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Murray–Darling Basin Authority

The SDL Assessment: Technical Methods – Overview

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We acknowledge the Traditional Owners and Custodians of Country throughout the Murray–Darling Basin and their continuing connection to land, waters and community. We offer our respects to the people, the cultures and the Elders past and present.

Aboriginal people should be aware that this publication may contain images, names or quotations of deceased persons.

Executive Summary

On of the key tasks of the Basin Plan is to set the long-term average sustainable diversion limits (Sustainable Diversion Limits or SDLs) for the Basin's water resources. The SDLs determine how much surface and groundwater can be taken by towns and communities, farmers and industries sustainably. Each area in the Basin has its own limit on water take for both ground and surface water.

The *Water Act 2007* (Cth) (the Water Act)[1] requires that SDLs reflect an Environmentally Sustainable Level of Take (ESLT). An ESLT is defined as the level of water extraction that, if exceeded, would compromise key environmental assets, key ecosystem functions, the productive base, or key environmental outcomes of the water resource.

In the course of conducting the Basin Plan Review (the BPR) the MDBA is assessing whether or not the SDLs continue to reflect an ESLT, and support the Basin Plan's environmental outcomes (this is referred to as SDL Assessment). An assessment methodology has been developed to support this work, drawing on updated monitoring and modelling information, hydroclimate information and other new science.

This document:

- provides a high-level overview of the assessment methodology, including the various technical methods which have been used to develop the evidence base which has supported the work of SDL Assessment; and
- identifies the supporting documents and reports which describe these methods in further detail, or which have been relevant to the task.

[1] *Water Act 2007* (Cth)

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Glossary

Basin Plan Review (BPR) - under the Water Act 2007 (Cth) (**Water Act**) the MDBA is required to review the Basin Plan 2012 (the **Basin Plan**) in 2026.

Drivers – refers to the identified cause of performance (either positive or negative) against observed findings. The SDL Assessment will prioritise the identification of drivers of poor outcomes in order to mitigate these risks however may also interrogate the drivers of good performance in order to identify actions that are effective.

Environmental Watering Plan (EWP) – refers to Chapter 8 of the Basin Plan[2] which comprises the Environmental Watering Plan or EWP. The EWP is a significant aspect of the Basin Plan, establishing environmental objectives, a management framework for environmental water and the methods and principles which apply to support use of environmental water. Through these settings the EWP provides complementary long-term planning and annual prioritisation for the Basin as a whole (Basin-scale) and for each water resource plan area.

Environmental Water Requirements (EWRs) – represent the water requirements of priority environmental assets and priority ecosystem functions to support their environmental objectives. These are developed consistent with the Environmental Watering Plan (EWP) by Basin governments and included in their long-term watering plans (LTWPs), Environmental Water Management Plans (EWMPs) and Flow Studies in Victoria.

Environmentally Sustainable Level of Take (ESLT) – is defined by the Water Act, for a water resource means the level at which water can be taken from that water resource which, if exceeded, would compromise:

(a) key environmental assets of the water resource; or
(b) key ecosystem functions of the water resource; or
(c) the productive base of the water resource; or
(d) key environmental outcomes for the water resource.[3]

Evaluation (Basin Plan Evaluation) – refers to the Evaluation of the Basin Plan undertaken consistent with Chapter 13 of the Basin Plan. The 2025 Basin Plan Evaluation[4] assessed the performance and impact of the Basin Plan.

Groundwater - refers to: (a) water occurring naturally below ground level (whether in an aquifer or otherwise); or (b) water occurring at a place below ground that has been pumped, diverted or released to that place for the purpose of being stored there; but does not include water held in underground tanks, pipes or other works.[3]

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[2] Murray-Darling Basin Authority, (2012) Basin Plan 2012.
[3] Section 4 of the Water Act 2007 (Cth)
[4] MDBA (Murray-Darling Basin Authority) (2025a) 2025 Basin Plan Evaluation MDBA website, accessed 14 January 2026.

Groundwater Dependent Ecosystem (GDE) – refers to Basin ecosystems that are either completely groundwater dependant, or that rely on groundwater for part of the time.

Long-term watering plans (LTWPs) – are prepared by Basin governments consistent with Part 4 of Chapter 8 of the Basin Plan. LTWPs outline the long-term objectives and strategies to (a) inform decisions on how water recovered under the Basin Plan should be prioritised and delivered, and (b) meet the watering requirements of environmental assets and functions. They also ensure water for the environment delivery aligns with the Murray-Darling Basin Authority (MDBA) Environmental Watering Strategy and the Environmental Watering Plan (EWP). Note, LTWP may also be referred to as Long Term Environmental Watering Plans (LTEWP).

Matter reports – reports prepared in accordance with Schedule 12 of the Basin Plan.

Matter 2 report – prepared by the MDBA every 5 years on the *protection and restoration of water-dependent ecosystems and ecosystem functions in the Murray-Darling Basin, including for the purposes of strengthening their resilience in a changing climate*.

Matter 7 report – prepared by the MDBA and the Commonwealth Environmental Water Holder every 5 years on the *achievement of environmental outcomes at a Basin-scale by reference to targets in Schedule 7*.

Matter 8 report – prepared by Basin governments every 5 years, on *the achievement of environmental outcomes at an asset scale*.

Surface water – includes: (a) water in a watercourse, lake or wetland; and (b) any water flowing over or lying on land: (i) after having precipitated naturally; or (ii) after having risen to the surface naturally from underground.[3]

Sustainable Diversion Limit (SDL) – is the maximum long-term annual average quantity of water that can be taken, on a sustainable basis, from the Basin water resources as a whole, and the water resources, or particular parts of the water resources, of each water resource plan area.

Sustainable Diversion Limit (SDL) Assessment – the process of assessing whether the SDLs reflect an ESLT and, ultimately, their effectiveness in supporting the environmental outcomes of the Basin Plan.

Sustainable Diversion Limits Assessment and Response Framework – the document that explains the process which has informed the initial SDL Assessment.

Sustainable Rivers Audit (SRA) – is a trend and current condition assessment of the Murray–Darling Basin across environmental, social, economic, and First Nations cultural themes, mostly relative to Basin Plan objectives and outcomes.

Water Resource Plans (WRP) – are a key tool for implementing the Basin Plan. These plans are prepared by Basin governments in accordance with Water Act and Basin Plan requirements. They outline how community, environmental, economic and Cultural outcomes will be met and resolve jurisdiction water management rules that meet the Basin Plan requirements. They set rules on how much water can be taken from the system, inform accounting settings and ensure the SDL is not exceeded over time.

1 Purpose and Scope

1.1 Purpose of the SDL Assessment

The Sustainable Diversion Limit (SDL) assessment process enables the MDBA to assess whether the SDLs reflect an Environmentally Sustainable Level of Take (ESLT) and, ultimately, the effectiveness of the SDLs in supporting the Basin Plan environmental outcomes.

1.2 Legislative and Basin Plan Context

The Water Act defines the ESLT as the level of water extraction that, if exceeded, would compromise key environmental assets, key ecosystem functions, the productive base, or key environmental outcomes of the water resource. The SDL assessment methods are designed to evaluate whether SDLs continue to reflect an ESLT and maintain the objectives of the Basin Plan. This concept is central to the Water Act.

SDLs determine how much surface and groundwater can be taken by towns and communities, farmers and industries sustainably. There are 109 SDL units across the Basin, and each area has its own limit on water take for ground (80 units) and surface water (29 units).

1.3 Relationship Between the Basin Plan Review and SDL Assessment & Response Framework

The Basin Plan Review (BPR) provides the MDBA with an opportunity to assess the SDLs using updated monitoring and modelling information, community knowledge and lived experience, hydroclimate information and other new science. It also provides an opportunity to test that assessment under a range of plausible futures under changing climates.

The SDL Assessment is undertaken consistent with the requirements of the Water Act, elements of which are described in the *Sustainable Diversion Limit Assessment and Response Framework* (the Framework). The Framework describes the purpose and approach to SDL Assessment (which includes the development of response options).

2 Key Documents

A series of documents have been produced by the MDBA to describe various aspects of the technical methods that have contributed to the SDL Assessment, recognising differences between assessment as it relates to surface water and groundwater.

In addition to the Framework, the Surface Water Technical Methods and Groundwater Technical Methods reports are intended to support a better understanding of the approach which has been taken.

Figure 1 provides an overview of the structure and layout of the technical methods documents that are available to support the Discussion Paper.

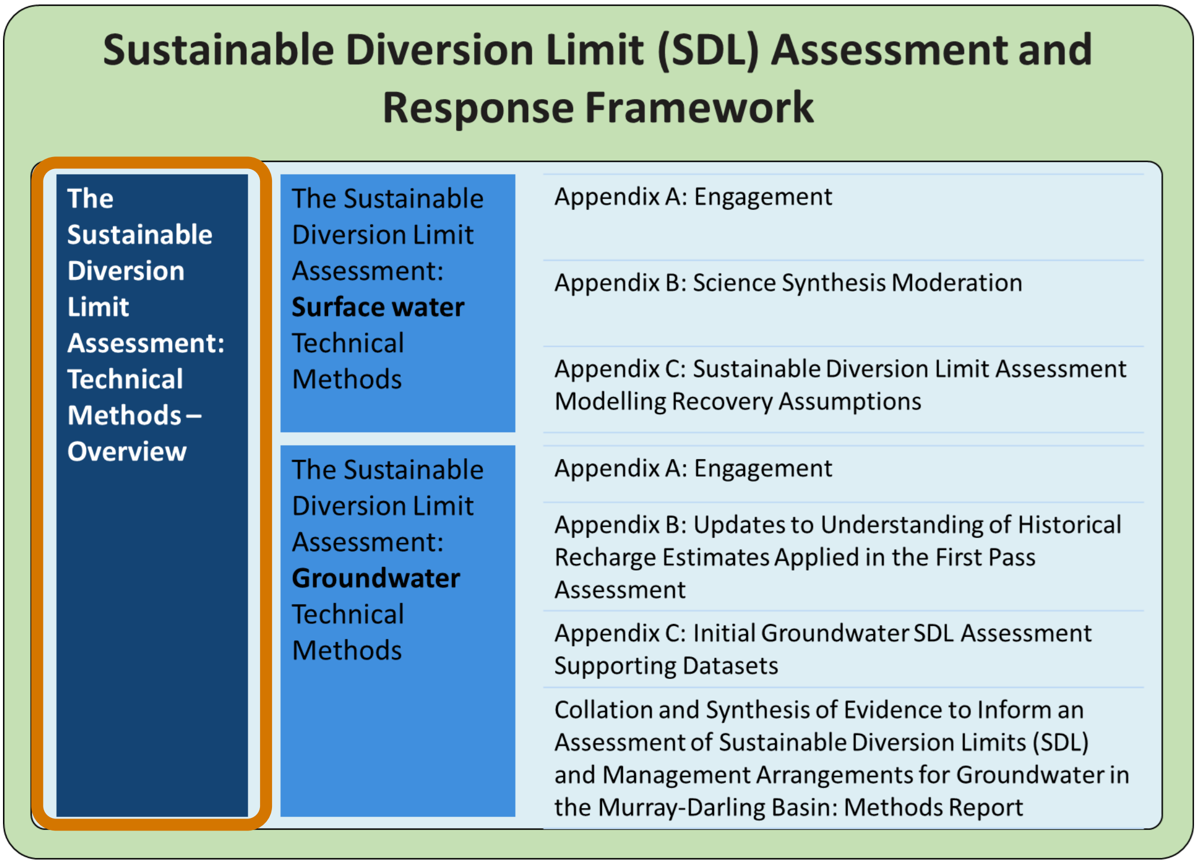

Figure 1 Structure and layout of the SDL Assessment technical methods reports

2.1 The Sustainable Diversion Limit Assessment: Surface Water Technical Methods

This document set outlines the technical methods and analysis that has been applied to 29 surface water resource units in the Murray–Darling Basin (the Basin). It includes information on the development and application of the method and results:

- **Appendix A: Engagement:** this appendix provides detail around the engagement approach used to develop and apply the surface water methods.
- **Appendix B: Science Synthesis Moderation:** the results of the assessment have been shared for with Basin government representatives, this appendix explains how feedback and other lines of evidence have informed moderation of the initial results.
- **Appendix C: Sustainable Diversion Limit assessment modelling recovery assumptions:** this appendix provides an understanding of the modelling assumptions and water recovery within models for each resource unit.

2.2 The Sustainable Diversion Limit Assessment: Groundwater Technical Methods

This document set focuses on the technical methods analysis and that was applied to 80 groundwater resource units in the Basin:

- **Appendix A: Engagement:** this appendix provides detail around the engagement approach used to develop and apply the groundwater methods.
- **Appendix B: Updates to understanding of historical recharge estimates applied in the first pass assessment:** this appendix provides detail around changes to our understanding of historical recharge estimates applied in the 'first pass' assessment, and the implications of using Sustainable Yields 2 information where available.
- **Appendix C: Initial Groundwater Sustainable Diversion Limit Resource Unit Results:** the SDL Assessment has involved analysis of multiple sources of data, this appendix provides information and links to those related to groundwater.

An independent report produced by Australasian Groundwater and Environmental Consultants Pty Ltd for MDBA titled 'Collation and Synthesis of evidence to inform an assessment of Sustainable Diversion Limits (SDL) and management arranges for groundwater in the Murray Darling Basin (MDB): Methods Report[5] forms part of the Groundwater Technical Methods.

2.3 Relationship With Recent Programs of Work and Additional Reference Documents

The SDL Assessment has been completed in the context of many other programs of work undertaken within the MDBA in recent years. Some of these programs have contributed datasets, methodologies or opportunities to pilot methods to compare monitoring or modelled information against environmental outcomes, and the surface water and groundwater technical methods documents detail that information.

Other related Murray Darling Basin Authority (MDBA) reference documents include*:*

- Sustainable Diversion Limit Assessment and Response Framework[6]
- The Basin Plan Review: Early Insights Paper[7]
- The Sustainable Rivers Audit[8]
- The Sustainable Yields Report/s[9]
- The Basin-wide EWR Tool Manual (2026)[10]
- Development of a Method for the Review of the Environmentally Sustainable Level of Take for Groundwater (2025)[5]

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[5] AGE (Australasian Groundwater and Environmental) (2025) *Collation and Synthesis of Evidence to Inform an Assessment of Sustainable Diversion Limits (SDL) and Management Arrangements for Groundwater in the Murray-Darling Basin (ID: BPR202411): Methods Report.*

[6] MDBA (Murray-Darling Basin Authority) (2026) *Sustainable Diversion Limit Assessment and Response Framework: An approach developed for the Basin Plan Review.*

[7] MDBA (Murray-Darling Basin Authority) (2024) Early Insights Paper | Murray–Darling Basin Authority MDBA Website, accessed 8 January 2025.

[8] MDBA (Murray-Darling Basin Authority) (2025b) Sustainable Rivers Audit | Murray–Darling Basin Authority MDBA Website, accessed 8 January 2025.

[9] MDBA (Murray-Darling Basin Authority) (2025c) 2025 Sustainable Yields | Murray–Darling Basin Authority MDBA Website, accessed 8 January 2025.

[10] MDBA (Murray–Darling Basin Authority) (2026b) https://github.com/MDBAuth/EWR_tool/, GitHub website, accessed 16 January 2026.

The approach used and method adopted was informed by research undertaken through the MD-WERP program, MD-WERP reports can be accessed at Climate adaptation | Murray–Darling Basin Authority[11]

[11] MDBA (Murray-Darling Basin Authority) (2025d) Climate adaptation | Murray–Darling Basin Authority, MDBA Website, accessed 30 January 2026.

3 Evolution of the SDL Assessment Methods

3.1 Background to the Original ESLT Methods

The methods which were originally used to determine an ESLT involved using the criteria set in the Basin Plan to identify environmental assets, functions and outcomes, which in turn required the specification of site-specific ecological targets and site-specific flow indicators (SFIs) for those locations (then referred to as hydrologic indicator sites, HIS). This approach recognised that there was a lack of defined ecological water needs at large (i.e. catchment-to-Basin) scales — instead, there was a series of information-rich areas across the Basin based on decades of research and monitoring by scientists, communities and Basin governments. The environmental water needs at these information-rich areas (HIS) were used to represent the broader water requirements of the reach, catchment and Basin[12].

The site-specific ecological targets were developed by applying the Basin-wide environmental objectives and ecological targets at a finer scale for each of the HIS. The SFIs were the "first generation" of environmental water requirements applied for Basin Plan purposes, built to support the targets of the specified HIS. The SFIs served as the primary flow-to-ecology metrics, against which success was measured via assessment of hydrological modelling data. The approach enabled a comparison of the environmental outcomes that could be supported by flows under various Basin Plan policy options. This assessment allowed for the volume of water that would meet an ESLT and other Basin-wide environmental objectives to be estimated.

3.2 Rationale for a New Approach

The Basin Plan Review is an opportunity to update the ESLT methods to draw on updated science, knowledge and science-to-policy methodologies. The revised methods include best available knowledge, updated models and assessment methods which provide the MDBA with a robust information base to consider as part of the BPR in 2026.

Major elements of the improved knowledge set include the 15 years of environmental water delivery under the Basin Plan and the associated environmental response and condition monitoring by Basin governments and Commonwealth governments. These efforts have refined our understanding of the ecological response to environmental water delivery and have informed successive evaluations of the effectiveness of the Basin Plan more generally. Compared to the original 2012 Basin Plan information base, we have been able to broaden the focus beyond a strong reliance on modelling (to explore a range of water recovery volume options as per the previous ESLT methods), and to include a far deeper on-ground understanding of what can be achieved for the environment through the Basin Plan, built from a range of evidence including scientific studies and community input.

[12] Swirepik, I, Burns, C, Dyer, FJ, Neave, A, O'Brien, MG, Prude, GM, Thompson RM (2015) 'Establishing Environmental Water Requirements for the Murray–Darling Basin, Australia's Largest Developed River System', *River Research and Applications,* 32 (6): 1153-1165.

An additional and important feature of new knowledge since 2012 has related to the emerging impacts of climate change and an improved understanding of the future climatic trends. Over the last 15 years, the Basin Plan and Basin government water sharing arrangements have been tested under a wide range of climatic conditions, including the 2017–19 Tinderbox drought and the 2022/23 floods. Rainfall under climate change is anticipated to be more variable. The lived experience, combined with ongoing advancements in our scientific understanding of climate change, allow for a deeper investigation of the performance of the SDLs under a future climate.

3.3 Key Improvements in the Revised SDL Assessment Methods

Significant improvements from the original methods to the revised methods include:

- The use of updated science from Basin jurisdiction Long-Term Watering Plans (LTWPs), Environmental Works and Measures Program (EWMPs) and Flow Studies, reflecting the best available flow-to-ecology information for the Basin SDL Resource Units.
- An increase in spatial resolution, moving from ~100 Site-specific Flow Indicators (SFIs) to ~3,500 EWRs across the Basin.
- The ability to test the risks to outcomes under various hydroclimate futures through the use of Climate Scenarios (through Sustainable Yields project).
- The ability to test the risks to outcomes under various policy futures through the use of updated modelling scenarios.
- The ability to test the risks to outcomes through not only a change to flows, but a change to other hydroclimate variables such as temperature, rainfall and runoff through the Thresholds of Change module of Sustainable Yields.
- The ability to map flow-based risks to Environmental Themes (waterbirds, native vegetation, native fish, etc) and to flow components (e.g. baseflows, freshes, overbank).
- Consideration of the current condition of assets and functions through a broad evidence base.
- Clearer articulation of sources of uncertainty.

2.4 MDBA Science Quality Assurance

The concept of best available scientific knowledge, as described in the Water Act, provides a guiding frame for how the MDBA approaches science and knowledge and connects this approach with Basin policy, planning, management and operational needs.

Development of the SDL assessment technical methods follows the MDBA's science and knowledge approach by utilising best available science[13] and incorporating the MDBA's science quality assurance guidelines in the workflow. This ensured the quality of the science processes that were adopted, including new modelling, monitoring and science synthesis processes to inform the SDL assessment.

The MDBA's Basin Plan Review Program implemented a framework for quality assurance which was used during the development and application of the SDL Assessment technical methods. The framework

[13] MDBA (Murray–Darling Basin Authority) (2025e) Our science and knowledge approach | Murray–Darling Basin Authority MDBA Website, accessed 16 January 2026.

recommended a process of seeking feedback on science inputs progressively through internal panels, MDBA advisory committees or forums and to a fully independent review.

These guidelines and quality assurance processes were developed to align and support governance processes and to ensure science used by the MDBA is:

- The best available and impactful
- Delivered in a reliable, accurate and up to date manner, with current trends and findings
- Transparent, accessible and appropriately reviewed.

4 Conceptual Approach

4.1 Environmental Outcomes of the Basin Plan

There is a strong relationship between the active and adaptive management of water resources and the capacity to achieve environmental outcomes across the Basin. The Basin Plan recognises this connection through an established hierarchy of environmental objectives, outcomes and targets. The Basin Plan (specifically through the Environmental Watering Plan) also recognises that flow is one driver amongst many, and that there are non-flow related drivers of ecosystem response. For this reason, the SDLs and associated environmental water delivery are one vital component (alongside others) to support of a sustainable river system.

The concept of an ESLT and the requirement that the SDLs reflect an ESLT is central to the scheme of the Water Act, and the sustainable management of the Basin's water resources and connected ecosystems. These limits are established to balance the competing demands for water where unsustainable extraction threatens ecosystem health over the long-term.

In approaching the SDL Assessment, the MDBA has used best available science and knowledge to identify environmental outcomes for the Basin Plan. These outcomes were designed to ensure the ecological sustainability of key environmental assets (KEAs), key ecosystem functions (KEFs), the productive base and key environmental outcomes (KEOs) as contemplated by the requirements of an ESLT.

For surface water, the ESLT characteristics and additionally the Basin Plan's environmental outcomes were expressed as expected outcomes for the ecological themes of ecosystem functions, including river flows and connectivity, native vegetation, water birds and native fish, and other species. These are ecological outcomes that can be measured on-ground via the ecological themes. Their achievement will be influenced by a range of drivers, both water and non-water related.

For groundwater, the four components of the ESLT (interpreted as ESLT characteristics) are as follows:

- Groundwater Dependent Ecosystems (GDEs), relating to Basin ecosystems that that have a moderate or high dependence on groundwater, as an expression of Key Environmental Assets
- Connectivity, relating to groundwater – surface water connectivity (e.g. groundwater discharge to streams or springs), as an expression of Key Ecosystem Function
- Water quality, relating to the protection of the groundwater resource from salinisation, as an expression of Key Environmental Outcome; and
- Productive base, relating to the maintenance of the groundwater resource volume and quality, such that these uses are maintained.

The GDEs, connectivity, productive base and water quality are referred to as the ESLT characteristics.

Important points of reference

The SDL Assessment draws on the elements of the Basin Plan which support the expression and assessment of environmental objectives and outcomes. Some of the key elements that inform the SDL assessment include:

- **Environmental Objectives:** The Environmental Watering Plan sets out broad environmental objectives for water dependent ecosystems, ecosystem functions and the productive base, supporting the development of the Basin-wide environmental watering strategy (BWS) and the long-term watering plans which are prepared by Basin governments.
- **Outcomes:** The BWS describes the expected outcomes for the ecological components of river flows and connectivity, native vegetation, water birds and native fish.
- **Environmental assets and ecosystem functions:** The long-term watering plans (LTWPs), prepared by the Basin governments, identify the priority environmental assets and ecosystem functions for environmental water planning at the surface water Resource Plan area scale, in accordance with criteria specified in the Basin Plan.
- **Environmental Watering Requirements (EWRs):** The long-term watering plans (LTWPs) prepared by Basin governments define Environmental Watering Requirements (EWRs). These EWRs indicate the relationships between water availability (how often and how much water) and achieving environmental objectives for key assets, functions, productive base and ecosystems. The SDL Assessment uses EWRs to ensure that the best available science is applied in determining water requirements.

Note: There are factors other than environmental water availability that can influence whether expected environmental outcomes are achieved, such as vegetation clearing, loss of floodplain connectivity, infrastructure, over-harvesting of biota, introduced species and chemical pollution. For this reason, the SDL Assessment aims to identify the major drivers of risk to the desired environmental outcomes, and engage with governments, experts, First Nations and communities to understand the full range of measures and actions needed to effectively engage with the underlying issue.

4.2 Environmental Outcomes and Assessment Proxies

Surface Water

To understand the current condition and trends of these key assets and functions, the MDBA uses various monitoring sources such as the Matter Reporting received from each Basin government, Flow-MER (the Commonwealth Environmental Water Holder's science program)[14] groundwater level and salinity monitoring, and MDBA's Sustainable Rivers Audit (SRA)[15].

To understand the likelihood that surface water flows are sufficient to support the hydrology needs of these key assets and functions under various policy and climate settings, the MDBA uses the environmental water requirements (EWRs) from the Basin jurisdiction long-term water plans (LTWPs) in NSW, SA, QLD and the ACT, and from Environmental Water Management Plans (EWMPs) and Flow Studies in Victoria. These EWRs allow an increase in resolution, an update to the knowledge base and an ability to map to ecological objectives. The EWRs have their own specific performance targets associated with supporting healthy ecosystems. The information base for these EWRs, their objectives and targets

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[14] CEWH (Commonwealth Environmental Water Holder) [The Flow - Monitoring, Evaluation and Research Program]() CEWH Website, accessed 16 January 2026.

[15] MDBA (Murray-Darling Basin Authority) (2025b) [Sustainable Rivers Audit | Murray–Darling Basin Authority]() MDBA Website, accessed 8 January 2026.

are captured in two models developed by the MDBA in collaboration with Basin governments, which are the EWR tool and EWR tool plus.

The EWRs map to some or all of six 'Environmental Themes', which are drawn from LTWPs and the Basin-wide environmental watering strategy (BWS)[16]. For the purpose of the assessments, flows and connectivity, a component of ecosystem functions, were separated out to allow individual analysis:

- ecosystem functions (EF)
- flows and connectivity (FC)
- native fish (NF)
- waterbirds (WB)
- native vegetation (NV)
- other species (OS)

These six themes are appropriate for SDL Assessment as they are measurable, representative indicators of broader ecosystem health at the Basin-scale, are responsive to environmental watering, and widely valued by communities of the Basin.

Further detail on the values and objectives that relate to the EWRs is available in the Basin jurisdiction LTWPs and are specific to the areas within those LTWPs. Figure 2 shows the relationship between Murray–Darling Basin policy instruments and their objectives.

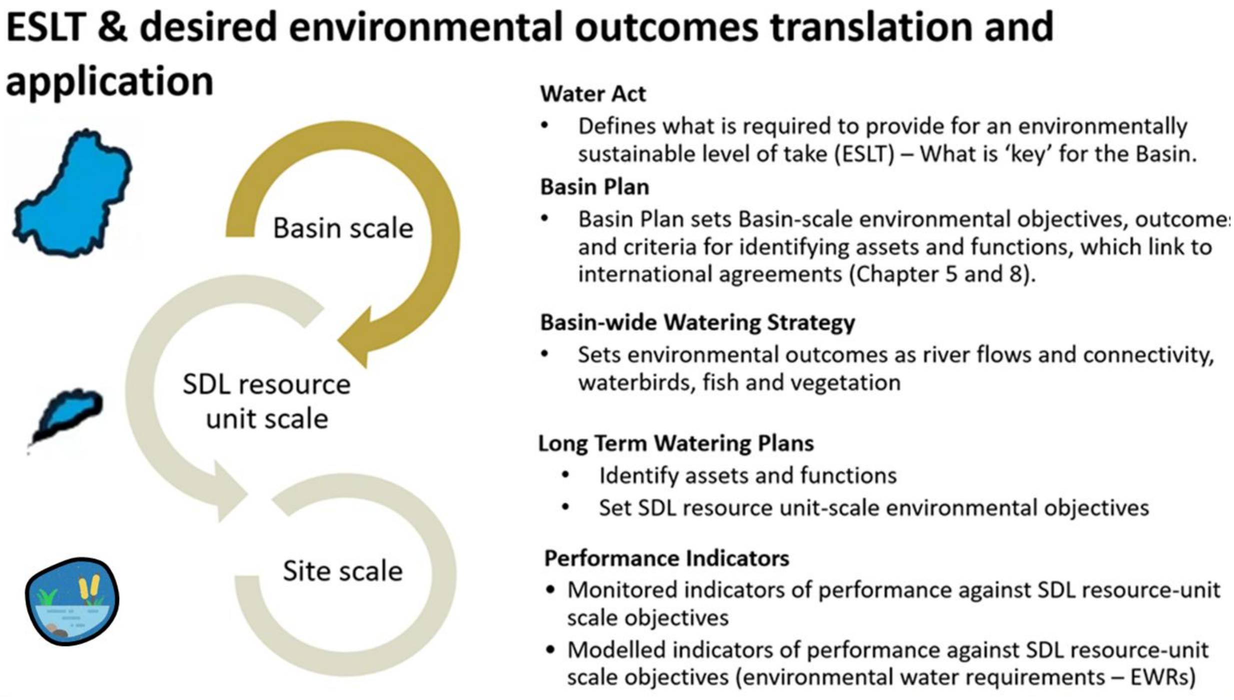

Figure 2 ESLT translation of outcomes

The flow of water within river systems plays a critical role in maintaining the health and stability of ecosystems. Hydrological events such as bankfull and overbank flows, fresh flows, and baseflows

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[16] MDBA (Murray-Darling Basin Authority (2025f) *Basin-wide Environmental Watering Strategy,* Murray–Darling Basin Authority Canberra, 2025.

support a diverse range of flora and fauna by ensuring the availability of essential habitats, sustaining ecological connectivity, and facilitating key biological processes[12]. Given the critical importance of flow regimes to sustaining water-dependent ecosystems, it is vital that the interactions between hydrological patterns and ecological outcomes is represented through the SDL Assessment. By understanding these relationships, we can apply a systematic assessment to the performance of flows as a proxy for environmental outcomes.

EWRs describing the flows to support ecosystems are developed considering historical data, surveys and research. Therefore, they may not represent the flows required in the future under a hotter and potentially drier climate. This is worth considering when viewing results as EWR performance assessed under a future climate scenario will give us an indication of risk rather than a prediction of ecosystem outcomes.

Groundwater

For groundwater, water level and salinity trends were analysed to determine whether the current level of groundwater extraction is likely to be supporting the ESLT characteristics (productive base, groundwater dependent ecosystems (GDEs), surface water – groundwater connectivity, and water quality). The method also considered whether the ESLT characteristics are at risk if use were to increase to the SDL; this was a consideration since for many groundwater SDL resource units, the average use is less than 50% of the SDL.

The outputs from the overall analysis feeds into the SDL Assessment, which together with outcomes from other lines of evidence (such as Sustainable Yields), helps inform the MDBA in making an assessment around the ability of SDLs to represent an ESLT both now and into the future.

4.3 Lines of Enquiry: Structure, Logic and Decision Role

To support a robust and comprehensive assessment, the SDL Assessment methods seek to bring in multiple lines of evidence to support the evidence base for decision-making, including seeking feedback and input from Basin governments and advisory committees. This includes:

- Eco-hydrology modelling informed by climate science, prepared for the Basin Plan Review i.e. Sustainable Yields future hydroclimate scenarios.
- Environmental and groundwater monitoring and reporting sources which provides an analysis of observed data i.e. Sustainable Rivers Audit, Matter Reporting, groundwater level and salinity monitoring, and Basin Plan Evaluation.
- Scientific knowledge generated from ecohydrology and hydrogeological research and investigations, including Sustainable Yields Ecological thresholds of change, BPR Outlook and Basin government-based climate risk assessments; and
- Internal expert elicitation.

Three lines of enquiry (LoE) were developed (refer Figure 3). These LoEs supported inquiry under current and full implementation of Basin Plan settings and under the current and future climate scenarios.

Three lines of enquiry to support narrative

Lines of enquiry	1. At time of the review (as at June 2024)	2. BP fully implemented	3. What does the future hold? (to the next review & beyond to 2050)
Exploratory questions	Are there any areas of immediate risk where we lack confidence in the achievement of BP environmental outcomes? If so, why?		What are the risks to the achievement of BP environmental outcomes under possible future climates?
	• What is current environmental condition and trend? • What are the drivers? • Have any significant risks emerged since 2012?	• How effective is the SDL in supporting BP desired environmental outcomes when BP is fully implemented? • What are the drivers? • Are any new risks emerging? • How urgently do we need to respond?	• What are the drivers? • What new risks might emerge? • How urgently do we need to respond?

Figure 3 Lines of Enquiry

- **Line of Enquiry 1 – Current implementation of the Basin Plan (and level of use) as at June 2024 –** to explore the outcomes of Basin Plan implementation to date, recognising implementation is ongoing.
- **Line of Enquiry 2 – Full Basin Plan implementation (and full use of the SDL) –** to assess whether, under a fully implemented Basin Plan, the SDLs continue to reflect an ESLT and support the Basin Plan environmental outcomes.
- **Line of Enquiry 3 – Full implementation under a range of plausible future hydroclimates –** to provide a view of potential long-term impacts of climate change under full Basin Plan implementation, full use of the SDL and plausible future hydroclimate scenarios, through to the next Basin Plan Review (2036 using hydroclimate sequences centred around 2030) and a planning horizon centred around 2050.

For both surface water and groundwater, all three Lines of Enquiry supported the assessment, recognising however, that different evidence bases for groundwater and surface water necessitated separate approaches to each of the three LoEs i.e.:

- For surface water: Line of Enquiry 2 was applied as the 'primary' Line of Enquiry; tested by reference to Line of Enquiry 1 and 3; and
- For groundwater: Line of Enquiry 1 was applied as the 'primary' Line of Enquiry as it provides the best (most certain) line of information about the extent to which groundwater resources continue to support environmental outcomes (and noting the use is currently less than half of the SDL in nearly 70% of SDL resource units and the absence of groundwater models).

The availability of each information type varies for each of the three lines of enquiry. The relevance, reliability and certainty of supporting lines of evidence data also varies and these factors were considered as part of the multiple lines of evidence approach. Representative examples of supporting lines of evidence used for both surface water and groundwater are shown in the Table 1 and Table 2 below.

Table 1: Surface water - Lines of evidence (information type & examples) and their relevance to the three lines of enquiry

Information type	Examples	Line of enquiry 1	Line of enquiry 2	Line of enquiry 3
Eco-hydrology modelling	• BP implementation management scenarios • LoE 1 and 2 – Extended historical climate sequence (1895-2023) • LoE 3 – MDB Sustainable Yields future hydroclimate scenarios • Environmental water requirements from LTWPs	✓	✓	✓
Monitoring (analysis of observed data)	• Sustainable Rivers Audit • Matter reporting 2024 • Basin Plan Evaluation • FlowMER	✓	N/A	N/A
Other policy and Management considerations	• NB Connectivity/toolbox • Constraints roadmap	N/A	✓	N/A
Climate risk assessments	• Sustainable Yields Ecological thresholds of change • BPR Outlook including strategic climate risk assessment • BPR Water quality climate risk assessment • Ramsar climate adaptation projects • Basin jurisdiction-based climate risk assessments	N/A	N/A	✓
Other	• Relevant research • Expert elicitation / panels • MD-WERP projects (various)	✓	✓	✓

Table 2: Groundwater - Lines of evidence (information type & examples) and their relevance to the three lines of enquiry

Information type	Examples	Line of enquiry 1	Line of enquiry 2	Line of enquiry 3
Modelling	• Existing recharge estimates • SY2 baseline diffuse recharge estimates	✓	✓	✓
Monitoring (analysis of observed data)	• Bore locations – Basin jurisdiction database or provided by jurisdictions • Water level and water quality data – BoM database • Water use data – Section 71 data reported to MDBA • GDEs – BoM Atlas • Connectivity data – WERP RQ7	✓	✓	N/A
Other policy and Management considerations	• Accredited Water Resource Plan rules • Groundwater methods report (MDBA, 2020)	✓	NA	N/A
Climate risk assessments	• SY2 recharge estimates	N/A	N/A	✓
Other	• Relevant research • MD-WERP project (RQ8b)	✓	✓	✓

4.4 Role of Monitoring, Modelling and Expert Synthesis

Consistent with the MDBA's approach to science and knowledge approach[17], the SDL Assessment process draws on multiple lines of evidence through a structured process to assess whether ESLT components are being supported. It draws upon:

- on-ground monitoring results relative to targets specified in Schedule 7 of the Basin Plan (such as fish breeding, ecosystem health maintenance, or vegetation growth and recovery) and evaluated and reported on in accordance with Chapter 13 and Schedule 12 of the Basin Plan, to provide an indication of progress towards overall environmental objectives over the recent short-term.
- modelled assessment of the relative achievement of Environmental Watering Requirements (EWRs), to provide an indication of the provision of flows to support outcomes over the long-term i.e. >100 years; and
- other available evidence and information including Matter Reporting received from each Basin government, Flow-MER (the Commonwealth Environmental Water Holder's science program), groundwater level and salinity monitoring, and MDBA's Sustainable Rivers Audit.

By synthesising and weighing up the performance of the monitoring assessment and modelling assessment outcomes, the risk of compromise to key assets and functions can be evaluated, and ultimately an assessment made about whether the needs of the environment are likely to be supported by the SDLs.

Conservation and natural resource management often require decision making under uncertainty, where data may be incomplete and consequences are potentially severe. In such cases, expert elicitation is widely used to quantify uncertainty across various fields of conservation and natural resource management [18].

A structured elicitation process was used to synthesise available monitoring reports and to provide a condition rating and confidence score for each theme in each SDL resource unit. The more detailed surface water and groundwater technical methods provide further information on the elicitation process that was conducted as part of the SDL Assessments.

4.5 Drivers of System Health (Flow and Non-flow Drivers)

Sustainable Diversion Limits (SDLs) are a key driver for supporting Basin Plan environmental outcomes. However, it is recognised that there are many possible drivers supporting or impacting these outcomes. MDBA developed an Environmental Assessment Outcome framework, adapted from the well-established Eco-evidence Framework[19], which utilised multiple lines of evidence to support the assessment of other potential drivers of system health. This includes non-SDL flow related drivers (e.g. operational and other environmental water delivery constraints) and non-SDL non-flow related drivers

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[17] MDBA (Murray–Darling Basin Authority) (2025g) https://www.mdba.gov.au/publications-and-data/publications/our-science-and-knowledge-approach MDBA website, accessed 21 January 2026

[18] Hemming V, Burgman MA, Hanea AM, McBride MF and Wintle BC (2018) 'A practical guide to structured expert elicitation using the IDEA protocol', Methods in Ecology and Evolution, 9(1): 169-180, doi:10.1111/2041-210X.12857.

[19] Norris RH, Webb JA, Nichols SJ, Stewardson MJ and Harrison ET (2012) 'Analyzing cause and effect in environmental assessments: using weighted evidence from the literature', *Freshwater Science*, 31(1): 5-21.

(e.g. pest-species). It is also worth noting that some of the "non-flow drivers" such as pest-species, are also indirectly flow-related. Determining the priority and presence of non-SDL drivers and how they may be detrimentally affecting our ability to achieve desired Basin Plan environmental outcomes informs the type of response that is most appropriate. This may result in a recommendation to revise SDLs or explore other response mechanisms (or both) or to reconsider the Basin Plan objectives and desired outcomes.

3 Climate Change and Future Risk Assessment

3.1 Role of Climate Change in the SDL Assessment

The Basin has a highly variable climate, influenced by changes in weather systems, large-scale circulation and climate drivers. An important component of the SDL Assessment is testing environmental outcomes under plausible future climates. These scenarios were provided through the MDBA's Sustainable Yields (SY) program, and they ensured the SDL Assessment process could examine whether climate change could exacerbate (or alleviate) any of the current or emerging risks to flow supporting environmental outcomes, or whether increased risks to environmental outcomes are indicated.

3.2 Sustainable Yields Hydroclimate Scenarios

The Commonwealth Scientific and Industrial Research Organisation (CSIRO), through its work on the Sustainable Yields (SY) program, provided hydroclimate modelling based on best available science and advice provided by the Independent Hydroclimate Science Expert Panel (IHSEP) in 2023/24. The hydroclimate modelling provided by CSIRO was run through the river system models by MDBA to generate future hydroclimate scenarios that contain modelled flow data throughout the Basin (including projected changes to runoff under the plausible future climate scenarios). These scenarios were also used to model the impact of climate change on groundwater recharge, this was done using WAVES, a soil-vegetation-atmosphere-transfer model. The hydroclimate scenarios were used to assess the ecological thresholds of change to inform the SDL Review.

3.3 Time Horizons and Planning Context (2030s and 2050s)

The settings for the SY hydroclimate scenarios focus on model simulations for two future timeframes centred around 2030 (to support the Basin Plan Review and policy) and 2050 (for long-term water planning). This approach ensures we have the information to plan for both the range of futures and the likelihood of ongoing change. These scenarios are explained further in the Sustainable Yields Report[9].

3.4 Thresholds of Change and Ecological Risk

The ability to test ecological impacts and risks to environmental outcomes were assessed not only from the change to flows, but a change to other hydroclimate variables such as temperature, rainfall and runoff provided through the Sustainable Yields body of work.

5 Overview of the SDL Assessment Methods

5.1 Overview of Surface Water Methods

Surface water assessments were conducted across 29 SDL resource units[20] using two approaches which both drew from a wide base of evidence informed by engagement with the Basin Governments: monitoring elicitation and hydrological modelling (refer to Figure 4).

For LoE1, monitoring elicitation complements the hydrological analysis by assessing current environmental condition. MDBA staff conducted this process using multiple lines of evidence, including but not limited to:

- Matter 8 reports from Basin Governments,
- The Sustainable Rivers Audit (SRA),
- Catchment and river-scale information from the Commonwealth Environmental Water Holder via the Flow-MER reports.

The MDBA assessed the current environmental condition of SDL resource units against the six environmental themes (where applicable) using a five-point scale (Very Poor to Very Good). Final scores were then determined by calculating the median of panel members assessments, with a review step involving Basin jurisdiction government staff to corroborate or comment on the results.

Hydrological performance was evaluated under all three Lines of Enquiry (LoE) using modelled flow data over a 129-year period (1895-2024) to determine how often EWRs are met. That performance (proportion of EWR success) was compared against pre-Basin Plan conditions and a without-development baseline with the relative distance between each used to standardise results across SDL resource units for each LoE. Two key metrics were used:

- **Frequency Ratio (FR)**: the proportion of years an EWR is met relative to its target frequency.
- **Maximum Recommended Interevent Period (MRIP)**: the longest allowable gap between flow events, which is ecologically critical for some assets.

The MDBA integrated the results from the modelled EWR performance and monitoring elicitation of current condition by following a Science Synthesis process adapted from Norris et al[21]. The process drew upon the broad range of MDBA's ecological expertise to make preliminary results (including associated confidence estimates) about the extent to which desired Basin Plan outcomes are currently being achieved in each SDL resource unit. They also provided statements surrounding the likelihood that those outcomes would be met in the future given estimated EWR achievement for each tested scenario.

[20] MDBA (Murray-Darling Basin Authority) (2025h) Surface Water SDL Resource Units - Dataset - Data.gov.au, accessed 16 January 2026.

[21] Norris RH, Webb JA, Nichols SJ, Stewardson MJ and Harrison ET (2012). 'Analyzing cause and effect in environmental assessments: using weighted evidence from the literature.' *Freshwater Science*, 31(1), pp.5-21

Data coverage across the Murray–Darling Basin is incomplete, and some surface water resource units may not have had sufficient information for each of the LoEs to be explored fully. Additionally, in some resource units water take has a relatively low influence on its flow regime. In these cases, a simplified assessment process was used, which did not rely on EWR results as primary information.

Insight was also sought from Basin governments to inform the likely influence of non-flow related factors, to examine the preliminary results, and to review and refine the qualitative statements and associated confidence. Any new information provided through the internal expert review and Basin government feedback steps was then considered by the science synthesis group to formalise a final set of statements, grades and narratives. The consideration of the many lines of evidence alongside expert review constituted the multiple lines of evidence approach adopted for the surface water technical assessment. The Multiple Lines of Evidence approach allows consideration of different types and scales of evidence to generate better informed conclusions.

The final qualitative statements were used to develop narratives for each SDL resource unit and for each of the key Basin Plan themes (i.e. waterbirds, native fish, native vegetation, ecosystem functions, other species, and flows and connectivity).

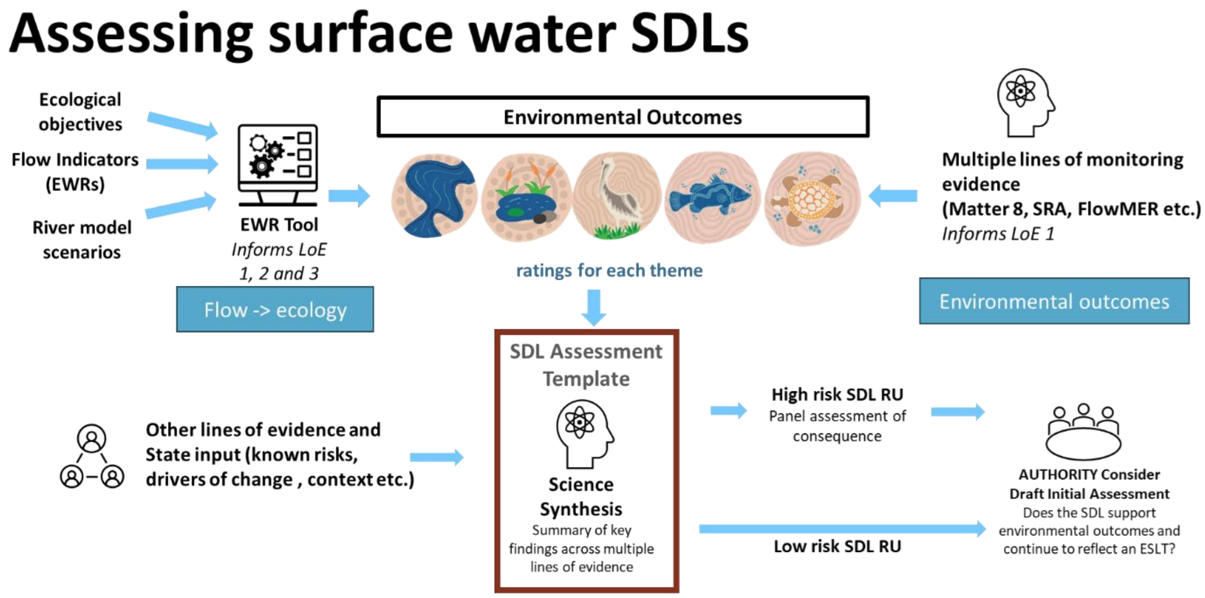

Figure 4 Summary diagram of the surface water SDL assessment methods

Further details of this method can be found in The Sustainable Diversion Limit Assessment: Surface Water Technical Method overview and its appendices.

5.2 Overview of Groundwater Methods

For groundwater SDL resource units, the management arrangements and application of the Lines of Enquiry (LoE) differed from those for surface water (refer to Figure 5). There were only 2 groundwater SDL resource units for which water recovery was required under the Basin Plan, and water extraction is significantly lower than the SDLs in many groundwater SDL resource units (use is currently less than half of the SDL in nearly 70% of SDL resource units). For this reason the groundwater assessment adopted a prioritisation process to determine which resource units warranted a more detailed investigation.

The assessment focussed on whether the SDLs continue to support the ESLT characteristics and reflect an ESLT. Line of Enquiry 1 considered the risks of current use to the achievement of the ESLT and environmental outcomes, while Lines of Enquiry 2 and 3 considered those same risks assuming full utilisation of the SDL, under historical and a range of possible future climates, respectively.

To determine if the SDL reflects an ESLT, the initial groundwater SDL assessment method involved a three-step approach - a 'first pass' and 'second pass' assessment that established if there is a potential risk to the ESLT. Where this was the case, the assessment was further developed through a panel assessment.

The first pass initial SDL assessment was applied across 80 groundwater SDL resource units[22] to assess if there was potential risk to ESLT characteristics. It involved updating knowledge, prioritisation, application of ESLT filters, the application of resource condition indicators (RCIs), consideration of additional lines of evidence, analysis of updated recharge data and then consideration of climate scenarios.

The LoE 1 analysis used a consistent approach across all SDL resource units using monitoring data for groundwater levels and salinity levels as the resource condition indicators. A potential risk to ESLT characteristics was identified if groundwater level declines were occurring over 30% of the relevant area, or salinity was increasing over 30% of the relevant area. There was also consideration of some specific information about the management and use in the resources, which was largely provided by the Basin governments.

For LoE2 and LoE3, there were no 'fit for purpose' groundwater models available at the time of the assessment to evaluate the impact of full use of the SDL or the impact of climate change on recharge. Instead, the primary data considered for this assessment was the recharge estimates provided through modelling undertaken through the Sustainable Yields (SY2) program. This modelling re-estimated the diffuse baseline recharge estimates and provided estimates of the change in diffuse, instream, and flood recharge under the Sustainable Yields future hydroclimate scenarios.

While the first pass assessment used a broad-scale approach to identify risk, the second pass assessment looked in more detail at the 19 SDL resource units that were identified through the initial assessment. This included deeper analysis of the water level and salinity data to consider spatial and temporal trends. It also considered the specific hydrogeology and management of each of the areas and information provided by the Basin government groundwater managers.

Basin governments were engaged at all stages including development of the initial groundwater method and during the first and second pass processes to confirm analysis and assessments to establish a common view of risks being identified for the SDL resource unit. This process provided an opportunity to incorporate any additional information or available science from Basin governments (i.e. additional recharge information).

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[22] MDBA (Murray-Darling Basin Authority) (2025i) Groundwater SDL Resource Units - Dataset - Data.gov.au, data.gov.au, accessed 16 January 2026.

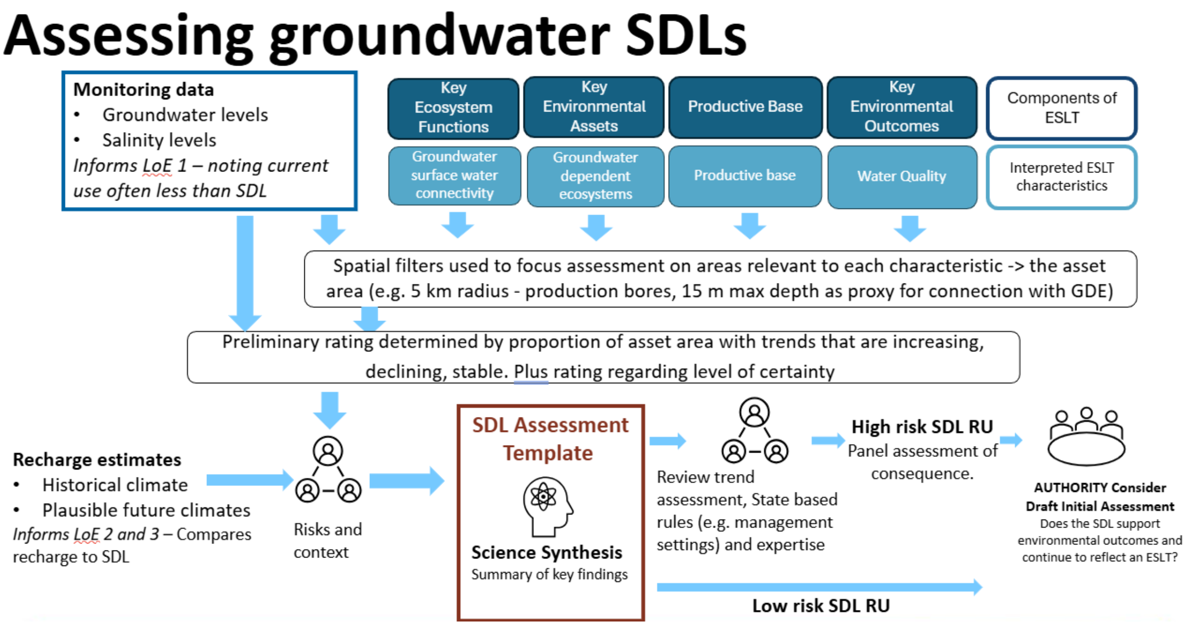

Figure 5 Summary diagram of the Groundwater SDL Assessment methods

Further details of this method can be found in The Sustainable Diversion Limit Assessment: Groundwater Technical Method overview and its appendices.

4 Assumptions, Limitations and Sources of Uncertainty

4.1 Addressing Uncertainty Underpinning the SDL Assessment

Uncertainty is an inherent feature of monitoring and/or modelling broad-scale ecological and environmental systems, which are complex, interconnected, and constantly changing. For example, models are influenced by incomplete or uneven data, natural variability, and the need to simplify real-world processes across large spatial and temporal scales.

As part of the SDL Assessment a number of steps introduced levels of uncertainty, including:

- Climate modelling e.g. uncertainty in rainfall projections impacting on runoff projections
- Hydrology modelling including structural, parameter and input bias
- Ecological modelling, including EWRs
- Condition monitoring and
- Aggregation and synthesis
- Assumptions including buffer ranges in groundwater
- Assumptions in estimating climate impacts on groundwater without a numerical model
- Data paucity

Conservation and natural resource management often requires decision making under uncertainty, where data may be incomplete and consequences are potentially severe. In such cases, expert elicitation is widely used to quantify uncertainty across various fields of conservation and natural resource management [23]. MDBA's approach to science and knowledge approach[17] supports a positive working connection between the scientific, policy and management functions to help navigate decision-making under uncertainty.

Multiple lines and sources of evidence were also used to inform the assessment. MDBA's approach to SDL assessments, explained in the surface water and ground water technical methods reports, provide further information on the treatments of uncertainties arising from use of assumptions, knowledge gaps or data limitations and ensures clear documentation to ensure findings acknowledge these uncertainties.

5 Consultation and Engagement

5.1 Engagement with Basin Governments

Consultation and engagement was undertaken with Basin governments during development of the surface water and groundwater methods and to confirm inputs to the SDL assessments (such as monitoring outcomes, EWR tools and metrics).

The MDBA undertook a multi-year Basin jurisdiction elicitation process, allowing Basin government technical representatives to review and provide input on groundwater method development, EWR tool development, initial modelling and monitoring assessment outcomes, and to provide additional insights as to key risks, drivers and considerations to support the initial SDL assessments. The detailed surface water and ground water technical methods documents provide further information of the specific engagement points with Basin governments including the elicitation processes used to confirm inputs to the SDL assessment.

Expert advice was sought during development of the SDL assessment technical methods from various forums, including consultative and governance committees such as the Murray–Darling Basin Authority and the Advisory Committee on Social, Economic and Environmental Sciences[24]. Further, independent advice was obtained by appointing an independent panel to review the technical methods and to provide advice on its limitations and recommendations for improvement into the future. This advice contributed to the development of the assessment process and has been incorporated in this and associated reports.

5.2 First Nations People's Science and Knowledge

The MDBA has committed to respectful engagement with First Nations people and their science and knowledge underpinned by Free, Prior, and Informed Consent (FPIC) and consistent with our Indigenous Cultural and Intellectual Property (ICIP) Policy.

The MDBA has access to a range of contextual information about matters relevant to First Nations people including reports and case studies that have been commissioned by the MDBA and have been

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[23] Hemming V, Burgman MA, Hanea AM, McBride MF and Wintle BC (2018) 'A practical guide to structured expert elicitation using the IDEA protocol', Methods in Ecology and Evolution, 9(1): 169-180, doi:10.1111/2041-210X.12857.
[24] MDBA (Murray-Darling Basin Authority) (2025j) https://www.mdba.gov.au/about-us/governance-and-committees/advisory-committee-social-economic-and-environmental-sciences MDBA website, accessed on 21 January 2026.

published. The documents include First Nations people's views about matters relevant to them at a range of scales (site/asset, Nation scale, basin-wide). We do not have FPIC or ICIP permission for application of existing information in the specific context of the SDL assessments.

There remains an opportunity to continue engagement with First Nations people on the SDL Assessment Approach and on how First Nations people could contribute to the final SDL assessment results (to be included in the Basin Plan Review Final Report in late 2026) during the SDL assessment response approach.

5.3 Consultation and Ongoing Engagement

As part of the public consultation process for the discussion paper, there will be further opportunities for the MDBA to engage with a wide variety of stakeholders including Basin governments (including through bilateral and multilateral discussions), key subject-matter experts, First Nations and communities on the initial proposed responses resulting from the SDL Assessments.

Australian Government

Murray–Darling Basin Authority