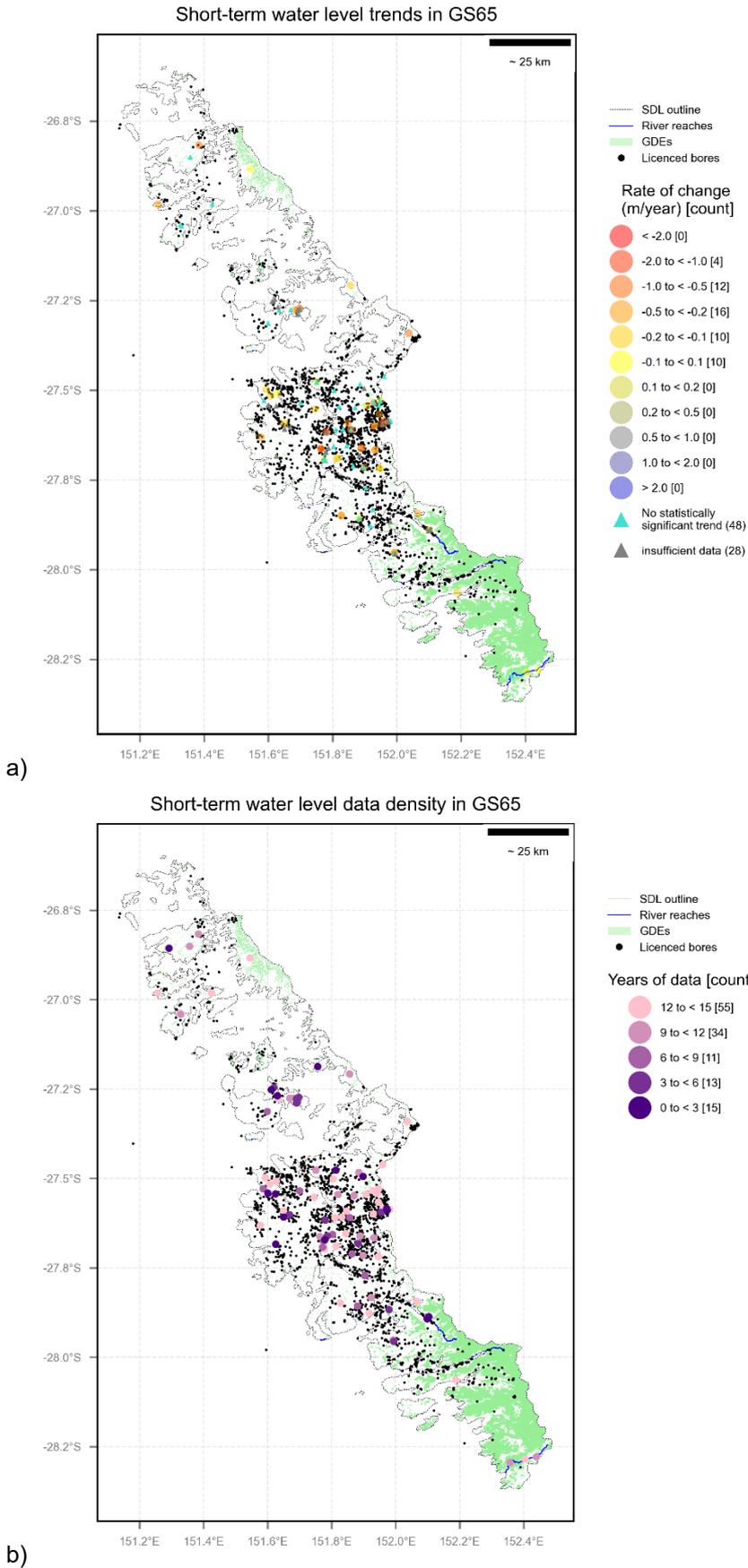


Figure 10 Short-term (2012 to 2024) groundwater level trends (a) and data availability (b)

Ternary plot for GS65

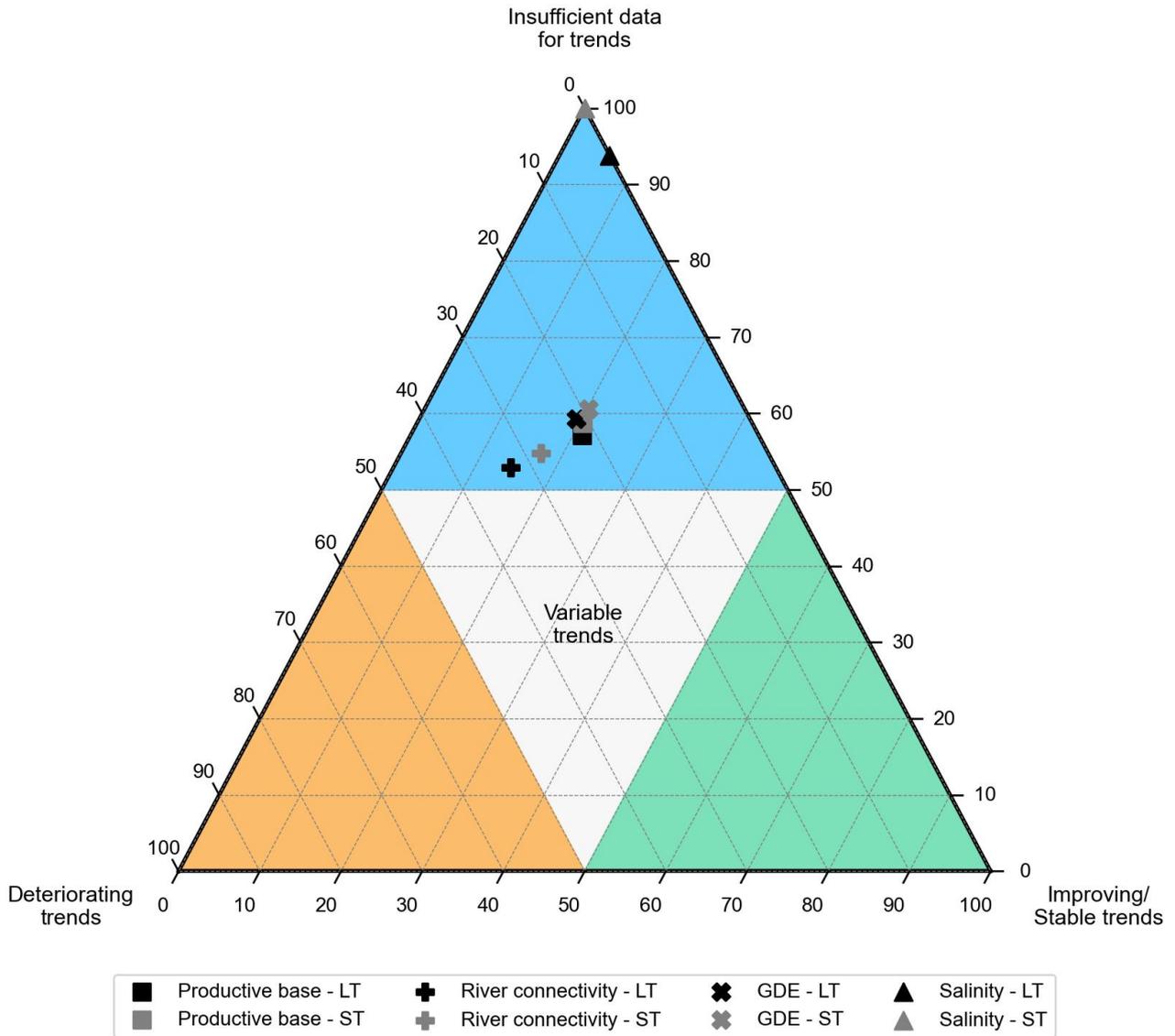


Figure 11 Stage 4 assessment outcome: trends in resource condition indicators for ESLT values

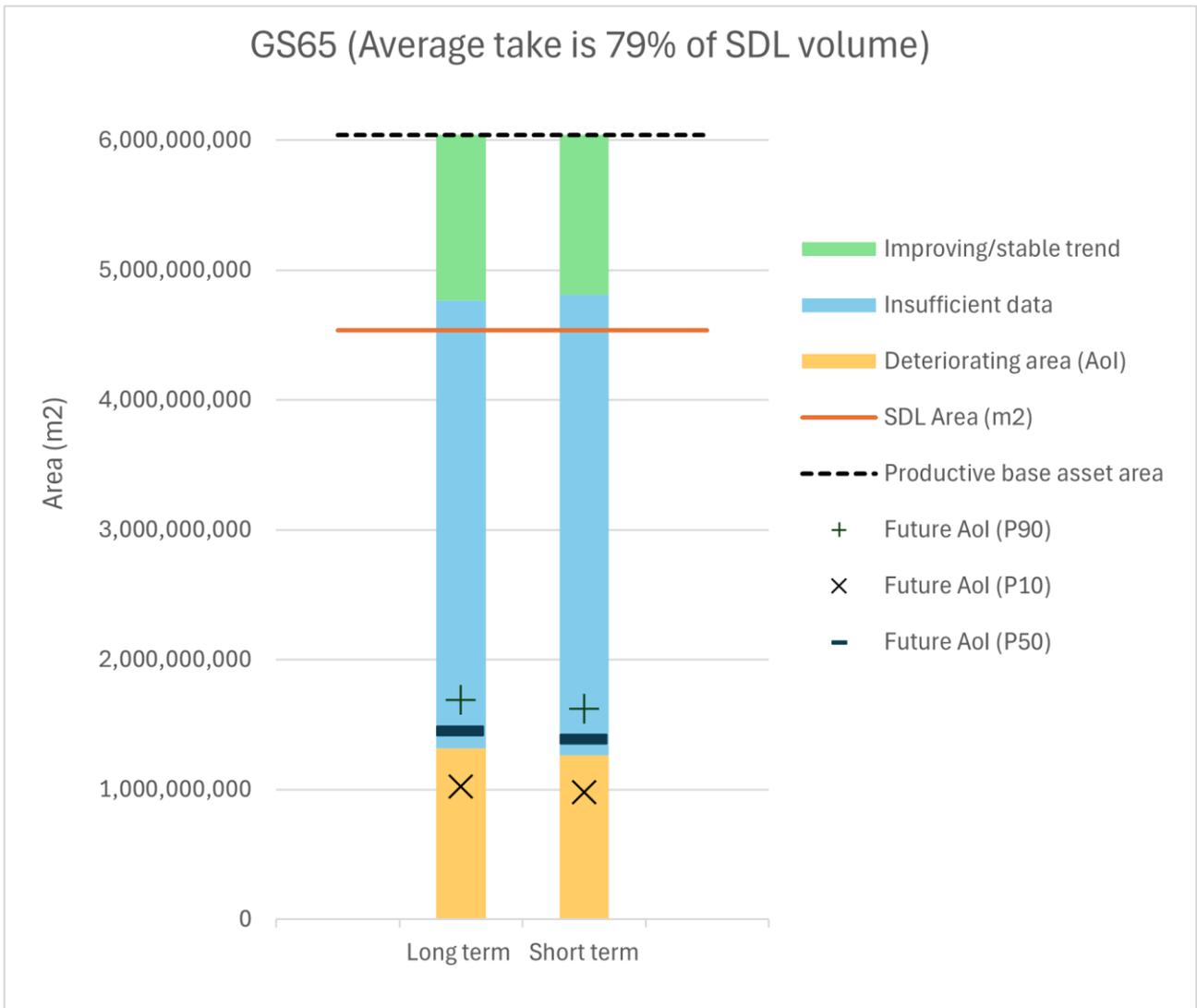


Figure 12 Estimates for change in area of influence (AoI) due to climate change

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.
- Lee S, Irvine DJ, Duvert C, Rau GC, Cartwright I, (2024) A high resolution map of diffuse groundwater recharge rates for Australia. *Hydrology and Earth System Sciences*, 28(7), 1771-1790, doi: 10.5194/hess-28-1771-2024.
- MDBA (2020) Groundwater report cards For Sustainable Diversion Limit Resource Units under the Murray–Darling Basin Plan. Canberra, Australia. www.mdba.gov.au/sites/default/files/publications/mdba-groundwater-report-cards-november-2020.pdf.
- Queensland Department of Environment and Science (DES), (2019). Healthy Waters Management Plan: Condamine River Basin. Brisbane: Department of Environment and Science, Queensland Government (pp 234). Available from https://environment.desi.qld.gov.au/_data/assets/pdf_file/0019/87103/hwmp-condamine-river-basin.pdf accessed on 17 January 2025.
- Queensland Department of Natural Resources Mines and Energy (DNRME), (2019) Condamine and Balonne Risk Assessment Report. Department of Natural Resources, Mines and Energy, Queensland Government, Brisbane (pp 240). Available from www.mdba.gov.au/sites/default/files/publications/qld-condamine-balonne-risk-assessment-report-20192.pdf accessed on 17 January 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>.