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MURRAY–DARLING BASIN AUTHORITY

Groundwater report cards

For Sustainable Diversion Limit Resource Units under the Murray–Darling Basin Plan

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The Murray−Darling Basin Authority pays respect to the Traditional Owners and their Nations of the Murray−Darling Basin. We acknowledge their deep cultural, social, environmental, spiritual and economic connection to their lands and waters.

The guidance and support received from the Murray Lower Darling Rivers Indigenous Nations, the Northern Basin Aboriginal Nations and our many Traditional Owner friends and colleagues is very much valued and appreciated.

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

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Abbreviations

ASGE – Achieving Sustainable Groundwater Entitlements program

Basin – Murray–Darling Basin

Basin state – Queensland, New South Wales, Victoria, South Australia or Australian Capital Territory

BDL – baseline diversion limit

CSIRO – Commonwealth Scientific and Industrial Research Organisation

DEPI – Department of Environment and Primary Industries

ESLT – environmentally sustainable level of take

GAB – Great Artesian Basin

GDE – groundwater dependent ecosystem

GMA – groundwater management area

GMU – groundwater management unit

KEA – key environmental assets

KEF – KEFs

KEO – key environmental outcomes

LTAAEL – Long-term average annual extraction limit

MDB – Murray–Darling Basin

MDBA – Murray–Darling Basin Authority

PB – productive base

PEL – preliminary extraction limit

RCL – resource condition limit

RRAM – Recharge Risk Assessment Method

S&D– Stock and domestic

SAFE – Secure Allocations, Future Entitlements

SDL – sustainable diversion limit

SF – sustainability factor

SIS – salt interception scheme

SKM – Sinclair Knight Merz

WAVES – Water Vegetation Energy and Solute (groundwater recharge model)

WRP – water resource plan

WSPA – water supply protection area

Introduction

The Murray–Darling Basin Authority (the MDBA) has a vision for a healthy working Basin that supports strong and vibrant communities, productive and resilient industries, and healthy and diverse ecosystems. One of the key actions to achieve this vision is ensuring a balance between the water needs of communities, industries and the environment, while protecting and restoring the ecological and other values of water-dependent ecosystems so they remain healthy.

The Basin Plan provides a coordinated approach to water use across the Murray-Darling Basin (MDB). The Basin Plan is developed under the *Water Act 2007 (Cwlth)* and represents one more step in the ongoing journey of managing our water resources. It limits water use at environmentally sustainable levels by determining long-term average sustainable diversion limits for both surface water and groundwater resources.

The Basin Plan was a significant step for groundwater management as it was the first time that:

- a limit on groundwater use was established across the Basin (in contrast to surface water, where a cap has been in place since the mid-1990s); and
- a consistent set of management arrangements was applied across all the Basin's groundwater resources.

SDL resource unit report cards

This report provides a series of report cards that summarise the technical information used to assist in the determination of the sustainable diversion limits (SDLs) and baseline diversion limits (BDLs) for each SDL resource unit, as described in Schedule 4 of the Basin Plan and incorporating relevant amendments in July 2018.

The report cards provide the location of the SDL resource unit, estimated volume of recharge, volume of entitlements and estimated volume of stock and domestic (S&D) use, salinity of the groundwater, the risk assessment, the preliminary extraction limit (PEL) and the BDL and SDL. Where SDL resource units are covered by models, the report cards also present additional information on the spatial distribution of groundwater take, any drawdown of groundwater levels, details on surface water and groundwater interactions, graphs showing groundwater levels over time at key monitoring sites and descriptions of the hydrogeology and water management arrangements.

This report is intended for those stakeholders who wish to further understand the information used to set the groundwater SDLs and BDLs. This document should also be read in conjunction with the Murray–Darling Basin Plan Groundwater Methods Report (2020), which explains the groundwater assessment framework used to derive the SDLs.

The report cards replace previous versions of the groundwater SDL resource unit summary report cards that were developed: for the *Guide to the Proposed Basin Plan* released in October 2010 (CSIRO and SKM, 2010b) and for the draft Basin Plan released in November 2011 (MDBA, 2012). The updated report cards reflect changes made as a result of the Basin Plan amendments that became law in July 2018 (MDBA, 2018).

The amendment:

- Addressed boundary issues to reflect alignment with state water management plans to reduce complexity and administrative burden:
    - NSW Western Porous Rock WRP (WRP) area (GW6) and Eastern Porous Rock WRP area (GW16) were amalgamated into the NSW Murray–Darling Basin Porous Rock WRP area (GW6).
    - Lachlan and South Western Fractured Rock WRP area (GW11) and New England Fractured Rock and Northern Basalts WRP area (GW17) were amalgamated into the NSW Murray–Darling Basin Fractured Rock WRP area (GW11).
    - WRP area boundary changes in Darling Alluvium (GW7), Murray Alluvium (GW8), Murrumbidgee Alluvium (GW9), Macquarie-Castlereagh Alluvium (GW12) and Namoi Alluvium (GW14). These area changes are less than 1% of the NSW MDB area and do not change the SDLs in the SDL resource units.
    - Vertical boundary changes to some NSW groundwater SDL resource units to align with state plans and allow separate accounting for buried resources (where one SDL resource unit is buried by another).
    - Queensland Border Rivers WRP area (GW19) and Moonie WRP area (GW20) were amalgamated into the Queensland Border Rivers-Moonie WRP area (GW19).
- Incorporated the recommendations from the SDL reviews for the Western Porous Rock SDL resource unit (GS50) (NSW), Eastern Porous Rock WRP area (GW16) (NSW) and Goulburn-Murray: Sedimentary Plain SDL resource unit (GS8c) (Vic) to a combined total increase of the groundwater SDL from 3,334 GL/y to 3,494 GL/y in these areas. Details are summarised in Table 1. The increases in extraction limits have been assessed to have minimal potential impacts on the environment.
- Transferred 2.14 GL/y of entitlement associated with a salt interception scheme from the BDL of the Mallee (Murray Group Limestone) (GW3) SDL resource unit to the BDL of the SA Murray Salt Interception Schemes (GS7) SDL resource unit. There was no change to the SDL of the SA Murray Salt Interception Schemes SDL resource unit as the current SDL allows for more take than the current BDL.
- Revised the BDL for the Australian Capital Territory SDL resource unit (GS52) to account for additional water used by the Commonwealth in the ACT in 2009 than what was estimated. Changed to the groundwater compliance methodology (MDBA, 2018a). After consulting the Basin states, the Authority proposed that a 10-year rolling average compliance method be used for groundwater SDL resource units. Under the proposed method, each year from 1 July 2019, the Basin states are required to report on the volume of water extracted during a water year (annual actual take) from a surface or groundwater SDL resource unit; and the volume that is allowed to be extracted during a water year (annual permitted take) from the same surface or groundwater SDL resource unit as well as the difference between both volumes. A non-compliance with a groundwater SDL in a water year will occur if the average annual actual take over the 10 year period ending with that water year is greater than a) the average annual permitted take over the same period, and b) the Basin state does not have a reasonable excuse for the excess.

Table 1: Changes to groundwater BDL and SDL reflecting amendment to the Basin Plan under Schedule 4 (MDBA, 2018)

Basin state	WRP area	SDL resource unit	Basin Plan BDL (GL/y)	BDL (GL/y)	Basin Plan SDL (GL/y)	SDL (GL/y)	SDL change (GL/y)	State plan limit
NSW	NSW Western Porous Rock (GW6)	Western Porous Rock (GS50)	63.1	No change	116.6	226.0	+109.4	530.5
		Gunnedah – Oxley Basin (GS17)	22.1	No change	114.5	127.5	+13.0	205.6
		Sydney Basin (GS41)	3.12	No change	17.2	19.1	+1.9	60.4
VIC	Goulburn-Murray (GW2)	Goulburn-Murray: Sedimentary Plain (GS8c)	203.5	No change	203.5	223.0	+19.5	223.0
		Goulburn-Murray: Highlands (GS8b)	38.3	No change	50.5	68.7	+18.2	41.6
	Wimmera-Mallee (GW3)	Wimmera-Mallee: Sedimentary Plain (GS9b)	68.9	No change	190.7	190.1	-0.6	68.9
		Wimmera-Mallee: Highlands (GS9a)	1.26	No change	2.14	2.75	+0.6	1.26
SA	South Australian Murray Region (GW4)	Mallee (Murray Group Limestone) (GS3b)	65.7	63.6	65.7	63.6	-2.1	63.6
		SA Murray Salt Interception Schemes (GS7)	11.1	13.2	28.6	28.6	No change	13.2
		Total					**+159.9**	

Stakeholders who require additional information may use [the contact form on our web site]() or email: [engagement@mdba.gov.au]().

Determining the groundwater BDLs and SDLs

The total of groundwater BDLs and SDLs across the Basin, as specified in Schedule 4 of the Basin Plan, are 2,386 GL/y and 3,494 GL/y, respectively. The BDL is the MDBA's assessment of the limits on groundwater use under existing water management arrangements and describes the baseline against which SDLs are assessed. The approach the MDBA used to establish the BDLs and SDLs is described in the Murray–Darling Basin Plan Groundwater Methods Report (MDBA, 2019).

The SDLs and BDLs in the Basin Plan reflect the different aquifer characteristics, levels of management and knowledge of the groundwater resources across the Basin. Considering this, the groundwater resources in the Basin have been split into 19 groundwater WRP (WRP) areas, which includes five combined WRP plan areas for surface water and groundwater. These 19 WRP areas have been further divided into 65 SDL resource units. There is an SDL volume for each SDL resource unit. Some SDL resource units have more than one SDL to reflect that water is or can be extracted from different aquifers within the same resource unit. As a result, there are 80 SDLs contained in the Basin Plan.

The SDL resource unit boundaries were determined using existing state planning boundaries and hydrological, geological and hydrogeological units, such as river catchments, geological formations and aquifers.

The *Water Act 2007 (Cwlth)* requires that the SDLs reflect an environmentally sustainable level of take (ESLT), which is defined as the level at which water can be taken from that water resource which, if exceeded, would compromise:

- key environmental assets (KEA) of the water resource; or
- KEFs (KEFs) of the water resource; or
- the productive base (PB) of the water resource; or
- key environmental outcomes (KEO) for the water resource.

To meet the ESLT requirements for groundwater, the MDBA determined that a groundwater SDL must:

- maintain KEAs that have any dependence on groundwater (KEA);
- maintain base flow groundwater contributions to rivers and streams (KEF);
- ensure that productive use of the aquifer is sustainable without compromising the hydrogeological integrity of the aquifer (PB); and
- protect against decreasing groundwater quality, in particular salinisation of the groundwater resource (KEO).

The groundwater SDLs were informed by numerical modelling or an analytical risk assessment.

Numerical modelling was carried out in 15 SDL resource units where fit for purpose models were available. Where numerical models were not available the MDBA used a recharge risk assessment method (RRAM), developed by the MDBA and consulting organisations (CSIRO and SKM, 2011), to inform the SDLs. Both the numerical groundwater modelling and the RRAM provide estimates of the potential volume of water available for consumptive use (PEL).

The PEL represents the MDBA's initial assessment of the volume of water that can be taken from a groundwater SDL resource unit. The MDBA then applied an assessment framework that considered other factors which had not been included as part of the process for determining the PEL.

The groundwater assessment framework had seven SDL categories, which are:

1. Deep groundwater;
2. Non-renewable groundwater;
3. Connected resources;
4. Achieving Sustainable Groundwater Entitlements program (now ceased);
5. SDL resource units with proposed reductions;
6. Existing planning arrangements; and
7. Unassigned groundwater.

The SDL in each report card has been matched to one of these assessment categories. More details on how the Groundwater Assessment Framework has been applied are contained in the Murray–Darling Basin Plan Groundwater Methods Report (MDBA, 2020).

The requirement to set SDLs is one of a number of elements of the Basin Plan that are needed to deliver a healthy working Basin (e.g. WRP requirements, Water Quality and Salinity Management Plan, etc.). Importantly, the SDLs set the upper limit for groundwater use in a particular SDL resource unit. Within the limits set by the SDLs, localised impacts will be managed through water management arrangements in WRPs which will be developed and implemented by the Basin states and assessed and accredited by the MDBA.

Modelled SDL resource units

Where available, the MDBA used numerical groundwater models to inform the determination of groundwater SDLs. In contrast to surface water, where models were available for most surface water catchments in the Basin, there were only 11 groundwater models available that covered 12 of the 80 SDL resource units in the Basin. However, these groundwater models cover more that 73% of the 2007-08 consumptive groundwater take within the MDB and were an important element to determining the PEL.

The 11 groundwater models focus on the higher use alluvial groundwater systems in NSW, Victoria and Queensland. These groundwater models were developed or modified for the CSIRO Murray–Darling Basin Sustainable Yields Project. All NSW groundwater models were originally developed and calibrated by the New South Wales Office of Water or its predecessors.

The groundwater modelling approach involved the formulation of a series of standard predictive scenarios run over a fifty-year period, designed to test possible future extraction limits under different climatic conditions. The groundwater models tested these extraction scenarios against the

ESLT characteristics using resource condition limits (RCLs). The RCLs represented points in the model where objective tests, such as the stabilisation of groundwater levels or no increased impact on surface water, were used to assess if the level of impact was acceptable. The RCL sites were based on existing groundwater monitoring networks and were chosen to reflect the spatial risk that groundwater take poses to the ESLT.

Further information on the application of the numerical groundwater models in the development of the Basin Plan is available in other Basin Plan supporting documents (CSIRO and SKM, 2011).

Recharge risk assessment method

The recharge risk assessment method (RRAM) is a risk assessment process used to determine the PEL for SDL resource units without a numerical groundwater model. The method was developed by the MDBA, CSIRO and Sinclair Knight Merz (SKM) specifically for the Basin Plan (CSIRO and SKM 2011).

The method establishes a sustainability factor (SF) by assessing the level of risk that groundwater take poses to the ESLT characteristics of the groundwater system. The PEL is then determined by applying the SF to the volume of rainfall recharge received by the SDL resource unit. The PEL can therefore be expressed as a fraction of the recharge that can be taken, with all the groundwater in storage reserved for the environment.

The RRAM is described in four steps, as follows:

> **Step 1:** The first step was to determine rainfall recharge across the Basin using the Water Vegetation Energy and Solute (WAVES) model and upscaling techniques developed for the Murray–Darling Basin Sustainable Yields project and subsequently refined for the Basin Plan (CSIRO and SKM, 2010a). Additional recharge information was also used where it was made available by the Basin states.

Basin wide recharge modelling explored several historic and future climate scenarios. Of these scenarios, the median historic climate recharge scenario was used for all SDL resource units. Prior to the draft Basin Plan in November 2011, the historic dry climate recharge scenario was used for all SDL resource units where the PEL was greater than the BDL. For the draft Basin Plan the median historic climate recharge scenario was used. The decision to use the median historic climate recharge scenario was made in response to recommendations from a peer review conducted during the development of the Basin Plan.

Risks to the four ESLT characteristics

The next three steps determined the sustainability factor (SF) using a risk matrix that assessed the:

- risks to the four ESLT characteristics; and
- level of uncertainty within an SDL resource unit.

Step 2: Criteria were developed to assess the level of risk that groundwater extraction represents to compromise one of the ESLT characteristics. A higher risk resulted in a lower SF, with the following risk rankings used:

- High risk – 10% of recharge;
- Medium risk – 50% of recharge; or
- Low risk – 70% of recharge.

Step 3: The risk of groundwater extraction compromising groundwater quality was assessed separately. Where there is a risk of groundwater extraction compromising groundwater quality the SF was further reduced. Each SDL resource unit was separated into four salinity classes:

Table 2: RRAM salinity classes

Salinity Class	Salinity (mg/L)
Class 1	0 – 1,500
Class 2	1,500 – 3,000
Class 3	3,000 – 14,000
Class 4	14,000+

Where groundwater extraction created a risk of compromising salinity Class 1 or 2 groundwater, the following factors were applied to the SF determined in Step 2:

- Class 1 – 80% of the available recharge volume (from Step 1)
- Class 2 – 90% of the available recharge volume (from Step 1)
- Class 3 and 4 – 100% of the available recharge volume (from Step 1).

The level of uncertainty within an SDL resource unit

Step 4: The level of uncertainty reflects the quantity and quality of information and data that is available and the level of understanding of the groundwater processes. Where there is a low degree of uncertainty regarding the groundwater system, no change was made to the SF. However, a high degree of uncertainty required the SF to be further reduced. The reduction was determined by the level of risk to the ESLT characteristics determined in
Step 2:

- Risk to ESLT characteristics is high or medium – SF reduced by 50%; or
- Risk to ESLT characteristic is low – SF reduced by 25%.

The resulting SF from these four steps was then applied to the available recharge volume determined in Step 1, to determine the PEL.

Figure 1 shows an example of a graphical representation of the four steps in the RRAM process used to determine the PEL (potential volume that can be taken), prior to any other assessments used to inform SDLs. Further information on the application of the RRAM process is available in Murray–Darling Basin Plan Groundwater Methods Report (MDBA, 2020).

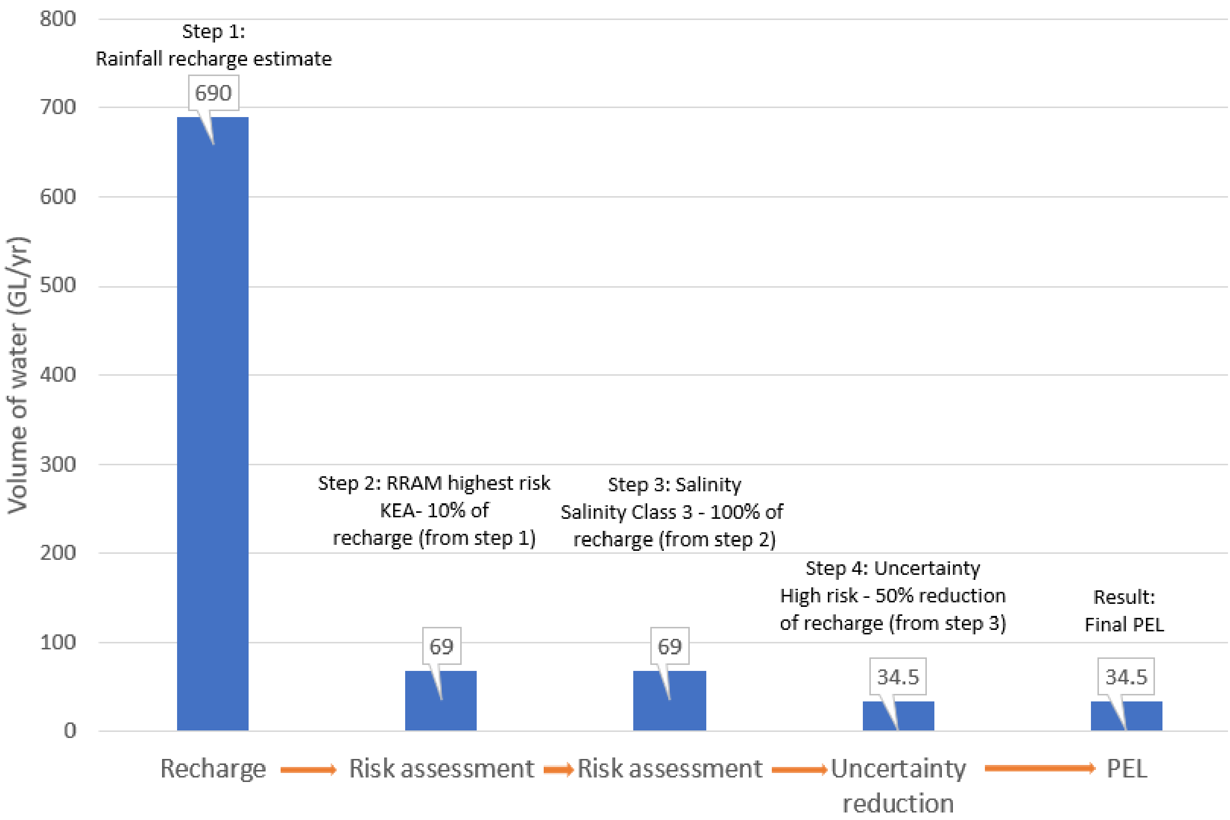

Figure 1: Example of the RRAM process showing the reduction in groundwater volume (GL/y) after each assessment step to determine the PEL

Groundwater assessment framework

The MDBA developed a groundwater assessment framework, building on PEL values, to determine groundwater SDLs that reflect the ESLT. This framework was developed and refined during the development of the Basin Plan.

Applying the assessment framework

In applying the groundwater assessment framework, a two-stage approach was taken. The first stage considered the characteristics (geology, recharge, ESLT characteristics etc.) of the individual groundwater resource units. Each groundwater SDL resource unit was characterised as either:

- Deep groundwater;
- Non-renewable groundwater;
- Connected to surface water resources; or
- Not connected to surface water resources.

The second stage assessed the BDL in relation to the PEL and the groundwater management arrangements in place to determine the SDLs in the connected and non-connected resource units.

The assessments then considered if:

- there was an existing reduction program in place (e.g. Achieving Sustainable Groundwater Entitlements program);
- the BDL was greater than the PEL and whether there was a need for an entitlement reduction program;
- better science or knowledge of the resource existed; or existing or proposed water management arrangements in place and how did they relate to the BDL and PEL. If there was, the SDL was set to the BDL; or
- the BDL was less than the PEL and if the resource unit was:
    - connected to surface water resources; and
    - the SDL was equal to the BDL; or
    - the SDL was greater than the BDL (unassigned groundwater); or
    - there was no connection to surface water resources (unassigned groundwater).

Note that unless indicated otherwise, usage and entitlement data presented in the report cards use data up to 2012, as well as amendments since that time (up to 2018).

Changing groundwater SDLs

The Basin Plan sets out requirements and methods for altering groundwater SDLs. These details are covered in Chapter 7 and address the methods and circumstances where the SDLs can be amended.

Under s6.06 of the Basin Plan the MDBA conducted independent reviews of the BDLs and SDLs of three groundwater areas:

- Western Porous Rock WRP area (NSW);
- Eastern Porous Rock WRP area (NSW), and
- Goulburn Murray: Sedimentary Plain SDL resource unit (Victoria).

The reviews were undertaken as when the Basin Plan was being finalised in 2012, concerns were raised by the NSW and Victorian Governments in relation to the groundwater SDLs in three areas. The Basin Plan also states the type of information to be considered in each review and identifies the process for selecting experts to undertake the reviews.

As per the provisions of the Basin Plan, a review panel was assembled to undertake each review. Also, to ensure the most up to date information was available to the review panels, MDBA in partnership with the relevant state appointed a consultant to bring together and synthesise the relevant information for each review. The review reports and associated synthesis reports have been published on the MDBA website.

In summary, each review recommended that the SDLs under consideration could be increased 'once assurances have been given by the relevant state to demonstrate that the resource will be managed by state policies and plans to limit impacts to acceptable levels'. This outcome reflects the view of the review panels that a less conservative approach to setting SDLs could be considered if suitable management actions are in place to manage the potential impacts of increased groundwater take. The MDBA accepted the review panel recommendations and the Basin Plan was amended in July 2018.

How to read the report card RRAM summary tables

For the SDL resource units where the RRAM has been applied, the report cards include two summary tables (see example tables for RRAM and PEL, below). To assist the reader to interpret the tables this section details how the tables should be read.

Noting that recharge has been determined in Step 1 of the RRAM, the ‘RRAM summary table’ provides the outcome of the risk assessment and the resulting sustainability factor (SF) is determined by Steps 2, 3 and 4 of the RRAM. This table shows:

1. The level of risk to KEAs, KEFs and productive base, and the associated SF derived from Step 2. The highest level of risk is highlighted in grey, in the table.
2. The further reduction applied in Step 3 for salinity classes 1 and 2. Note, in this example, it has been determined that there is no risk to salinity classes 3 and 4, and hence, the SF is not adjusted; this is denoted by ‘N/A’ in the table.
3. Any further reduction applied via Step 4. Where there is a high uncertainty, the SF in Step 4 is informed by the Risk to ESLT identified in Step 2 (i.e. if there was a high or medium risk the SF is 0.5 but if there was a low risk the SF is reduced by 25 percent to 0.75). Where there is a low uncertainty, there is no further reduction to the SF; this is denoted by ‘N/A’ in the table.

The result of these steps is the SF for each salinity class as shown in the ‘PEL summary table’.

Example table – RRAM summary table:

RRAM Step 2: Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3: Risks to fresh water	Salinity Class (KEO)			RRAM Step 4: Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Med	Med	Low	**Risk (Y/N)**	Yes	Yes	No	**Risk to ESLT**	Medium
				% of Area	16%	2%	82%	**Uncertainty Level**	High
SF	0.50	0.50	0.70	**SF**	0.80	0.90	N/A	**SF**	0.50

The ‘PEL summary table’ presents the recharge, the SF and the PEL for each salinity class and totals for the SDL resource unit. The final SF for each salinity class is calculated by:

1. Identifying the highest risk and the associated SF in Step 2 (highlighted grey).
2. Multiplying the SF from Step 2 with the SF in Step 3 for each salinity class (where there is a N/A, the SF is not adjusted).
3. Multiplying the SF from Step 3 with the SF in Step 4 for each salinity class (where there is a N/A, the SF is not adjusted).
4. The result of these steps is the SF for each salinity class.

The PEL is then calculated by multiplying the SF for each salinity class by the volume of recharge to the area covered by each salinity class. The PEL for each salinity class are summed together to give the total PEL for the SDL resource unit.

Example table – PEL summary table:

Salinity class	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)	53.8	1.71	23.00	101.7	180.2
SF	0.20	0.23	0.25	0.25	N/A
PEL (GL/y)	10.8	0.39	5.75	25.4	42.3

Calculations from the 'Example tables', above

In the 'RRAM summary table':

RRAM Step 2: SF associated with the highest level of risk (highlighted in grey) = 0.5
RRAM Step 3: SF from RRAM Step 2, multiplied by SF in RRAM Step 3:
Salinity Class 1 (0.5 x 0.8) = 0.40
Salinity Class 2 (0.5 x 0.9) = 0.45
Salinity Class 3 & 4 (0.5 x N/A) = 0.50
RRAM Step 4: SFs from RRAM Step 3, multiplied by SF for RRAM uncertainty (Step 4):
Salinity Class 1 (0.4 x 0.5) = 0.20
Salinity Class 2 (0.45 x 0.5) = 0.23
Salinity Class 3 & 4 (0.5 x 0.5) = 0.25

In the 'PEL summary table':

SFs from RRAM Step 4 multiplied by recharge for each salinity class equals the PEL:
Salinity Class 1 (0.2 x 53.8) = 10.8 GL/y
Salinity Class 2 (0.23 x 1.71) = 0.39 GL/y
Salinity Class 3 (0.25 x 23.00) = 5.75 GL/y
Salinity Class 4 (0.25 x 101.7) = 25.4 GL/y

Total recharge for the SDL resource unit equals the sum of the recharge volumes of the salinity classes, i.e. 53.8+1.71+23.00+101.7 = 180.2 GL/y

The total PEL for the SDL resource unit equals the sum of the PELs for each salinity class, i.e. 10.8+0.39+5.75+25.4 = 42.3 GL/y

South Australia

Angas Bremer (GS1)

The Angas Bremer SDL resource unit is located in the south-west of the MDB on a floodplain between the Eastern Mount Lofty Ranges and Lake Alexandrina (Figure 2). The most productive aquifer is the Murray Group Limestone, which is semi-confined and up to 100 m thick. The limestone varies between a clayey soft limestone, a hard sandy limestone and a soft bryozoal limestone (Cresswell and Herczeg, 2004). The Quaternary sediments overly the Murray Group Limestone and comprise of 10 to 35 m of sand, silt and clays that form discontinuous and inter-lensing aquifers that are both confined and unconfined in nature (Zulfic and Barnett, 2007).

Managed aquifer recharge (MAR) is practiced in the SDL resource unit area, as a means of storing water extracted from local streams and the Murray River, for extraction at a later time. Typically, groundwater is used more during drought, due to the limited availability of surface water supplies. This was particularly the case during the Millennium drought (2001–2009).

The 2001 Water Allocation Plan for the Angas Bremer Prescribed Wells Area limited water take to 6.57 GL/y. The SDL for the resource unit was set: (i) at the SA plan limit (plus estimated S&D usage) for the Murray Group Limestone, and (ii) through the unassigned groundwater assessment (25% factor) for the Quaternary Sediments. The total SDL for the SDL resource unit is 7.66 GL/y.

The Angas Bremer groundwater SDL resource unit sits within the Eastern Mount Lofty Ranges WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 3: Summary table for the Angas Bremer

Summary characteristic	Name / description / volume
SDL resource unit	Angas Bremer (GS1) GS1a Quaternary Sediments GS1b Murray Group Limestone
Groundwater covered	a) Groundwater in Quaternary sediments b) Groundwater in the Murray Group Limestone, and all other groundwater, excluding groundwater in Quaternary Sediments
WRP Area	Eastern Mount Lofty Ranges (GW5)
GMU(s) Covered	Angas Bremer Prescribed Wells Area
Recharge (RRAM Step 1)*	a) 6.40 GL/y b) 0 GL/y
Recharge Input	a) WAVES recharge modelling b) Angas Bremer Prescribed Wells Area – Groundwater Status Report 2007
PEL**	a) 4.35 GL/y b) N/A
BDL	a) 0 GL/y b) 6.57 GL/y Total: 6.57 GL/y
SDL***	a) 1.09 GL/y b) 6.57 GL/y Total: 7.66 GL/y
Licensed Entitlement****	a) 0 GL/y b) 6.50 GL/y Total: 6.5 GL/y
Measured groundwater use****	a) 0 GL/y b) 6.60 GL/y Total: 6.60 GL/y
Estimated S&D Use****	a) 0 GL/y b) 0.07 GL/y Total: 0.07 GL/y
Entitlement plus S&D	a) 0 GL/y b) 6.57 GL/y

*Rainfall recharge is considered negligible for the Murray Group Limestone (Zulfic & Barnett, 2007). Groundwater recharge to the Quaternary Sediments includes rainfall recharge only (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge does not account for water that is discharged from the system via base flow to streams, outflow to other aquifer and/or evapotranspiration.

**PEL is for the Quaternary Sediments, as it is the only part to receive rainfall recharge required in the RRAM.

***SDL set at the SA plan limit plus estimated S&D usage for the Murray Group Limestone (Water Allocation Plan for the Angas Bremer Prescribed Wells Area 2001) (existing planning arrangements), and the unassigned groundwater assessment (25% factor) for the Quaternary Sediments.

****All entitlement and use information was supplied by the SA Government. The licensed entitlement and S&D was provided in a letter to the MDBA on 1 March 2011. The measured use information was for 2007-08 and was provided by the SA Government (CSIRO and SKM, 2010c). The measured use was greater than entitlement due to carry-over from the previous year and aquifer storage and recovery extractions (S. Barnett, pers. comm., 31 May 2010). SA has been providing annual reporting on water use compared to annual permitted take, under Section 71 of the *Water Act 2007 (Cwlth)* using methods from the relevant draft or accredited WRP.

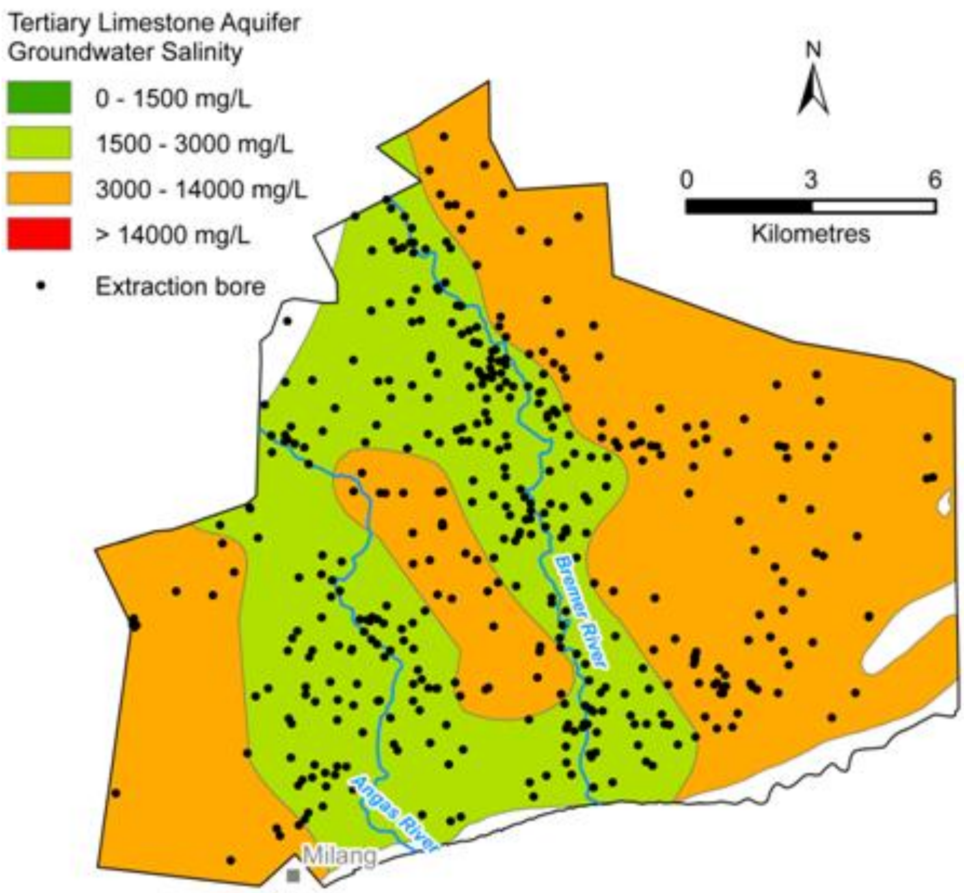

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Figure 2: Angas Bremer SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 4 and Table 5 provides a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a low level of uncertainty.

Table 4: RRAM summary table for the Angas Bremer

RRAM Step 2: Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3: Risks to fresh water	Salinity Class (KEO)			RRAM Step 4: Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	Yes	Yes	No	**Risk to ESLT**	Low
				% of Area	16%	2%	82%	**Uncertainty Level**	Low
SF	0.70	0.70	0.70	**SF**	N/A	0.90	N/A	**SF**	N/A

Table 5: PEL summary table for the Angas Bremer

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	0.0	1.79	3.69	0.92	6.40
SF	N/A	0.63	0.70	0.70	N/A
PEL (GL/y)**	0.0	1.13	2.58	0.64	4.35

*Recharge per salinity class was derived using salinity datasets of high uncertainty and should be used as a guide only.

**PEL is for the Quaternary Sediments which is the upper most aquifer of the SDL resource unit.

Eastern Mount Lofty Ranges (GS2)

The Eastern Mount Lofty Ranges is located in the far south west of the Murray–Darling Basin in SA (Figure 3). The Marne, Bremer and Finniss Rivers and numerous other small streams drain through the SDL resource unit and into the River Murray and Lake Alexandrina.

The SDL resource unit comprises fractured rock highlands, associated with the Adelaide Geosyncline, and the sedimentary plains of the Murray Basin. The fractured rock aquifer consists of rocks of several different geological units including the Barossa Complex, Kanmantoo Group, Normanville Group and Adelaidean Sedimentary Rocks. The sedimentary plains are a relatively small part of the area and include unconsolidated sediments of the Murray Basin, including the Murray Group Limestone and Quaternary Sediments. The fractured rock aquifer is the most developed and represents one of the most well understood fractured rock aquifers in the Basin due to the significant effort on recharge studies (Green and Stuart, 2008).

There was no current water management plans covering the SDL resource unit when the Basin Plan was made. However, a new water allocation plan for the Eastern Mount Lofty Ranges Prescribed Water Resources Area was adopted by the SA Government in December 2013. The plan limit defined in the Water Allocation Plan for the Eastern Mount Lofty Ranges Prescribed Water Resources Area (incorporating the Eastern Mount Lofty Ranges Prescribed Wells Area) is 38.5 GL/y. This was adopted as the SDL for the SDL resource unit.

The Eastern Mount Lofty Ranges groundwater SDL resource unit sits within the Eastern Mount Lofty Ranges WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 6: Summary table for the Eastern Mount Lofty Ranges

Summary characteristic	Name / description / volume
SDL resource unit	Eastern Mount Lofty Ranges (GS2)
Groundwater covered	All groundwater
WRP Area	Eastern Mount Lofty Ranges (GW5)
GMU(s) Covered	Eastern Mount Loft Ranges Prescribed Wells Area
Recharge (RRAM Step 1)*	174.0 GL/y
Recharge Input	WAVES recharge modelling
PEL	78.7 GL/y
BDL	34.7 GL/y
SDL**	38.5 GL/y
Licensed Entitlement***	32.2 GL/y
Measured groundwater use	6.99 GL/y (2015-16)
Estimated S&D Use***	2.47 GL/y
Entitlement plus S&D	34.7 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge also does not account for water that is discharged from the system via base flow to streams, outflow to other aquifer and/or evapotranspiration.

**SDL set at the Eastern Mount Lofty Ranges plan limit (existing planning arrangements).

***All entitlement and use information supplied by the SA Government. The licensed entitlement and S&D use figures were provided in a letter to the MDBA on 1 March 2011. SA has been providing annual reporting on water use compared to annual permitted take, under Section 71 of the *Water Act 2007 (Cwlth)* using methods from the relevant draft or accredited WRP.

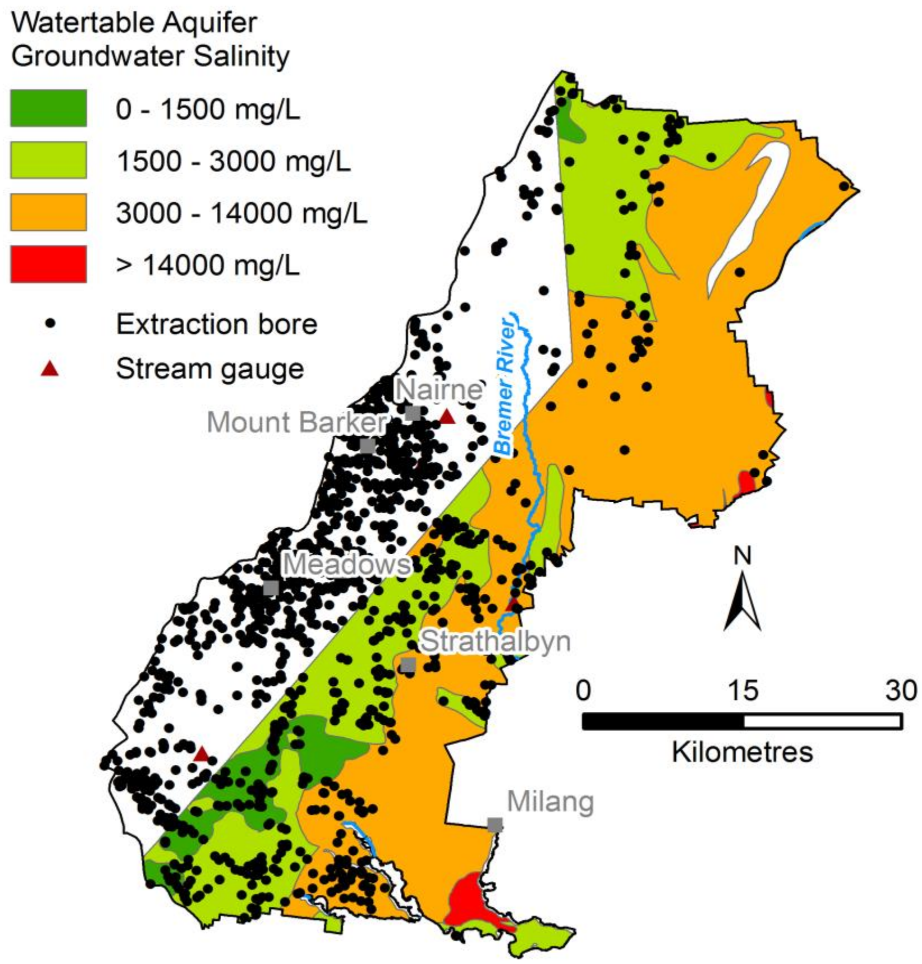


Figure 3: Eastern Mount Lofty Ranges SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000). The Basin in a Box dataset does not include groundwater salinity information for the western part of the SDL resource unit and no further groundwater salinity information was available at the time of assessment.

Recharge risk assessment method outcome

Table 7 and Table 8 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- medium risk for KEFs (initially ranked as high risk given there are unregulated river reaches, but reduced to medium risk on the basis that local management rules will mitigate the risk associated with the unregulated gaining rivers)
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a low level of uncertainty.

Table 7: RRAM summary table for the Eastern Mount Loft Ranges

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Med	Low	**Risk (Y/N)**	Yes	Yes	No	**Risk to ESLT**	Med
				% Area	4%	56%	40%	**Uncertainty Level**	Low
SF	0.70	0.50	0.70	**SF**	0.80	0.90	N/A	**SF**	N/A

Note: The risk to KEF has been ranked medium with the understanding that local management rules will mitigate the risk associated with the unregulated gaining rivers.

Table 8: PEL summary table for the Eastern Mount Lofty Ranges

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	10.0	144.0	19.0	0.48	173.5
SF	0.40	0.45	0.50	0.50	N/A
PEL (GL/y)	4.00	65.0	9.50	0.24	78.7

*Recharge per salinity class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Mallee (GS3)

The Mallee SDL resource unit is located in the SA section of the Mallee Region which is south-east of the River Murray (Figure 4). There are five main hydrogeological units in the Mallee SDL resource unit, including aquifers and confining layers (Barnett and Osei-bonsu, 2006).

The uppermost Pliocene Sands aquifer, consisting of weakly cemented fine to coarse sand, is approximately 0 to 15 m thick and is absent in the west (Barnett and Osei-bonsu, 2006). The layer is underlain by the Bookpurnong Beds, which is present across the eastern portion of the area. The layer consists of clastic silts, clays and sands and acts as a confining layer to the underlying Murray Group Limestone.

The Murray Group Limestone aquifer contains consolidated, highly fossiliferous, fine to coarse bioclastic limestone, with an average thickness of 100 m (Barnett and Osei-bonsu, 2006). The aquifer is confined across most of the unit, but unconfined in the west where the Bookpurnong Beds pinch out. Beneath the Murray Group Limestone lies the confining Ettrick Formation, which consists of glauconitic and fossiliferous marl with a typical thickness of 15 m and separates the upper aquifers from the Renmark Group, which is an unconsolidated carbonaceous sand, silt and clay layer of approximately 150 m thick (Barnett and Osei-bonsu, 2006).

The Murray Group Limestone is the most highly developed aquifer in the SA MDB due its low salinity and high yields. It is also the largest known reserve of non-renewable groundwater in the Basin as it currently receives negligible rainfall recharge. Although the groundwater is considered non-renewable, the current level of development will not compromise the ESLT within a timeframe of 50 years because of the large volumes stored in the aquifer (over 100,000 GL).

The Water Allocation Plans for the Mallee Prescribed Wells Area (2000) and the Noora Prescribed Wells Area (2001) were used in the determination of SDLs for this SDL resource unit. The combined plan limit was 63.4 GL/y, with the SDL for the resource unit set based on: (i) the non-renewable groundwater assessment for the Murray Group Limestone, (ii) the unassigned groundwater assessment (25% factor) for the Pliocene Sands, and (iii) the deep groundwater assessment in the Renmark Group. The BDL and SDL for the Murray Group Limestone were updated in an amendment to the Basin Plan in July 2018 to transfer 2.14 GL/y of entitlement associated with a salt interception scheme from the Mallee (Murray Group Limestone) (GW3) SDL resource unit to the SA Murray Salt Interception Schemes (GS7) SDL resource unit.

The Mallee groundwater SDL resource unit sits within the South Australian Murray Region WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 9: Summary table for the Mallee

Summary characteristic	Name / description / volume
SDL resource unit	Mallee (GS3) GS3a Pliocene Sands GS3b Murray Group Limestone GS3c Renmark Group
Groundwater covered	a) Groundwater in the Pliocene sands b) Groundwater in the Murray Group Limestone c) Groundwater in the Renmark Group and all other groundwater, excluding groundwater in the Pliocene Sands and the Murray Group Limestone
WRP Area	South Australian Murray Region (GW4)
GMU(s) Covered	Mallee Prescribed Wells Area, the former Noora Prescribed Wells Area (note: prescription was revoked in 2017), and Border Zone Units 11A, 10A, 9A and 8A
Recharge to water table (RRAM Step 1)*	a) 267.5 GL/y b) 3.80 GL/y c) N/A
Recharge Input	a) WAVES recharge modelling b) Barnett & Osei-bonsu 2006 c) N/A
PEL**	c) 165.7 GL/y d) N/A e) N/A
BDL	a) 0 GL/y b) 63.6 GL/y c) 0 GL/y
SDL***	a) 41.4 GL/y b) 63.6 GL/y c) 2.00 GL/y
Licensed Entitlement****	a) 0 GL/y b) 63.4 GL/y c) 0 GL/y
Measured groundwater use****	a) 0 GL/y b) 40.8 GL/y c) 0 GL/y
Estimated S&D Use****	a) 0 GL/y b) 2.33 GL/y c) 0 GL/y
Entitlement plus S&D	a) 0 GL/y b) 65.7 GL/y c) 0 GL/y

*Groundwater recharge is to the Pliocene Sands and only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge does not account for water that is discharged from the system via base flow to streams, outflow to other aquifer and/or evapotranspiration.

**PEL is for the Pliocene Sands, as it is the only part of SDL resource unit that receives rainfall recharge required to determine the PEL.

***SDL based on the non-renewable groundwater assessment for the Murray Group Limestone, the unassigned groundwater assessment (25% factor) for the Pliocene Sands, and the deep groundwater assessment in the Renmark Group.

****All entitlement and use information was supplied by the SA Government. The licensed entitlement and S&D use figures were provided in a letter to the MDBA on 1 March 2011. SA has been providing annual reporting on water use compared to annual permitted take, under Section 71 of the *Water Act 2007* (*Cwlth*) using methods from the relevant draft or accredited WRP.

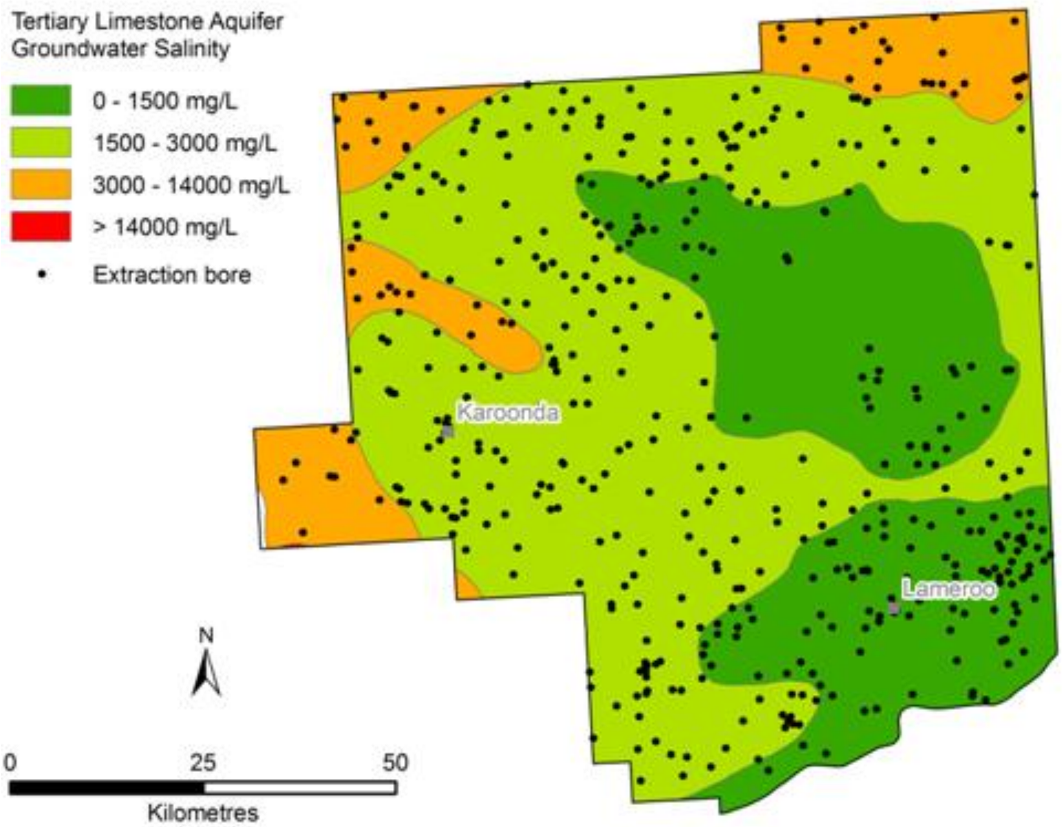


Figure 4: Mallee (Murray Group Limestone) SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 10 and Table 11 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a low level of uncertainty, due to the presence of a groundwater model.

Table 10: RRAM summary table for the Mallee (Pliocene Sands)

<table>
<tr><th rowspan="2">RRAM Step 2 Risks to KEA, KEF and PB</th><th rowspan="2">KEA</th><th rowspan="2">KEF</th><th rowspan="2">PB</th><th rowspan="2">RRAM Step 3 Risks to fresh water</th><th colspan="3">Salinity Class (KEO)</th><th colspan="2" rowspan="2">RRAM Step 4 Uncertainty</th></tr>
<tr><th>Class 1</th><th>Class 2</th><th>Class 3 & 4</th></tr>
<tr><td rowspan="2">Risk Ranking</td><td rowspan="2">Low</td><td rowspan="2">Low</td><td rowspan="2">Low</td><td>Risk (Y/N)</td><td>Yes</td><td>Yes</td><td>No</td><td>Risk to ESLT</td><td>Low</td></tr>
<tr><td>% Area</td><td>32%</td><td>55%</td><td>13%</td><td>Uncertainty Level</td><td>Low</td></tr>
<tr><td>SF</td><td>0.70</td><td>0.70</td><td>0.70</td><td>SF</td><td>0.80</td><td>0.90</td><td>N/A</td><td>SF</td><td>N/A</td></tr>
</table>

Table 11: PEL summary table for the Mallee

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	86.3	135.6	42.8	2.80	267.5
SF	0.56	0.63	0.70	0.70	N/A
PEL (GL/y)**	48.3	85.4	30.0	1.96	165.7

*Recharge per salinity class was derived using salinity datasets of high uncertainty and should be used as a guide only.

**PEL is for the Pliocene Sands which is the water table aquifer where there is rainfall recharge.

Marne Saunders (GS4)

The Marne Saunders SDL resource unit is located north-east of Adelaide in SA (Figure 5). The area stretches from the southern Barossa Highlands to the northern extent of the Eastern Mount Lofty Ranges and across the plains to the River Murray.

The SDL resource unit can be divided into two distinct regions: the hills region associated with the fractured basement outcrops of the Adelaide Geosyncline, and the plains region of the Murray Basin, of which the Murray Group Limestone is the most productive aquifer. The hills region is made up of rocks of the Kanmantoo Group including sandstone, siltstone, marble and greywacke with inliers of granite (SAMDBNRMB, 2009). The hills region has low permeability and contains limited fractures and joints where groundwater can be stored which limits recharge (Richardson *et al.*, 2008). Bore yields are typically poor and groundwater salinities variable, leading to low extraction in this region (DWR, 2001).

The plains region contains unconsolidated sediments, which form the sedimentary aquifers. The uppermost unconfined Quaternary sediments range from wind-blown sands in the uplands to alluvial sediments that vary in thickness from 60 m near the Palmer Fault to a few metres close to the River Murray (DWR, 2001). The Quaternary sediments on the plains are only saturated in the west where the Pooraka Formation acts as a confining layer to the underlying Tertiary sediments. In the east of the region, the Pooraka Formation pinches out thereby allowing hydraulic connection between the Quaternary sands and the Tertiary Murray Group Limestone aquifer. The Murray Group Limestone aquifer consists of highly fossiliferous limestone that varies in thickness from a few metres in the west to approximately 50 m on the eastern boundary (DWR, 2001). The Murray Group Limestone is underlain by the Ettrick Formation; a layer of grey-green sandy marls of varying thickness which acts as a confining layer to the underlying confined Renmark Group aquifer.

The 2010 Water Allocation Plan for the Marne Saunders Prescribed Water Resource Area had a plan limit of 4.97 GL/y and this was adopted as the SDL for this resource unit.

The Marne Saunders groundwater SDL resource unit sits within the Eastern Mount Lofty Ranges WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 12: Summary table for the Marne Saunders

Summary characteristic	Name / description / volume
SDL resource unit	Marne Saunders (GS4) GS4a Fractured Rock GS4b Murray Group Limestone GS4c Renmark Group
Groundwater covered	a) Groundwater in fractured rock b) Groundwater in: (i) the Murray Group Limestone; and (ii) Quaternary sediments c) Groundwater in the Renmark Group, and all other groundwater, excluding groundwater in Fractured Rock, Murray Group Limestone and Quaternary sediments
WRP Area	Eastern Mount Lofty Ranges (GW5)
GMU(s) Covered	Marne Saunders Prescribed Wells Area
Recharge (RRAM Step 1)*	8.00 GL/y
Recharge Input	Barnett & Zulfic, 2001
PEL**	3.40 GL/y
BDL	a) 2.09 GL/y b) 2.38 GL/y c) 0.50 GL/y Total: 4.97 GL/y
SDL***	a) 2.09 GL/y b) 2.38 GL/y c) 0.50 GL/y Total: 4.97 GL/y
Licensed Entitlement:*****	a) 2.00 GL/y b) 2.20 GL/y c) 0.50 GL/y Total: 4.70 GL/y
Measured groundwater use*****	2.50 GL/y
Estimated S&D Use***	a) 0.09 GL/y b) 0.18 GL/y c) 0 GL/y Total: 0.97 GL/y

*Groundwater recharge includes rainfall recharge in the Fractured Rock zone, lateral through flow from the Fractured Rock zone across the Palmer Fault and river recharge in the plains (Barnett & Zulfic, 2001). For more detail about how the recharge was set and how it was split into the salinity classes, refer to the RRAM report for SA (CSIRO and SKM, 2010c).

**PEL is for the water table aquifer where there is rainfall recharge.

***SDL set at the SA plan (existing planning arrangements).

****All entitlement and use information was supplied by the SA Government. The licensed entitlement and S&D were provided in a letter to the MDBA on 1 March 2011. The measured use information is for 2007-08 and was provided by the SA Government as reported in the SA RRAM report (CSIRO and SKM, 2010c). SA has been providing annual reporting on water use compared to annual permitted take, under Section 71 of the *Water Act 2007* (*Cwlth*) using methods from the relevant draft or accredited WRP.

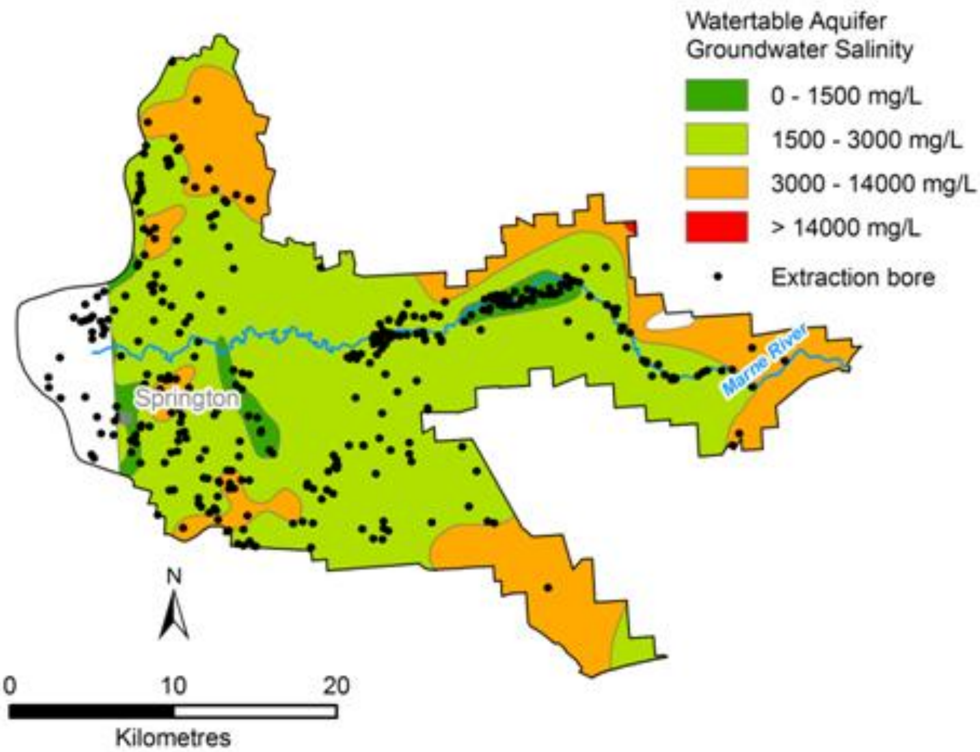


Figure 5: Marne Saunders SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000). The Basin in a Box dataset does not include groundwater salinity information for the western part of the SDL resource unit and no further groundwater salinity information was available at the time of assessment.

Recharge risk assessment method outcome

Table 13 and Table 14 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- medium risk for KEFs (initially ranked as high risk given there are unregulated river reaches, but reduced to medium risk on the basis that local management rules will mitigate the risk associated with the unregulated gaining rivers)
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a low level of uncertainty.

Table 13: RRAM summary table for the Marne Saunders

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Med	Low	Risk (Y/N)	Yes	Yes	No	Risk to ESLT	Med
				% Area	4%	70%	26%	Uncertainty Level	Low
SF	0.70	0.50	0.70	SF	0.80	0.90	N/A	SF	N/A

Note: The risk to KEF has been ranked medium risk instead of high risk with the understanding that local management rules will mitigate the risk associated with the unregulated gaining rivers.

Table 14: PEL summary table for the Marne Saunders

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	4.00	4.00	0.0	0.0	8.00
SF	0.40	0.45	N/A	N/A	N/A
PEL (GL/y)**	1.60	1.80	0.0	0.0	3.40

*Recharge per salinity class was derived using salinity datasets of high uncertainty and should be used as a guide only.

**PEL is for the water table aquifer where there is rainfall recharge.

Peake–Roby–Sherlock (GS5)

The Peake–Roby–Sherlock SDL resource unit is located east of Murray Bridge in SA (Figure 6). The SDL resource unit consists of two regions: the Mallee Highlands in the north-east, and the Coastal Plain which occupies most of the area.

In the highlands, the Murray Group Limestone forms the unconfined aquifer that contains salinities of 2,000–3,000 mg/L and is used for limited irrigation, and S&D purposes. Beneath the Coastal Plain, the shallow Quaternary limestone forms the unconfined aquifer which is unsuitable for general use because of its high salinity (over 20,000 mg/L). The water table is continuous between the highlands (where it can be up to 50 m below the ground) and the Quaternary limestone in the Coastal Plain (where it ranges from 3 to 8 m below the ground) (SAMDBNRM, 2009).

The deeper confined aquifer is the most developed aquifer in the SDL resource unit and is comprised of the Buccleuch Formation (bryozoal limestone) and underlying sands of the Renmark Group. This confined aquifer is hydraulically separated from the overlying unconfined aquifer by the low permeability Ettrick Formation marl (SAMDBNRM,2009). The Buccleuch Formation lies 90 to 100 m below the Coastal Plain with varying thickness (5 to 25 m) and limited lateral extent. In the east of the SDL resource unit, the Buccleuch Formation merges with the Renmark Group with groundwater flowing between these two units.

The Water Allocation Plan for the Peake–Roby–Sherlock Prescribed Wells Area, adopted by the SA Government in March 2011, had a plan limit of 5.99 GL/y. The plan limit was adopted as the SDL for this SDL resource unit.

The element of the Murray Group Limestone in the SDL resource unit is part of the largest known reserves of non-renewable groundwater in the Basin. Prior to adopting the state extraction limit for the Murray Group Limestone, the Authority assessed if the plan limit reflected an ESLT. Although the groundwater is non-renewable, it is considered that the plan limit will not compromise the ESLT within the time frame of the Basin Plan.

The Peake–Roby–Sherlock groundwater SDL resource unit sits within the South Australian Murray Region WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 15: Summary table for the Peake–Roby–Sherlock

Summary characteristic	Name / description / volume
SDL resource unit	Peake–Roby–Sherlock (GS5) GS5a Unconfined GS5b Confined
Groundwater covered	a) Groundwater in: (i) the unconfined Murray Group Limestone comprising the Coomandook and Bridgewater Formations; and (ii) the unconfined Quaternary limestone b) Groundwater in: (i) the confined Renmark Group; and (ii) the confined Buccleuch Group; and all other groundwater, excluding groundwater in the unconfined Murray Group Limestone/Coomandook and Bridgewater Formations; and the unconfined Quaternary limestone
WRP Area	South Australian Murray Region (GW4)
GMU(s) Covered	Peake, Roby and Sherlock Prescribed Wells Area
Recharge (RRAM Step 1)*	0 GL/y
Recharge Input	Barnett & Yan, 2008
PEL**	N/A
BDL	a) 3.41 GL/y b) 2.58 GL/y Total: 5.99 GL/y
SDL***	a) 3.41 GL/y b) 2.58 GL/y Total: 5.99 GL/y
Licensed Entitlement****	a) 3.22 GL/y b) 2.17 GL/y Total: 5.39 GL/y

Summary characteristic	Name / description / volume
Measured groundwater use** **	a) 0.001 GL/y b) 1.97 GL/y Total: 1.97 GL/y
Estimated S&D Use******	a) 0.19 GL/y b) 0.41 GL/y Total: 0.60 GL/y
Entitlement plus S&D	a) 3.41 GL/y b) 2.58 GL/y Total: 5.99 GL/y

*The productive aquifers are not recharged via rainfall infiltration or via leakage from overlying/underlying aquifers (Barnett & Yan, 2008).

**The SDL resource unit receives negligible recharge and the RRAM could not be applied to determine the PEL.

***SDL set at the SA plan limit (existing planning arrangements).

****All entitlement and use information from the Water Allocation Plan for the Peake–Roby–Sherlock Prescribed Wells Area 2011. SA has been providing annual reporting on water use compared to annual permitted take, under Section 71 of the *Water Act 2007* (*Cwlth*) using methods from the relevant draft or accredited WRP.

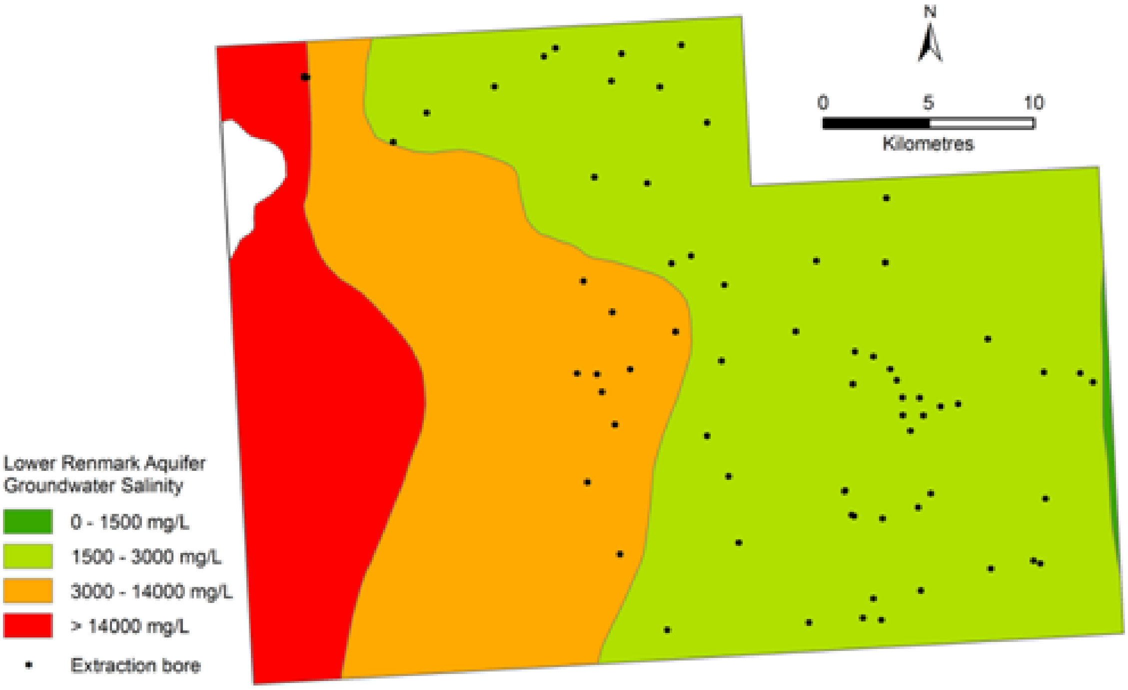


Figure 6: Peake–Roby–Sherlock (Lower Renmark formation) SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

The SDL resource unit receives negligible recharge and the RRAM could not be applied to determine the PEL. However, Table 16 provides a summary of the RRAM risk ranking as an indication of the level of risk associated with the resource. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a low level of uncertainty (Barnett and Yan, 2008).

Table 16: RRAM summary table for the Peake–Roby–Sherlock

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	Yes	Yes	No	**Risk to ESLT**	Low
				% Area	0.5%	55%	44%	**Uncertainty Level**	Low
SF	0.70	0.70	0.70	**SF**	0.80	0.90	N/A	**SF**	N/A

SA Murray (GS6)

The SA Murray SDL resource unit is located on either side of the River Murray in SA and incorporates the majority of the Basin in SA (Figure 7). The SA Murray SDL resource unit includes the area of the SA portion of the Basin that is not covered by water allocation plans and their associated SDL units. It extends from the Olary Ranges in the north to the Coorong and Lower Lakes in the south. It incorporates a range of fractured rock and sedimentary aquifers that have been described in the previous report cards (GS1 to GS5).

The hills are formed from outcropping Cambrian basement rocks that form fractured rock aquifers of varying yields. On the plains, the upper most Quaternary sediments mainly consist of the aeolian sands of the Woorinen Formation, underlain by Blanchetown Clay in some areas, which acts as a localised semi-confining layer to the underlying Tertiary sediments that contain the most significant aquifers of the system. The uppermost of these is the mostly unconfined Pliocene Sands aquifer (mainly composed of the Loxton–Parilla Sands). In the central areas and east of the SDL resource unit, the Pliocene Sands is separated from the underlying Murray Group Limestone aquifer, by the consolidated plastic silts and clays of the Bookpurnong Beds. The Murray Group Limestone is unconfined and contains the water table across much of the plains, other than in the east where the water table is within the Loxton–Parilla Sands. Beneath the Murray Group Limestone, the Ettrick Formation acts as a confining layer to the underlying Renmark Group aquifer.

Extraction in the SA Murray SDL resource unit is relatively minor, due to the high salinity of the groundwater in the region. There are no licensed entitlements. There was no transitional WRP, or other water management plan, at the time of setting the SDL.

The SA Murray SDL resource unit sits within the South Australian Murray Region WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 17: Summary table for the SA Murray

Summary characteristic	Name / description / volume
SDL resource unit	SA Murray (GS6)
Groundwater covered	All groundwater
WRP Area	South Australian Murray Region (GW4)
GMU(s) Covered	Mallee, Murraylands, Coorong, River Murray Prescribed Watercourse
Recharge (RRAM Step 1)*	483.3 GL/y
Recharge Input	WAVES recharge modelling
PEL	253.7 GL/y
BDL	1.80 GL/y
SDL**	64.8 GL/y
Licensed Entitlement***	0 GL/y
Measured Groundwater Use	Use not measured
Estimated S&D Use***	1.80 GL/y
Entitlement plus S&D	1.80 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information was supplied by the SA Government as reported in the SA RRAM report (CSIRO and SKM, 2010c).

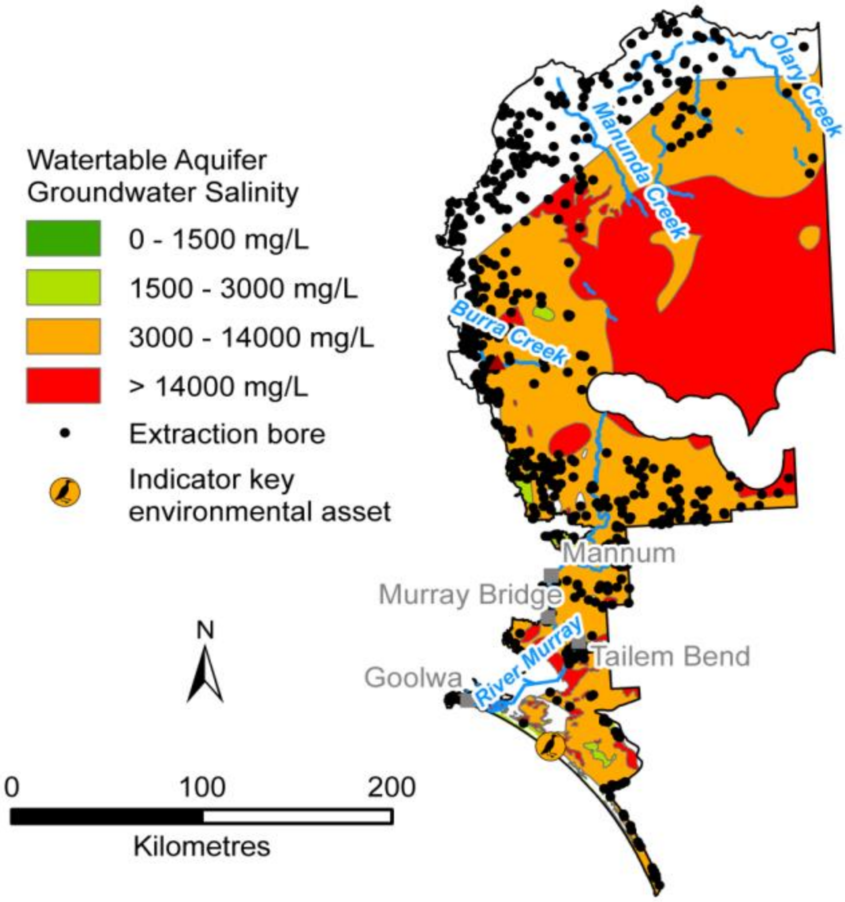


Figure 7: SA Murray SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000). The Basin in a Box dataset does not include groundwater salinity information for the northern part of the SDL resource unit and no further groundwater salinity information was available at the time of assessment.

Recharge risk assessment method outcome

Table 18 and Table 19 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 18: RRAM summary table for the SA Murray

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	Low
				% Area	0%	2%	98%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	N/A	N/A	N/A	**SF**	0.75

Table 19: PEL summary table for the SA Murray

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	0.0	36.0	347.7	99.6	483.3
SF	N/A	0.53	0.53	0.53	N/A
PEL (GL/y)	0.0	18.9	182.5	52.3	253.7

*Recharge per salinity class was derived using salinity datasets of high uncertainty and should be used as a guide only.

SA Murray Salt Interception Scheme (GS7)

The SA Murray Salt Interception Scheme SDL resource unit is located along the River Murray in SA (Figure 8). The SDL resource unit incorporates the River Murray floodplain and adjacent areas extending from the SA–Victorian border to just east of Morgan.

Within the floodplain, the main aquifer is the Monoman Sands (or Channel Sands) which consists of fine to coarse-grained, fluvial sands that are hydraulically connected to the regional groundwater flow system. These sands are overlain by silts and clays of the Coonambidgal Formation. The river and floodplain receives saline groundwater discharge from regional aquifers. In the western half of the area, the regional water table is located within the unconfined Murray Group Limestone aquifer which is up to 100 m thick. However, in the eastern half of the area, these sediments are structurally downwarped with the regional water table being located within the Loxton–Parilla Sands aquifer, which is separated from the underlying limestone aquifer by the silts and shelly clays of the Bookpurnong Beds. The Loxton–Parilla Sands aquifer consists of fine to coarse sands varying in thickness from approximately 30 to 100 m.

There was no interim or transitional WRP in place or other water management plan, at the time of setting SDLs and groundwater take is associated with several salt interception schemes located along the River Murray. The salt interception schemes intercepted approximately 11.1 GL in 2007-08 and were predicted to grow in the coming years. The most notable feature of salt interception schemes is that the take provides a “beneficial use” to achieve lower water tables, which reduces salt loads to rivers and results in improved floodplain environments.

The SDL (28.6 GL/y) for this resource unit was set to account for the current interception volume and the projected growth of the salt interception schemes, in recognition that the take represents beneficial use. The MDBA and SA government agree on the SDL.

The BDL was updated in an amendment to the Basin Plan in July 2018 to transfer 2.14 GL/y of entitlement associated with a salt interception scheme from the BDL of the Mallee (Murray Group Limestone) (GW3) SDL resource unit to the BDL of the SA Murray Salt Interception Schemes (GS7) SDL resource unit. There is no change to the SDL of the SA Murray Salt Interception Schemes SDL resource unit as the current SDL allows for more take than the current BDL. In discussions with SA it was agreed not to change the SDL. The SDL is sufficient for the expected growth in use by the salt interception scheme in the short to medium term.

The SA Murray Salt Interception Scheme groundwater SDL resource unit sits within the South Australian Murray Region WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 20: Summary table for the SA Murray Salt Interception Scheme

Summary characteristic	Name / description / volume
SDL resource unit	SA Murray Salt Interception Scheme (GS7)
Groundwater covered	All groundwater
WRP Area	South Australian Murray Region (GW4)
GMU(s) Covered	None
Recharge (RRAM Step 1)*	40.4 GL/y
Recharge Input	WAVES recharge modelling
PEL	28.3 GL/y
BDL	13.2 GL/y
SDL**	28.6 GL/y
Licensed Entitlement***	0 GL/y
Measured Groundwater Use	11.1 GL/y
Estimated S&D Use***	0 GL/y
Entitlement plus S&D	0 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**SDL set at the projected growth of the salt interception schemes in recognition that the take represents beneficial use (unassigned groundwater assessment).

***The volume of water extracted for salt interception scheme purposes in 2007-2008 (MDBC, 2008).

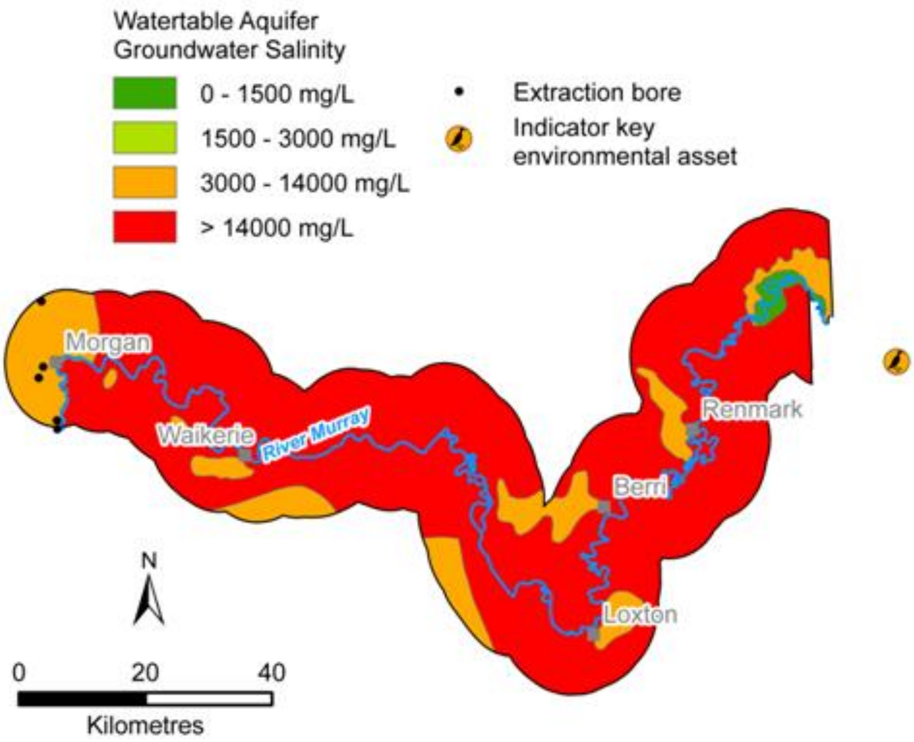


Figure 8: SA Murray Salt Interception Scheme SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 21 and Table 22 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a low level of uncertainty.

Table 21: RRAM summary table for the SA Murray Salt Interception Scheme

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	Low
				% Area	1%	0%	99%	**Uncertainty Level**	Low
SF	0.70	0.70	0.70	**SF**	N/A	N/A	N/A	**SF**	N/A

Table 22: PEL summary table for the SA Murray Salt Interception Scheme

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	0.04	0.0	6.54	33.8	40.4
SF	0.70	N/A	0.70	0.70	N/A
PEL (GL/y)	0.03	0.0	4.58	23.7	28.3

*Recharge per salinity class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Victoria

Overview

This section covers the SDL resource units in Victoria. These include (Figure 9):

- Goulburn–Murray: Shepparton Irrigation Region (GS8a)
- Goulburn–Murray: Highlands (GS8b)
- Goulburn–Murray: Sedimentary Plain (GS8c)
- Goulburn–Murray: deep (GS8d)
- Wimmera–Mallee: Highlands (GS9a)
- Wimmera–Mallee: Sedimentary Plain (GS9b)
- Wimmera–Mallee: deep (GS9c)

These units were proposed by the Victorian Government and are based on outcomes from the Secure Allocations, Future Entitlements (SAFE) project which was funded by the Commonwealth Government to progress the management of groundwater in Victoria and support the delivery of the National Water Initiative objectives. The SAFE project included consultation with the Victorian water corporations and water user groups. The MDBA adopted the Victorian proposal to aggregate the Victorian groundwater into the seven SDL resource units. This is to reflect water planning arrangements being implemented by the Victorian Government to align boundaries, as far as practical, with groundwater systems. This is also to ensure management decisions are better informed by the major influences on those systems. These units:

- cover all parts of a groundwater system that share common characteristics and/or are interconnected;
- are set at an operational and administrative scale appropriate for efficient management. Other boundaries, such as surface water catchments, administrative boundaries and existing groundwater management boundaries, are considered; and
- are set having regard to the need to enable trade to occur, as far as practical, between interconnected systems.

The MDBA believes that this aggregation will:

- help manage all groundwater resources in the MDB part of Victoria at ESLT;
- help better manage the water balance and interconnectedness of aquifers within each groundwater system;
- allow consistent and fair management of all water use from each groundwater system;
- support the needs of water users and the environment; and
- allow common management objectives to be developed for similar types of groundwater systems.

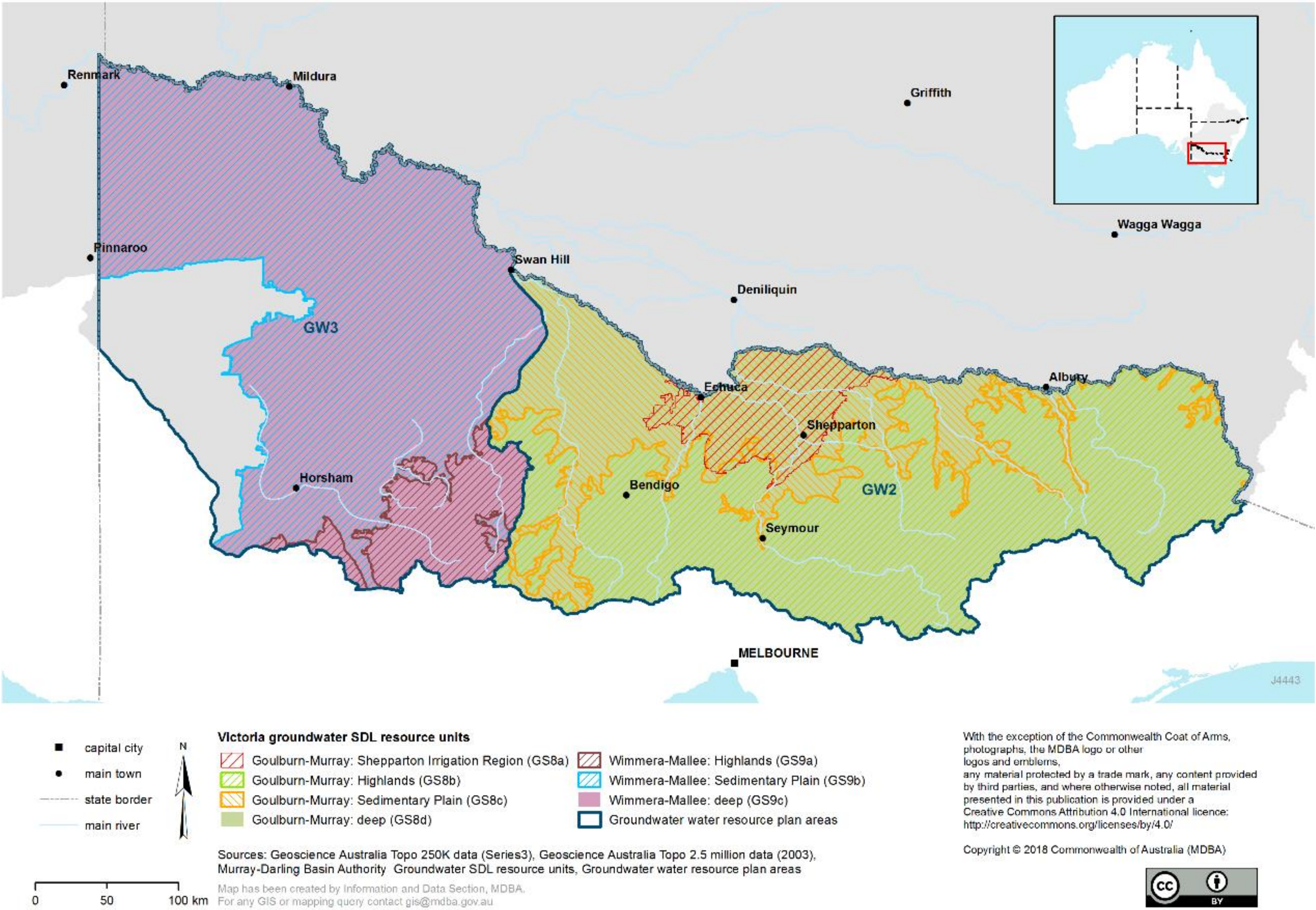


Figure 9: Victorian SDL resource units map

Goulburn–Murray (GS8)

The Goulburn–Murray WRP area includes the following four SDL resource units: Shepparton Irrigation Region, Highlands, Sedimentary Plain and Deep (Figure 10). These units were selected with input from the Victorian Government and are based on outcomes from the Secure Allocations, Future Entitlements (SAFE) project, which was funded by the Victorian and Commonwealth governments to progress the management of groundwater in Victoria and support the delivery of the National Water Initiative objectives.

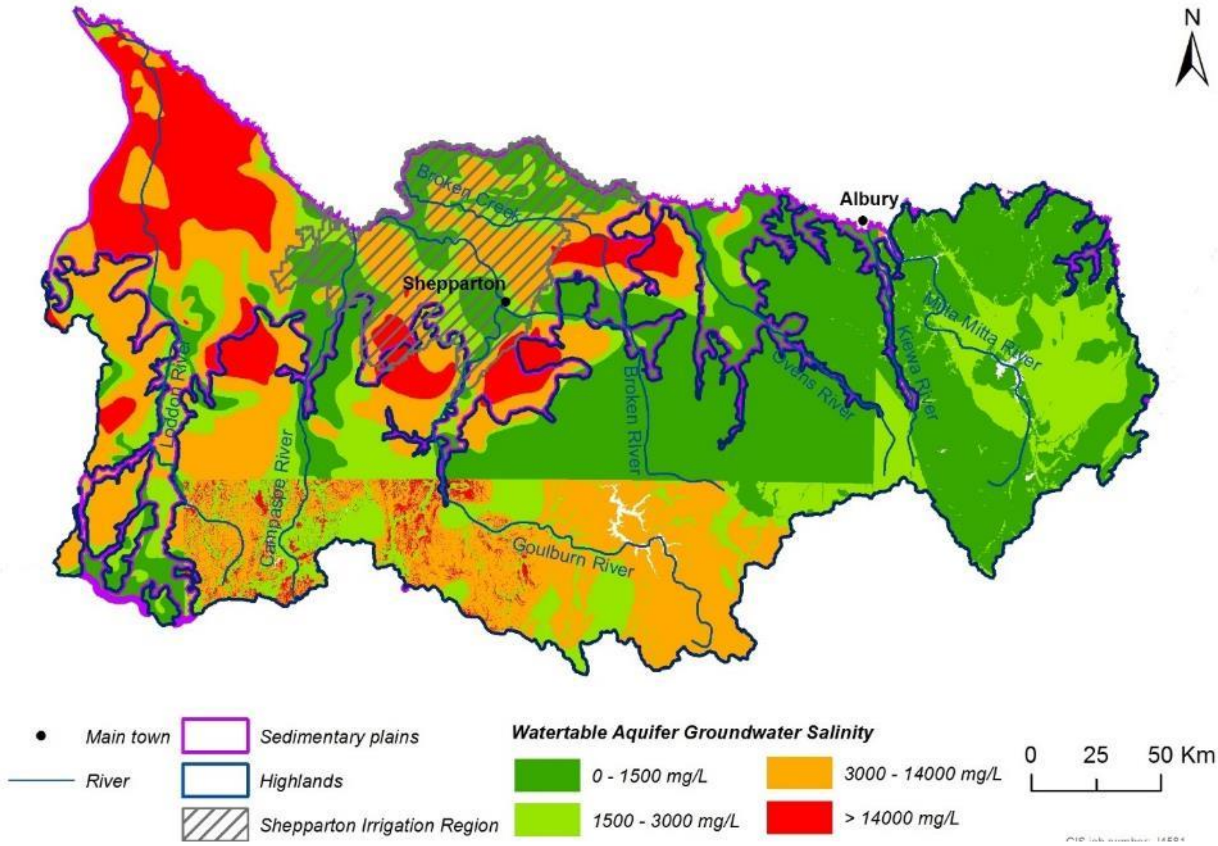


Figure 10: Goulburn–Murray SDL resource units map

Note: The groundwater salinity distribution for the Goulburn–Murray WRP area in Figure 10 was derived from the Basin in a Box dataset (MDBC, 2000). It is acknowledged that the groundwater salinity data is of low certainty (particularly given the contrast in salinity where datasets have been merged) however this information represents the best available at the time of reporting.

There are parts of the WRP area where the Victorian Government has existing groundwater planning arrangements and the remainder of the area is described as unincorporated. The Victorian planning areas include: Alexandra, Broken, King Lake, Upper Ovens, Lower Ovens, Mullindolingong, Lower Campaspe, Goorambat, Katunga, Mid Goulburn, Mid Loddon, Shepparton Irrigation Region, and Loddon Highlands (Figure 11).

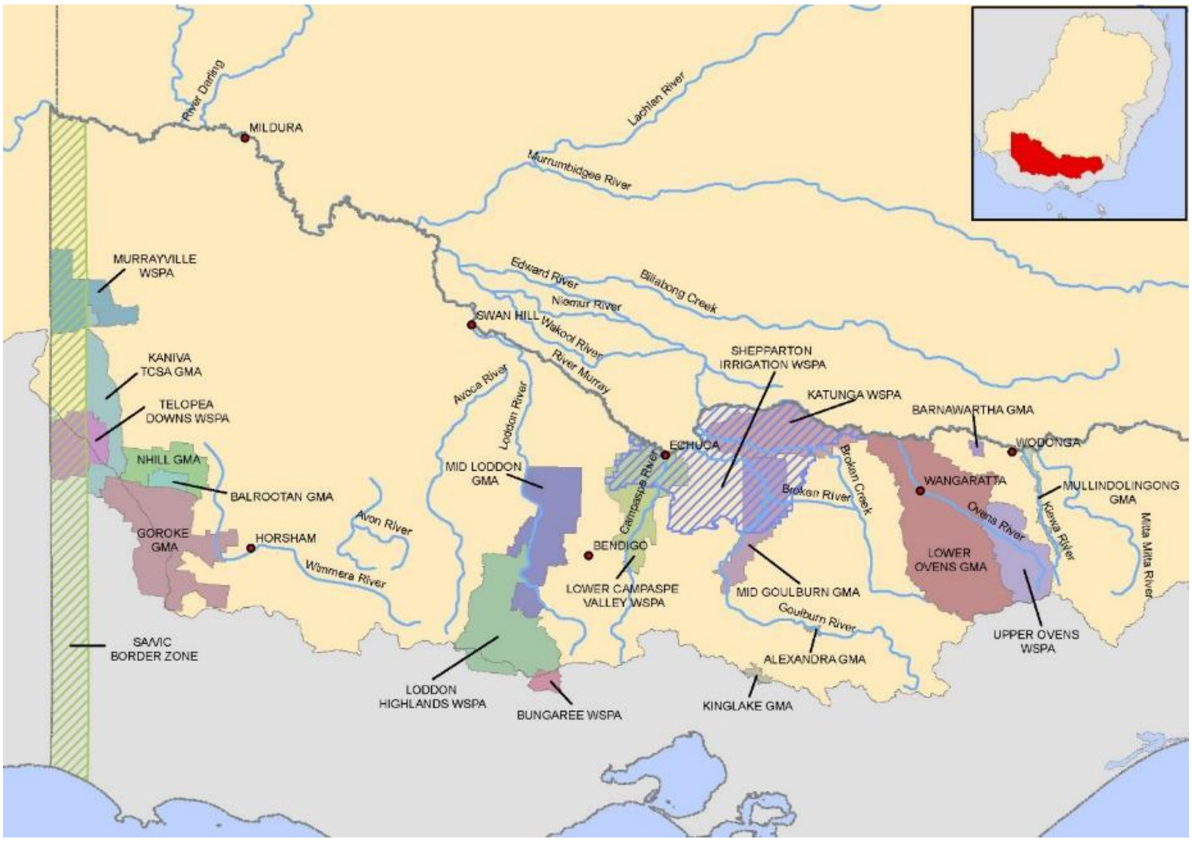


Figure 11: The Victorian groundwater management and planning areas

Goulburn-Murray: Shepparton Irrigation Region (GS8a)

The Goulburn-Murray: Shepparton Irrigation Region SDL resource unit covers groundwater resources from the ground surface down to a depth of 25 m and overlays the Murray Valley, Shepparton, Central Goulburn and Rochester Irrigation Areas (Figure 12). There are significant economic, social, and environmental values in the Shepparton Irrigation Region that are influenced by shallow groundwater, which can act as both a threat and a resource. Land salinisation and waterlogging from high water tables are a significant threat to agricultural productivity and the environment in the shallow groundwater. However, high water tables also provide an important resource in dry periods, although this can be unreliable due to low water levels in shallow bores. Groundwater extraction from the shallow Shepparton Formation is managed to control water table levels and reduce the risk of salinisation.

The SDL for the Goulburn-Murray: Shepparton Irrigation Region SDL resource unit was informed by the numerical modelling results (Scenario 3a) and the SDL has been set at entitlement (plus S&D) in recognition that the groundwater take provides a “beneficial use” to achieve lower water tables and reduced risk of salinisation.

The Goulburn-Murray: Shepparton Irrigation Region SDL resource unit sits within the Goulburn-Murray WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

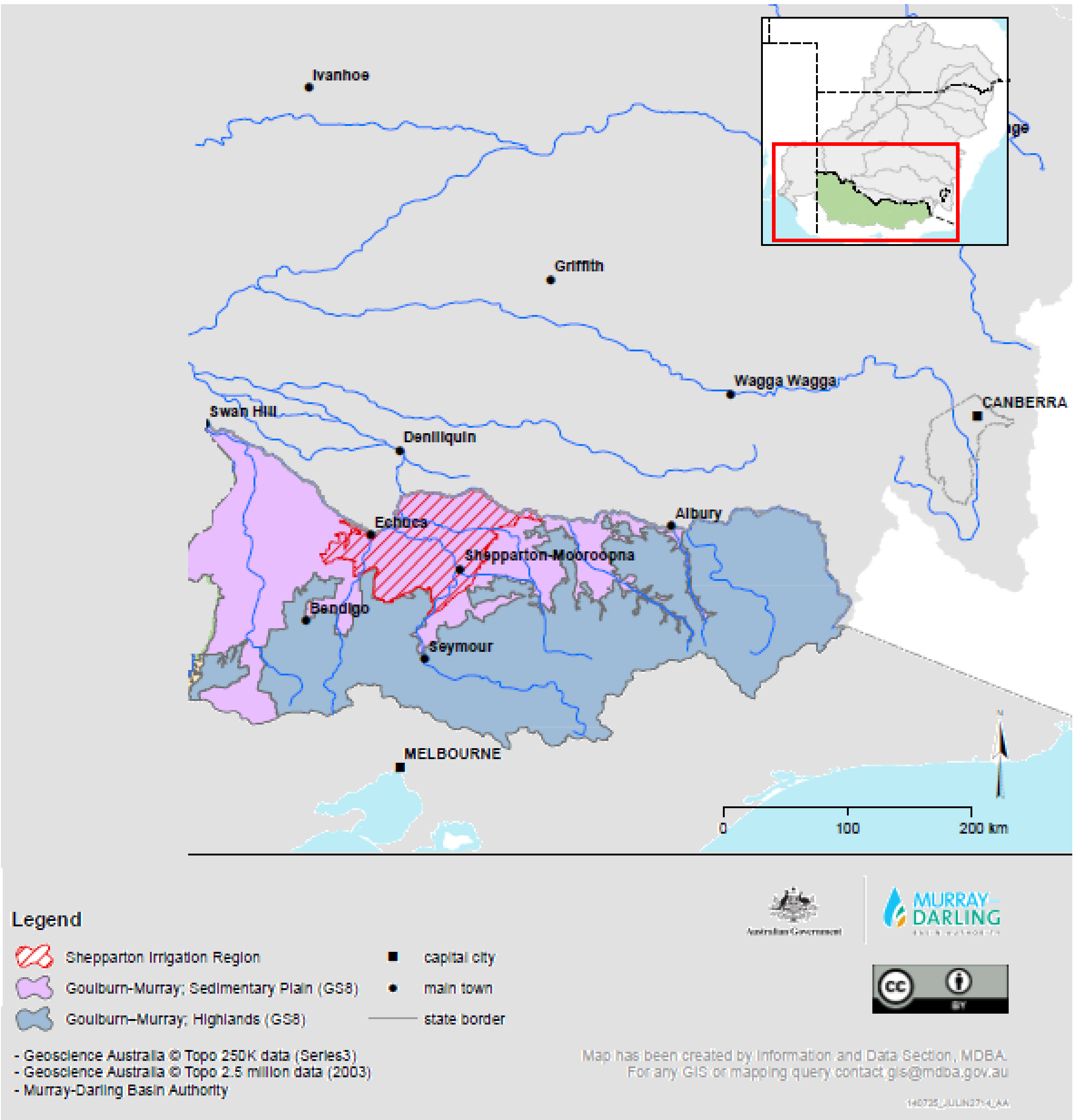


Figure 12: The Goulburn-Murray: Shepparton Irrigation Region SDL resource unit

Table 23: Summary table for the Goulburn Murray: Shepparton Irrigation Region

Summary characteristic	Name / description / volume
SDL resource unit	Goulburn–Murray: Shepparton Irrigation Region (GS8a)
Groundwater covered	All groundwater in the Shepparton Irrigation Region Water Supply Protection Area to a depth of 25 m below the land surface
WRP Area	Goulburn–Murray (GW2)
GMU(s) Covered	Shepparton Irrigation
Recharge*	498.0 GL/y
Recharge Input	Numerical Model
PEL**	120.0 GL/y
BDL	244.1 GL/y
SDL	244.1 GL/y
2009/2010 Licensed Entitlement****	239.4 GL/y
Measured Groundwater Use***	92.1 GL/y
Estimated S&D Use***	4.76 GL/y
Entitlement plus S&D	244.1 GL/y

*The groundwater recharge includes the following inputs into the associated groundwater model: rainfall, irrigation, river and lateral inflows.

**The PEL has been determined using the results from the groundwater modelling (Scenario 3a).

***All entitlement and use information provided by the Victorian Government on 30 September 2011.

Recharge risk assessment method outcome

Although the RRAM was not applied in this SDL resource unit due to the availability of the groundwater model, the risk rankings were determined to be:

- high risk for KEAs due to the presence of potential groundwater dependent KEAs (Lower Goulburn River Floodplain and Barmah–Millewa Forest)
- high risk for KEFs
- low risk for the productive base
- a risk to the key environmental outcome
- low level of uncertainty as there is a groundwater model for this area.

Goulburn–Murray: Highlands (GS8b)

The Goulburn–Murray Highlands SDL resource unit contains the Goulburn–Broken, Loddon–Campaspe, Murray and Ovens Highlands areas. These areas were proposed as SDL resource units in November 2011, however, a subsequent agreement with Victoria resulted in them not being used. In the context of this Basin Plan they have been used as the basis for the calculation of the PEL for the Goulburn–Murray Highlands (GS8b).

There are two Victorian Government water management units within the sub-unit; the Loddon Highlands Groundwater Management Area (GMA) which is managed under the Loddon Highlands Water Supply Protection Area (WSPA) Groundwater Management Plan adopted by the Victorian Government in November 2012, and the Upper Ovens River WSPA Water Management Plan adopted by the Victorian Government in January 2012. The remaining areas are not recognised by current groundwater management plans and are relatively undeveloped.

The Goulburn–Murray Highlands groundwater SDL resource unit sits within the Goulburn–Murray WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

The Goulburn–Murray Highlands SDL resource unit has been assessed as having a high risk to the KEF (i.e. base flows). The connectivity to surface water in this system relies on faults and fractures in the geological strata and this results in variable connections to surface water (e.g. a bore extracting water 4 km from a stream may have no impact on a stream as the fracture the bore is drawing water from does not intersect the stream). For this sub-unit the Authority used the unassigned water assessment to set the SDL, rather than setting the SDL at the BDL, given that protection of the surface water KEF will be provided through the inclusion of local management rules in WRPs.

The boundary of the SDL resource unit for the Goulburn–Murray Highlands was amended in July 2018 to reflect changes requested by the Victorian Government, based on a revised definition for the sedimentary plains/highland boundary. The boundary change and an inconsistency in the application of the RRAM used to determine the SDLs for highland areas across the NSW/Victorian state border also resulted in an amendment to the SDL volume for this SDL resource unit.

Goulburn–Broken Highlands

The Goulburn–Broken Highlands area located in the southern MDB headwaters to the Goulburn and Broken catchments in Victoria. The regional centre of Seymour is in this area. There is no recognised current state water management plan for the area and groundwater resources are relatively undeveloped.

The Goulburn–Broken highlands area aquifers are mostly fractured rock with some superficial alluvial cover in small areas. The fractured rocks are typically Devonian igneous rocks (granite) and volcanic rocks (ignimbrite, rhyolite, e.g. Marysville Group), and deformed sandstone and mudstone of various Palaeozoic ages (Carboniferous to Ordovician, e.g. Walhalla Group) (Heislers, 1993; GSV, 2010). These rocks are considered to be basement rocks where they underlie thicker sequences of Murray

Basin sediments on the sedimentary plain to the north. The aquifers are generally low yielding, with typical yields of less than 0.50 L/sec (Dimos et al., 1994; Hennessy et al., 1994), but can be more productive in zones of intense faulting and jointing.

Loddon–Campaspe Highlands

The Loddon and Campaspe Highlands area is associated with the upper Loddon and Upper Campaspe Rivers in Victoria. There is no current water management plan that covers the entire sub-unit and groundwater resources, regarding use, are relatively undeveloped. However, the Victorian Government’s Loddon Highlands Groundwater Management Area (GMA) is within the sub-unit that is managed under the Loddon Highlands WSPA Groundwater Management Plan adopted by the Victorian Government in November 2012.

The aquifers are mostly fractured rock with some superficial alluvial cover in small areas. The rocks are typically deformed sandstone and mudstone of Ordovician age (e.g. Castlemaine Group) (GSV, 2010) and Devonian igneous rocks (granite or granodiorite). There are also small zones of outcropped Quaternary basalt, Older Volcanics, Cambrian shale and Permian diamictite (Bacchus Marsh Formation) (Heislers, 1993; GSV, 2010). These rocks are considered to be basement rocks where they underlie thicker sequences of Murray Basin sediments on the sedimentary plain to the north. The aquifers are generally low yielding, with typical yields of less than 0.50 L/sec (Dimos et al., 1994), but can be more productive in zones of intense faulting and jointing.

Murray Highlands

The Murray Highlands area forms the headwaters of the River Murray upstream of Albury in Victoria. There is no current water management plan for the area, and groundwater resources in this area are relatively undeveloped. There is virtually no irrigation, although there is a very small amount of groundwater used from the alluvial sediment near Mitta Mitta.

The aquifers are mostly fractured rock with some superficial alluvial cover. The geology is complex and the rock types that constitute the water table aquifer are numerous. In the vicinity of the Kiewa River valley the dominant rock type is Ordovician schist or gneiss (Omeo Metamorphic Complex), whereas the eastern and central zones are typically composed of deformed sandstone and mudstone of Ordovician age (e.g. Adaminaby Group or Bendoc Group) and Devonian or Silurian igneous rocks (granite or granodiorite) (GSV, 2010). Some more minor areas consist of outcrop of Devonian ignimbrite and other volcanic rock types (e.g. Dartella Volcanic Group). These rocks are considered to be basement rocks where they underlie thicker sequences of Murray Basin sediments to the north.

Ovens Highlands

The Ovens Highlands area is associated with the Ovens River and its tributaries in Victoria. There is no current water management plan; however, surface water and groundwater is managed under the Upper Ovens River Water Supply Protection Area Water Management Plan adopted by the Victorian Government in January 2012.

The aquifers of the Ovens Highlands are mostly fractured rock with some superficial alluvial cover. The aquifer rocks are dominated by deformed sandstone and mudstone of Ordovician age (e.g.

Adaminaby Group) (GSV, 2010). There are also significant deposits of Devonian igneous rocks (granite or granodiorite) and an area of Devonian volcanic rocks in the south-west (e.g. rhyolite and ignimbrite). Some more minor areas consist of outcrop of Older Volcanics and Carbonaceous mudstone and sandstone (Heislers, 1993). These rocks are considered to be basement rocks where they underlie thicker sequences of Murray Basin sediments to the north.

Table 24: Summary table for the Goulburn–Murray Highlands

Summary characteristic	Name / description / volume
SDL resource unit	Goulburn–Murray: Highlands (GS8b)
Groundwater covered	All groundwater in the outcropping Palaeozoic rocks (or the in situ weathered horizon where it is within 5 m of the surface) from the land surface to 200 m below the surface
WRP Area	Goulburn–Murray (GW2)
GMU(s) Covered	Alexandra GMA, King Lake GMA, Loddon Highlands, Upper Ovens
Recharge (RRAM Step 1)*	3283.0 GL/y
Recharge Input	WAVES recharge modelling
PEL	164.2 GL/y
BDL	38.3 GL/y
SDL**	68.7 GL/y
Licensed Entitlement***	35.2 GL/y
Measured Groundwater Use	Use not measured
Estimated S&D Use***	3.14 GL/y
Entitlement plus S&D	38.3 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the Victorian Government on 30 September 2011.

Recharge risk assessment method outcome

Table 25 and Table 26 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource subunit is ranked:

- low risk for KEAs
- high risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 25: RRAM summary table for the Goulburn-Broken Highlands

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	Low	Risk (Y/N)	No	No	No	Risk to ESLT	High
				% Area	5%	43%	52%	Uncertainty Level	High
SF	0.70	0.10	0.70	SF	N/A	N/A	N/A	SF	0.50

Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater.

Table 26: PEL summary table for the Goulburn–Broken Highlands

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	67.6	1769.5	795.9	649.9	3282.9
SF	0.05	0.05	0.05	0.05	N/A
PEL (GL/y)	3.38	88.5	39.8	32.5	164.2

*Recharge per salinity class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Goulburn-Murray: Sedimentary Plain (GS8c)

The Goulburn–Murray: Sedimentary Plain SDL resource unit is in northern Victoria and underlies several surface water catchments, including the Loddon, Campaspe, Goulburn and Broken catchments
(Figure 13). The Sedimentary Plain comprises of Tertiary to Quaternary sediments that directly overlie Palaeozoic bedrock. The area consists of three main deposits, from shallowest to deepest: Shepparton Formation, Calivil Formation and Renmark Group (CSIRO, 2008d).

The uppermost Shepparton Formation varies in thickness from 70 to 100 m and is separated between a shallow and deep component at 25 m depth for management purposes. As previously discussed, the groundwater extraction from the shallow Shepparton Formation is managed in the SDL resource unit to control water table levels and reduce the risk of salinisation.

The Calivil Formation overlies the Renmark Group and has a relatively uniform thickness of 60 to 80 m. These alluvial fan deposits were formed from streams flowing over the earlier Renmark Group deposits. The Renmark Group was formed through the filling of deep channels carved into the surface by an ancient river system and subsequent spilling over into broad sediment sheets. The Renmark Group is up to 200 m thick and forms the basal deposit of almost the entire Murray geological Basin. In Victoria, the Calivil Formation and the Renmark Group together are referred to as the Deep Lead aquifer.

There is no current water management plan for the entire Victorian Riverine Sedimentary Plain sub-unit. However, there are several groundwater planning areas under the Victorian planning framework, including the Broken, Lower Campaspe, Katunga, Mid–Goulburn, Mid–Loddon and Lower Ovens.

The Goulburn–Murray: Sedimentary Plain groundwater SDL resource unit sits within the Goulburn–Murray WRP area (Figure 13). The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

The SDL for the Sedimentary Plain sub-unit was informed by the numerical modelling and was set at the BDL of 203.5 GL/y, which is very close to the PEL of 205.3 GL/y. This SDL volume however is highly unlikely to be extracted in the short to medium term given the current levels of development. Also, the peak groundwater use in the system of 112.0 GL/y in 2007-08 was at the height of the Millennium Drought.

Review

When the Basin Plan was being finalised in 2012, concerns were raised by Victoria in relation to the SDLs in this SDL resource unit. In response, the Basin Plan included a requirement for a review of the BDL and SDL for the Goulburn–Murray: Sedimentary Plain SDL resource unit to be conducted within two years of the commencement of the Basin Plan (by November 2014).

As per Section 6.06 (6 to 9) of the superseded version of the Basin Plan (Compilation No. 2 concluding at 13 Nov 2017), a review panel was assembled to undertake the review. To ensure the most up to date information was available to the review panel, the MDBA in partnership with Victoria, appointed a consultant to bring together and synthesise the relevant information for the review. The review report and associated synthesis reports have been published on the MDBA website. The review was completed in October 2014. The review panel recommended that:

1. The current agreed BDL for the Goulburn–Murray Sedimentary Plain of 203.5 GL/y be retained.
2. In relation to the SDL, the MDBA could consider:
    a) Changing the SDL for the Goulburn–Murray Sedimentary Plain from 203.5 GL/y to 222.9 GL/y as suggested by the then Department of Environment and Primary Industries (DEPI), once assurances were made by Victoria that it can demonstrate that the resource will be managed via State policies and plans in such a way that impacts on groundwater users and salinity are limited to acceptable levels; and
    b) improving the understanding of groundwater fluxes in the region (in particular the Katunga area) in the context of potential salinity impacts.
3. The revised definition proposed by DEPI for the sedimentary plains/highland boundary be adopted and the area changed accordingly.
4. The criteria used to assess groundwater model outputs be reviewed to more clearly align with the specified ESLT assessment criteria,
5. The MDBA should investigate and address the issue of excess SDL credits.
6. A rigorous, quantitative and comparative analysis of the SRP and NVic models be conducted to inform future potential management actions, including any actions under Recommendation 2 above.
7. The MDBA actively fosters the work of the 'cross jurisdictional NSW/Vic groundwater working group' to use modelling and other information to obtain a more robust understanding of the interaction of groundwater take and management decisions across borders and the consequences to the long-term sustainability of the connected groundwater systems.

The Authority accepted these recommendations and amended the SDL for the Goulburn–Murray: Sedimentary Plan SDL resource unit to 223.0 GL/y in July 2018 (rounded up from the recommendation of 222.9 GL/y).

Table 27: Summary table for the Goulburn–Murray: Sedimentary Plain

Summary characteristic	Name / description / volume
SDL resource unit	Goulburn–Murray: Sedimentary Plain (GS8)
Groundwater covered	All groundwater from the land surface to 200 m below the surface or 50 m below the base of the Tertiary sediments, whichever is the deeper, excluding groundwater in Goulburn–Murray Highlands.
WRP Area	Goulburn–Murray (GW2)
GMU(s) Covered	Lower Campaspe, Goorambat, Katunga, Mid Goulburn, Mid Loddon, Upper Loddon.
Recharge*	450.2 GL/y
Recharge Input	Numerical Model
PEL**	205.3 GL/y
BDL	203.5 GL/y
SDL	223.0 GL/y
2009/2010 Licensed Entitlement***	213.1 GL/y
Measured Groundwater Use***	112.4 GL/y
Estimated S&D Use***	8.11 GL/y
Entitlement plus S&D	221.2 GL/y

*The groundwater recharge includes the following inputs into the associated groundwater model: rainfall, irrigation, river and lateral inflows.

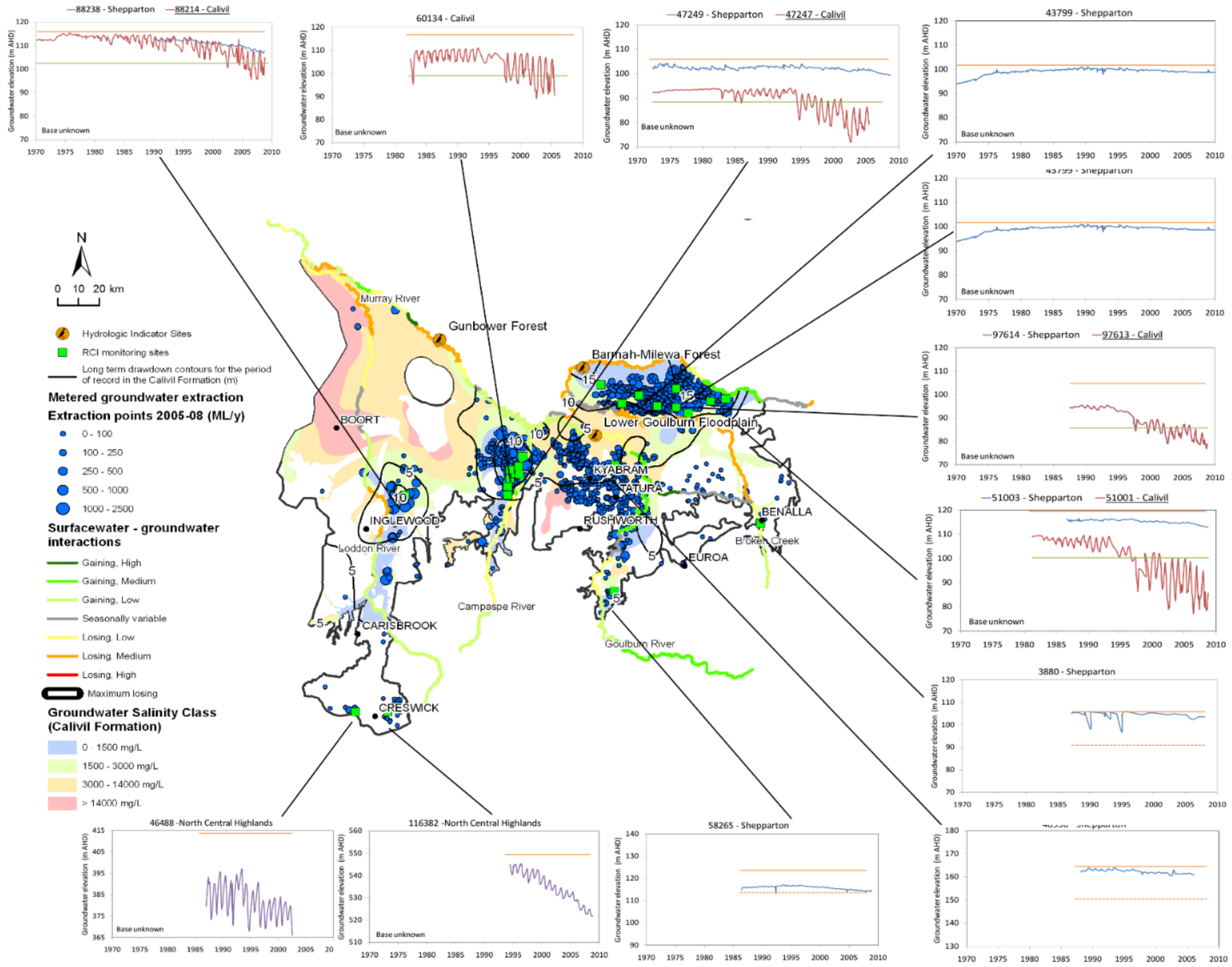
**The PEL has been determined using the results from the groundwater modelling (Scenario 3a).

***All entitlement and use information provided by the Victorian Government on 30 September 2011.

Recharge risk assessment method outcome

Although the RRAM was not applied in this SDL resource unit due to the availability of the groundwater model, the risk rankings were determined to be:

- high risk for KEAs due to the presence of potential groundwater dependent assets (Lower Goulburn River Floodplain, Barmah–Millewa Forest and Gunbower Forest)
- high risk for KEFs
- low risk for the productive base
- a risk to the key environmental outcome
- low level of uncertainty as there is a groundwater model for this area.



Ground surface

Base of Shepparton Formation

Groundwater elevation (m AHD) Shepparton Formation

Groundwater elevation (m AHD) Calivil Formation

Groundwater elevation (m AHD) Northern Central Highlands Formation

Existing RCL levels as per current groundwater management plans

Underlined Bore ID represents key hydrograph at nested site

Data Source:

Metered groundwater extraction – DSE (2009)

Surface water – groundwater interactions – CSIRO (2008a)

Groundwater salinity class – MDBA (2000)

(The Calivil Formation underlies the Shepparton Formation and has an average thickness of 75 metres)

(Fractured rock aquifers occurring in the Highlands extend from the surface to an average depth of 50 metres)

(The Shepparton Formation is the uppermost aquifer of the alluvial sequence and extends from the surface to an average depth of 80–100 metres)

Hydrogeology and water sharing arrangements

- The region is characterised by thick alluvial aquifers associated with Murray Basin sediments.
- The Renmark and Calivil Formation aquifers are the deepest of the sedimentary units in the region. The two units are generally highly connected and confined. The sediments are thickest in palaeovalleys extending north from the highlands, where they are referred to as 'deep leads'. The deep leads broaden towards the north and merge to form a continuous sheet. Coarse sands and gravels allow high hydraulic conductivities. Recharge to the deep lead aquifer occurs from two main sources: leakage from overlying formations and direct rainfall recharge where the Calivil Formation outcrops in the highlands. Salinities in the Renmark and Calivil aquifers are generally fresher than groundwater within the overlying sediments.
- The Shepparton Formation is the uppermost aquifer system in the alluvial sequence and provides the major source of recharge to the underlying Calivil and Renmark aquifers. Groundwater salinity ranges from 1,000 mg/L TDS to more than 20,000 mg/L TDS. For the irrigated Riverine plains area, much of the focus for groundwater management has been upon managing the impact of salt mobilisation on land and water resources, associated with recharge from irrigation leakage.
- Fractured rock aquifers associated with the catchment highlands are mostly not included within the SDL resource unit boundary. The notable exception is the Spring Hill and Upper Loddon WSPA, which are located in the south-west corner of the SDL resource unit, and comprise basalts overlying the Calivil formation deposits in narrow incised valleys.
- The SDL resource unit covers the following draft and final WSPAs and GMAs: Lower Campaspe Valley, Katunga, Shepparton Irrigation Region, Mid Loddon, and Loddon Highlands. Existing RCLs have been identified in the Campaspe, Katunga and Mid Loddon WSPs.

Resource condition analysis

- Selection of key monitoring sites:
  - Should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should be able to monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
  - The features requiring priority in this SDL resource unit include surface-groundwater interaction, the groundwater dependent environmental assets, the productive base of the resource in major zones of extraction, and water quality throughout.
  - Sites associated with existing RCLs have been included
  - It will be a challenge in fractured rock parts of the SDL resource unit (e.g. Loddon Highlands WSPA) to select sites representative of a broader area, given that the fractured rock hydrogeological setting can lead to variable and localised impacts from extraction
- Analysis of historical data:
  - There is evidence of substantial drawdown in the Calivil Formation from early to mid 1990s at various locations (e.g. 97613, 51001, 47247, 46488, and 116382).

Monitoring Points	Feature	Existing RCLs
48936,43799	Indicator Site	
60125, 60134, 89574, 89584, 89576, 89586, 110151	Productive base, surface-groundwater connectivity salinity	Existing RCLs defined in Campaspe Deep Lead Water Management Plan (Groundwater) (2003). The average annual groundwater level in the listed monitoring bores must be greater than 99.1 mAHD.
47247, 47253, 47255, 89576, 89585, 89586	Productive base, surface-groundwater connectivity salinity	Existing RCLs defined in Campaspe Deep Lead Water Management Plan (Groundwater) (2003). The average annual groundwater level in the listed monitoring bores must be greater than 88.5 mAHD
48282, 51001, 69545, 69710, 83964, 92446, 97613, 109680	Productive base	Existing RCLs defined in Katunga Groundwater Management Plan (2006). The average spring five-year groundwater level calculated using the listed monitoring bores must be 20 metres below ground level or higher
88214	Productive base, surface groundwater-connectivity salinity	Existing RCL defined in Mid-Loddon Groundwater Management Area, Local Management Rules, June 2009. The 3 year average of the maximum recovered groundwater level in bore 88214 must be greater than 11.5 metres below the natural surface.
48936, 58265	Surface-groundwater interaction	
46468, 116382	Productive base	

Figure 13: Goulburn–Murray: Sedimentary Plain groundwater SDL resource unit map

Goulburn–Murray: deep (GS8d)

The Goulburn–Murray: deep SDL resource unit covers groundwater 200 m below the surface or 50 m below the base of the Tertiary sediments, whichever is deeper. The SDL was created to ensure that all Basin water resources are covered in the Basin Plan. There is little to no development and the Victorian Government does not have groundwater management plans for this groundwater resource.

The Goulburn–Murray: deep SDL resource unit sits within the Goulburn–Murray WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 28: Summary table for the Goulburn-Murray: Deep

Summary characteristic	Name / description / volume
SDL resource unit*	Goulburn–Murray: deep (GS8d)
Groundwater covered	All groundwater, excluding groundwater in SDL resource units, Goulburn–Murray: Shepparton Irrigation Region, Goulburn–Murray: Highlands and Goulburn–Murray: Sedimentary Plain
WRP Area	Goulburn–Murray (GW2)
GMU(s) Covered	None
PEL	N/A
BDL	0 GL/y
SDL**	20.0 GL/y
Licensed Entitlement	N/A
Measured Groundwater Use	N/A
Estimated S&D Use	N/A
Entitlement plus S&D	N/A

*Deep groundwater in Victoria has been defined as all groundwater below 200 m from the land surface or 50 m below the base of the Tertiary sediments, whichever is deeper.

**Due to limited information, the SDL was set: at a volume considered appropriate for the size of the resource; considering the level of risk to the ESLT; and based on technical advice provided by a group of groundwater experts engaged by the MDBA to provide advice on technical elements of the Basin Plan.

Wimmera–Mallee (GS9)

The Wimmera–Mallee WRP area (Figure 14) includes the following three SDL resource units: Highlands, Sedimentary Plain and Deep. These SDL resource units were selected with input from the Victorian Government and are based on outcomes from the Secure Allocations, Future Entitlements (SAFE) project which was funded by the Victorian and Commonwealth governments to progress the management of groundwater in Victoria and support the delivery of the National Water Initiative objectives.

The Wimmera–Mallee WRP area and three SDL resource units reflect water planning arrangements being implemented by the Victorian Government to align boundaries, as far as practical, with groundwater systems. This is to ensure management decisions are better informed by the major influences on those systems.

The Murrayville WSPA is the only area within the Wimmera–Mallee WRP area where the Victorian Government has existing groundwater planning arrangements and the remainder of the area is described as unincorporated.

The Victorian West Wimmera GMA was excluded as a Basin water resource, under the *Water Act 2007 (Cwlth)*, on 27 September 2012. The West Wimmera GMA was excluded, as the area has a low connection to other Basin water resources and a large part of it lies outside the surface water boundary of the Basin. There is no requirement to set an SDL for these resources under the Basin Plan, and Victoria is not required to prepare or have accredited WRPs for this area. These excluded water resources, however, still remain subject to state water management regimes.

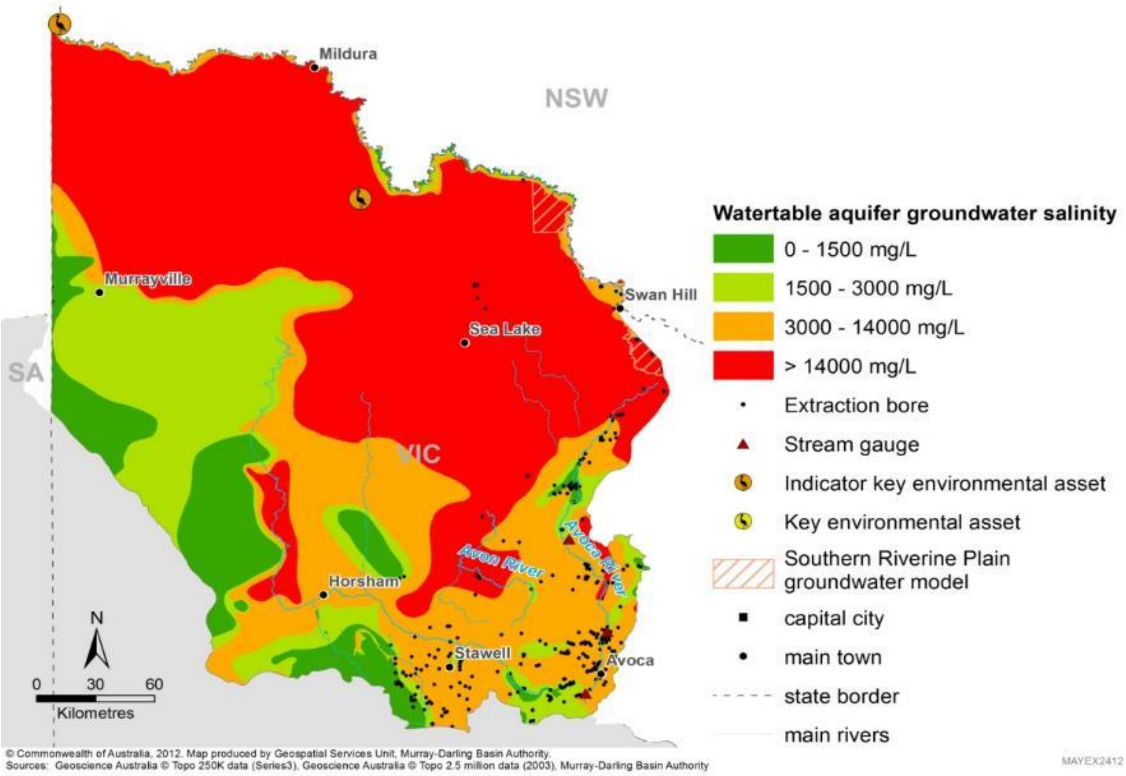


Figure 14: Wimmera–Mallee SDL resource unit map

Note: the groundwater salinity distribution for the Wimmera–Mallee WRP area in Figure 14 was derived from the Basin in a Box dataset (MDBC, 2000).

Wimmera–Mallee: Highlands (GS9a)

The Wimmera–Mallee: Highlands SDL resource unit consists entirely of groundwater not incorporated into any Victorian Groundwater Management Unit (GMU) (North West Unincorporated Area). Groundwater use is minimal and where it is used it is mainly for S&D purposes.

The aquifers of the Wimmera–Mallee Highlands are mostly fractured rock aquifers with some superficial alluvial cover. Overall, the dominant rock type is the Cambrian St Arnaud Group (marine sandstone, mudstone and shale) (GSV, 2010). The western region is predominantly composed of the deformed Silurian Grampians Group (sandstone). Minor outcrops of Devonian granite are also present in the Wimmera–Mallee Highlands. These rocks are considered to be basement rocks where they underlie thicker sequences of Murray Basin sediments in surrounding regions.

The boundary of the Wimmera–Mallee: Highlands SDL resource unit was amended in July 2018 to reflect changes requested by the Victorian Government based on a revised definition for the sedimentary plains/highland boundary. The boundary change resulted in an amendment to the SDL volume for this SDL resource unit.

The Wimmera–Mallee: Highlands SDL resource unit sits within the Wimmera-Mallee (groundwater) WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 29: Summary table for the Wimmera–Mallee: Highlands

Summary characteristic	Name / description / volume
SDL resource unit	Wimmera–Mallee: Highlands (GS9a)
Groundwater covered	All groundwater in the outcropping Palaeozoic rocks (or the in situ weathered horizon where it is within 5 m of the surface) from the land surface to 200 m below the surface
WRP Area	Wimmera–Mallee (groundwater) (GW3)
GMU(s) Covered	None
Recharge (RRAM Step 1)*	102.6 GL/y
Recharge Input	WAVES recharge modelling
PEL	4.80 GL/y
BDL	1.26 GL/y
SDL**	2.75 GL/y
Licensed Entitlement***	1.11 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.15 GL/y
Entitlement plus S&D	1.26 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information was provided by the Victorian Government as reported in the Victorian RRAM report (CSIRO and SKM, 2010d).

Recharge risk assessment method outcome

Table 30 and Table 31 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a high level of uncertainty.

Table 30: RRAM summary table for the Wimmera–Mallee: Highlands

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	Low	**Risk (Y/N)**	Yes	Yes	No	**Risk to ESLT**	High
				% Area	12%	14%	73%	**Uncertainty Level**	High
SF	0.70	0.10	0.70	**SF**	0.80	0.90	N/A	**SF**	0.50

Table 31: PEL summary table for the Wimmera–Mallee: Highlands

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	23.3	23.4	55.8	0.14	102.6
SF	0.04	0.05	0.05	0.05	N/A
PEL (GL/y)	0.93	1.05	2.79	0.01	4.78

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Wimmera–Mallee: Sedimentary Plain (GS9b)

The Wimmera–Mallee: Sedimentary Plain SDL resource unit is located in north-west Victoria between the River Murray and the SA border (Figure 15). The area has three layered aquifers: the Tertiary Confined Sands, the Murray Group Limestone and the Loxton–Parilla Sands. The Tertiary Confined Sands aquifer contains Tertiary sands and gravels and is confined by the Ettrick Formation and Geera Clay. The overlying Murray Group Limestone aquifer is confined or semi-confined by the Bookpurnong Beds. The Loxton–Parilla and Woorinen Sands overlie these units and constitute the water table aquifer (URS, 2008).

Salt interception schemes are located along the River Murray between the SA border and Robinvale. There are two functioning salt interception schemes, the Mildura–Merbein and Barr Creek Salt Drainage Diversion Schemes. The Mildura–Merbein scheme consist of a series of groundwater bores which pump saline groundwater from the alluvial aquifers along the River Murray to decrease the volumes of saline groundwater discharge to the river. The Barr Creek Salt Drainage Diversion Scheme is a series of drains which capture shallow saline groundwater. The primary aim of these schemes is to reduce salt entering the Murray River to ensure that the salinity targets for the river, particularly the salinity targets at Morgan, are maintained. The water is disposed of in evaporation basins some distance away from the river where it is lost via recharge to the groundwater at that location or via evaporation.

With the exception of the Murrayville WSPA, the Wimmera–Mallee: Sedimentary Plain SDL resource unit consists entirely of groundwater not incorporated into any GMU. Groundwater use is minimal, and where it is used, it is mainly for S&D purposes.

The boundary of the SDL resource unit for the Wimmera–Mallee Highlands was amended in July 2018 to reflect changes requested by the Victorian Government based on a revised definition for the sedimentary plains/highland boundary. The boundary change resulted in an amendment to the SDL volume for this SDL resource unit.

The Wimmera–Mallee: Sedimentary Plain SDL resource unit sits within the Victoria Wimmera-Mallee (groundwater) WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 32: Summary table for the Wimmera–Mallee: Sedimentary Plain

Summary characteristic	Name / description / volume
SDL resource unit	Wimmera–Mallee: Sedimentary Plain (GS9b)
Groundwater covered	All groundwater from the land surface to 200 m below the surface or 50 m below the base of the Tertiary sediments, whichever is the deeper
WRP Area	Wimmera–Mallee (groundwater) (GW3)
GMU(s) Covered	None
Recharge (RRAM Step 1)*	995.0 GL/y
Recharge Input	WAVES recharge modelling
PEL	517.0 GL/y
BDL**	68.9 GL/y
SDL***	190.1 GL/y
Licensed Entitlement****	30.0 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use****	3.00 GL/y
Entitlement plus S&D	33.0 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge does not account for water that is discharged from the system via baseflow and/or evapotranspiration.

**BDL for this subunit is 68.9 GL/y, minus any limit, under a law of the State of Victoria, on the taking of groundwater from the Victorian West Wimmera Groundwater Management Area.

***SDL calculated using the unassigned groundwater assessment (25% factor). SDL for this subunit is 190.1 GL/y, minus any limit, under a law of the State of Victoria, on the taking of groundwater from the Victorian West Wimmera Groundwater Management Area.

****All entitlement and use information was provided by the Victorian Government as reported in the Victorian RRAM report (CSIRO and SKM, 2010d).

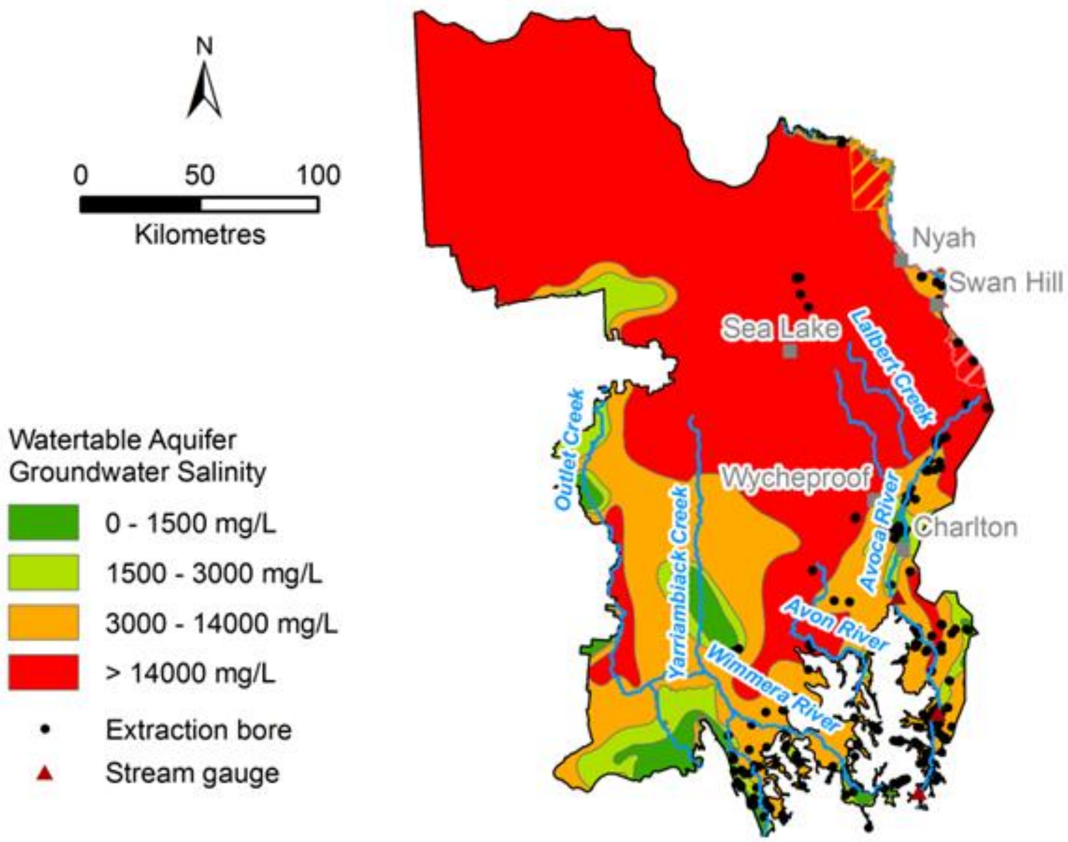


Figure 15: Wimmera–Mallee: Sedimentary Plain SDL resource subunit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 33 and Table 34 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a high level of uncertainty.

Table 33: RRAM summary table for the Wimmera–Mallee: Sedimentary Plain

<table>
<tr><th rowspan="2">RRAM Step 2 Risks to KEA, KEF and PB</th><th rowspan="2">KEA</th><th rowspan="2">KEF</th><th rowspan="2">PB</th><th rowspan="2">RRAM Step 3 Risks to fresh water</th><th colspan="3">Salinity Class (KEO)</th><th colspan="2" rowspan="2">RRAM Step 4 Uncertainty</th></tr>
<tr><th>Class 1</th><th>Class 2</th><th>Class 3 & 4</th></tr>
<tr><td rowspan="2">Risk Ranking</td><td rowspan="2">Low</td><td rowspan="2">Low</td><td rowspan="2">Low</td><td>Risk (Y/N)</td><td>Yes</td><td>Yes</td><td>No</td><td>Risk to ESLT</td><td>Low</td></tr>
<tr><td>% Area</td><td>3%</td><td>6%</td><td>91%</td><td>Uncertainty Level</td><td>High</td></tr>
<tr><td>SF</td><td>0.70</td><td>0.70</td><td>0.70</td><td>SF</td><td>0.80</td><td>0.90</td><td>N/A</td><td>SF</td><td>0.75</td></tr>
</table>

Table 34: PEL summary table for the Wimmera–Mallee: Sedimentary Plain

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	25.7	50.8	155.4	763.1	995.0
SF	0.42	0.47	0.53	0.53	N/A
PEL (GL/y)	10.8	24.0	81.6	400.6	517.0

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Wimmera–Mallee: deep (GS9c)

The Wimmera–Mallee: deep SDL resource unit covers groundwater below 200 m from the surface or 50 m below the base of the Tertiary sediments, whichever is deeper. The SDL was set during the development of the Basin Plan (November 2011) to ensure all Basin water resources were covered in the Basin Plan. There is little to no development and the Victorian Government does not have groundwater management plans for this groundwater resource.

The Wimmera–Mallee: deep SDL resource unit sits within the Wimmera-Mallee (groundwater) WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 35: Summary table for the Wimmera–Mallee: Deep

Summary characteristic	Name / description / volume
SDL resource unit*	Wimmera–Mallee: deep (GS9c)
Groundwater covered	All groundwater, excluding groundwater in SDL resource units, Wimmera–Mallee: Highlands and Wimmera–Mallee: Sedimentary Plain
WRP Area	Wimmera–Mallee (groundwater) (GW3)
GMU(s) Covered	None
PEL	N/A
BDL	0 GL/y
SDL**	20.0 GL/y
Licensed Entitlement	N/A
Measured Groundwater Use	N/A
Estimated S&D Use	N/A
Entitlement plus S&D	N/A

*Deep groundwater in Victoria has been defined as all groundwater below 200 m from the land surface or 50 m below the base of the Tertiary sediments, whichever is deeper.

**Due to limited information, the SDL was set: at a volume considered appropriate for the size of the resource; considering the level of risk to the ESLT; and based on technical advice provided by a group of groundwater experts engaged by the MDBA to provide advice on technical elements of the Basin Plan.

New South Wales

Adelaide Fold Belt MDB (GS10)

The Adelaide Fold Belt MDB SDL resource unit is located on the western border of the Basin (Figure 16). The town of Broken Hill is the major regional centre within the SDL resource unit. Groundwater resources in this area are relatively undeveloped.

The area encompasses part of the Barrier Ranges around Broken Hill; an uplifted rocky highland, where the local geological basement outcrops. The area contains part of the Willyama Supergroup and the Neoproterozoic Adelaidean sequence. The highly deformed metasedimentary schists of the Willyama Supergroup have undergone significant metamorphism, predominantly comprising Paleo- to Neo-Proterozoic high-grade metamorphic rocks. The Neoproterozoic Adelaidean sequence comprises sedimentary rocks with minor basalt layers (Geoscience Australia, 2008a). The permeability and porosity of these rocks is typically low. Groundwater in the area is mainly contained within the faults, fractures and shear zones of the fractured rock aquifer.

The Adelaide Fold Belt SDL resource unit was covered by the 2012 Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources. The long-term average annual extraction limit (LTAAEL) for the Adelaide Fold Belt under this plan was 30.3 GL/y, which was based on a NSW-developed risk assessment framework. In developing the Basin Plan, NSW requested that the MDBA adopt the NSW plan limit as the SDL. After consideration, the MDBA adopted a policy not to accept the NSW plan extraction limit as the SDL, for SDL resource units where the state plan limit is greater than the level of entitlement. Accordingly, the MDBA did not adopt the plan extraction limit as the SDL for this SDL resource unit. Using the RRAM and the unassigned groundwater assessment, the MDBA set the SDL at 6.90 GL/y.

The Adelaide Fold Belt MDB SDL resource unit sits within the NSW Murray–Darling Basin Fractured Rock WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 36: Summary table for the Adelaide Fold Belt MDB

Summary characteristic	Name / description / volume
SDL resource unit	Adelaide Fold Belt MDB (GS10)
Groundwater covered	All groundwater, excluding groundwater in the Western Porous Rock SDL resource unit
WRP Area	NSW Murray–Darling Basin Fractured Rock (GW11)
GMU(s) Covered	Adelaide Fold Belt
Recharge (RRAM Step 1)*	13.1 GL/y
Recharge Input	WAVES recharge modelling
PEL	6.90 GL/y
BDL	3.61 GL/y
SDL**	6.90 GL/y
Licensed Entitlement***	1.47 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	2.14 GL/y
Entitlement plus S&D	3.61 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers) and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources (2012).

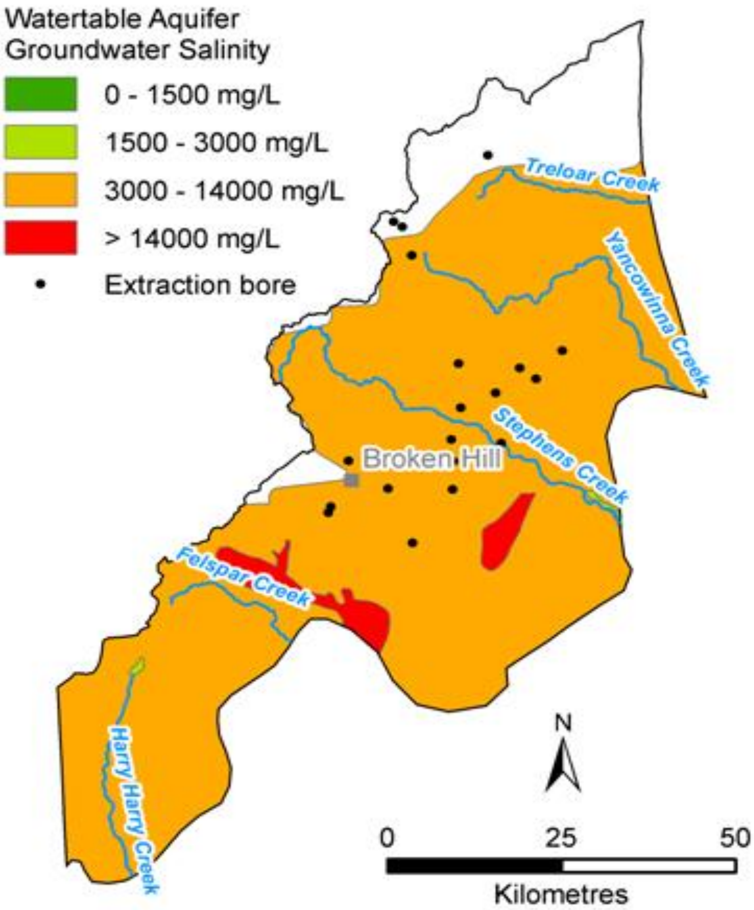


Figure 16: Adelaide Fold Belt MDB SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 37 and Table 38 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 37: RRAM summary table for the Adelaide Fold Belt MDB

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	Low
				% Area	0%	0.2%	99.8%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	N/A	N/A	N/A	**SF**	0.75

Table 38: PEL summary table for the Adelaide Fold Belt MDB

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	0.0	0.03	12.6	0.52	13.1
SF	N/A	0.53	0.53	0.53	N/A
PEL (GL/y)	0.0	0.02	6.61	0.27	6.90

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Bell Valley Alluvium (GS11)

The Bell Valley Alluvium SDL resource unit includes the Bell Valley Alluvium GMU which is located in Central NSW to the south of Wellington (Figure 17). The Bell River is a tributary to the Macquarie River and flows from south to north within a relatively narrow alluvial plain. Groundwater resources are relatively undeveloped. Many of the groundwater bores are in close proximity to the Bell River and are likely to induce stream depletion as a result of pumping.

The alluvial aquifer consists of basal gravels and sands overlain and interbedded with finer grained sediments of silty and sandy clays. Recharge to the alluvial aquifer occurs via two main processes, diffuse rainfall recharge and river recharge during high river flows. The river and the alluvial aquifer are considered to be closely connected, with groundwater extraction from near-river bores likely to result in stream depletion.

The Bell Valley Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for Macquarie Bogan Unregulated and Alluvial Water Sources. The LTAAEL under this plan this plan for the Bell Alluvial Water Groundwater Source was 3.29 GL/y, which was based on capping at the estimated current use. This LTAAEL was adopted as the SDL for this resource unit.

This SDL resource unit was identified as a connected system where groundwater discharge provides base flow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion. Therefore, the MDBA capped groundwater use at the current level of development and the SDL has been set at estimated current use (the state plan extraction limit) to ensure that the KEF (i.e. base flows) is not compromised.

The Bell Valley Alluvium SDL resource unit sits within the Macquarie–Castlereagh Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 39: Summary table for the Bell Valley Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Bell Valley Alluvium (GS11)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Macquarie–Castlereagh Alluvium (GW12)
GMU(s) Covered	Bell Valley Alluvium
Recharge (RRAM Step 1)*	2.30 GL/y
Recharge Input	WAVES recharge modelling
PEL**	0.12 GL/y
BDL**	3.29 GL/y
SDL***	3.29 GL/y
Licensed Entitlement****	4.93 GL/y
Measured Groundwater Use	3.28 GL/y
Estimated S&D Use****	0.01 GL/y
Entitlement plus S&D	4.94 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**In this SDL resource unit the PEL was less than the BDL and further investigations were carried out. It was determined that river recharge (not a component of the WAVES model) was sufficient in these systems to ensure that in capping the SDL at the BDL there will be no further impact on surface water resources beyond the level of that is accounted for within the BDL. Most of this system is narrow alluvial valleys in which recharge from rivers is a significant component of the aquifer water balance.

***SDL is set at current use (connected resources).

****All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources (2012).

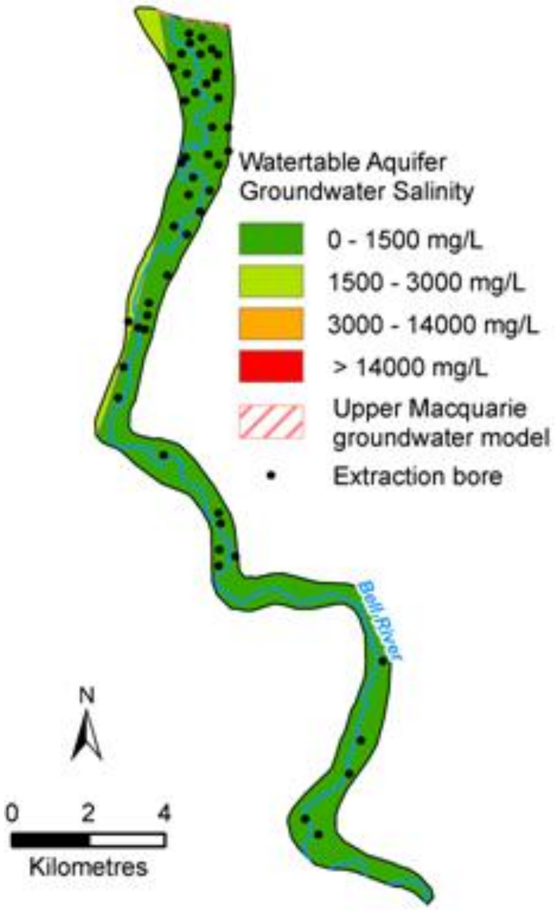


Figure 17: Bell Valley Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 40 and Table 41 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- high risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 40: RRAM summary table for the Bell Valley Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	High	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	94%	6%	0%	**Uncertainty Level**	High
SF	0.70	0.10	0.10	**SF**	N/A	N/A	N/A	**SF**	0.50

Table 41: PEL summary table for the Bell Valley Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	2.20	0.13	0.0	0.0	2.33
SF	0.05	0.05	N/A	N/A	N/A
PEL (GL/y)	0.11	0.01	0.0	0.0	0.12

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Belubula Alluvium (GS12)

The Belubula Alluvium SDL resource unit is located in the upper Lachlan Catchment in Central NSW (Figure 18). The Belubula River is a tributary to the Lachlan River upstream of Forbes. The alluvial sediments in the valley contain basal gravels and sands overlain and interbedded with silty and sandy clays along the valley floor and terraced floodplains. Recharge to the alluvial aquifer occurs via two main processes: diffuse rainfall recharge and river recharge during high river flows. The river and the alluvial aquifer are considered to be closely connected, with groundwater extraction from near river bores likely to result in stream depletion. Groundwater resources in this area are relatively undeveloped.

The Belubula Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources. The LTAAEL under this plan for the Belubula Valley Alluvial Groundwater Source was 2.88 GL/y, which was based on capping at estimated current use. This LTAAEL was adopted as the SDL for this resource unit.

This SDL resource unit was identified as a connected system where groundwater discharge provides base flow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion. Therefore, the MDBA capped groundwater use at the current level of development and SDL has been set at estimated current use (the state plan extraction limit) to ensure that the KEF (i.e. base flows) is not compromised.

In this SDL resource unit the PEL was less than the BDL (i.e. estimated current use) and further investigations were carried out. It was determined that river recharge (not a component of the WAVES model) was sufficient in these systems to ensure that in capping the SDL at the BDL, there will be no further impact on surface water resources beyond the level that is accounted for within the BDL. Most of this system is narrow alluvial valleys in which recharge from rivers is a significant component of the aquifer water balance.

The Belubula Alluvium SDL resource unit sits within the Lachlan Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 42: Summary table for the Belubula Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Belubula Alluvium (GS12)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Lachlan Alluvium (GW10)
GMU(s) Covered	Belubula Valley Alluvium
Recharge (RRAM Step 1)*	3.92 GL/y
Recharge Input	WAVES recharge modelling
PEL	0.20 GL/y
BDL	2.88 GL/y
SDL**	2.88 GL/y
Licensed Entitlement***	8.22 GL/y
Measured Groundwater Use	2.85 GL/y
Estimated S&D Use***	0.03 GL/y
Entitlement plus S&D	8.25 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL is set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources (2012).

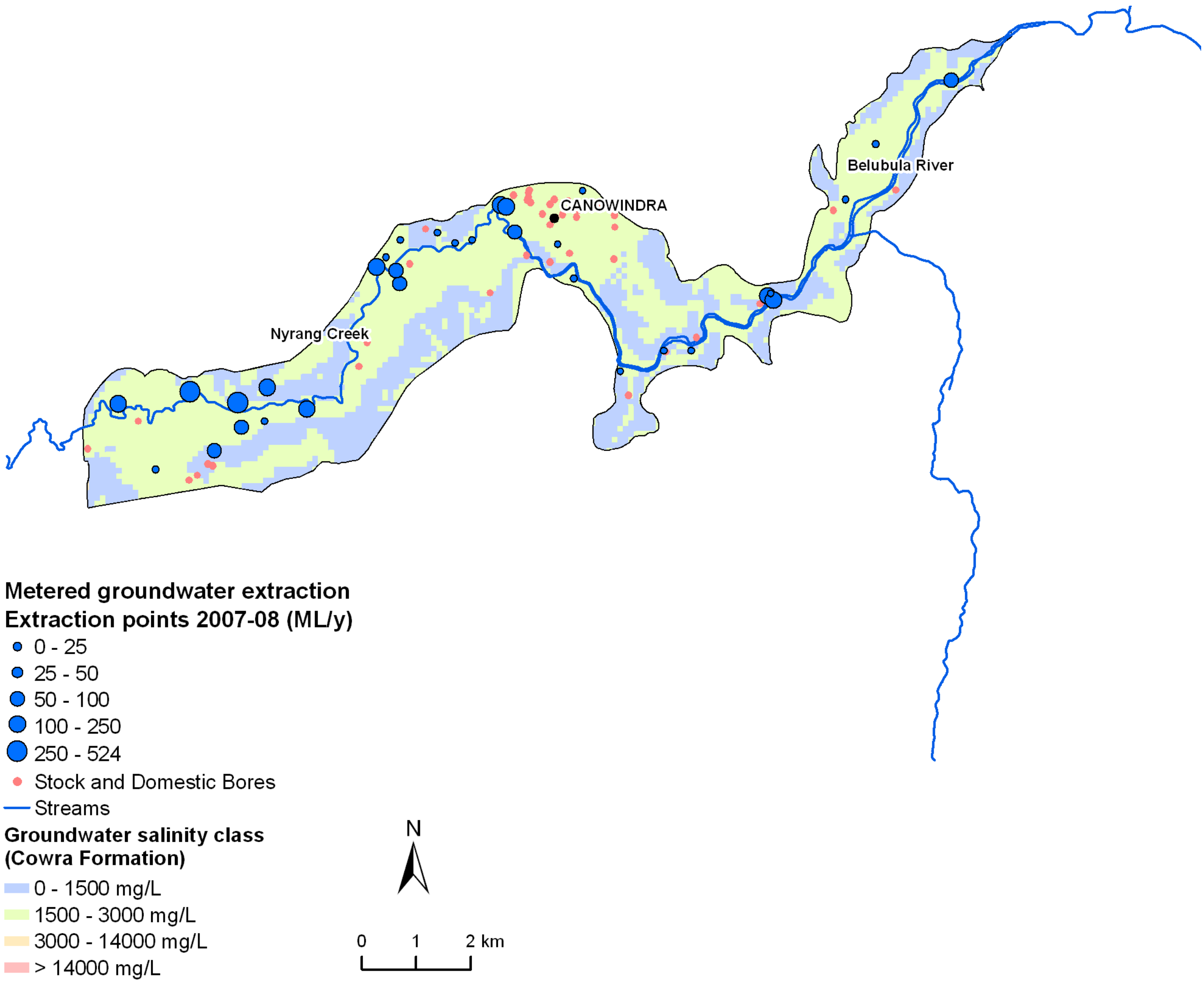


Figure 18: Belubula Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 43 and Table 44 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- medium risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 43: RRAM summary table for the Belubula Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	Med	Risk (Y/N)	No	No	No	Risk to ESLT	High
				% Area	36%	64%	0%	Uncertainty Level	High
SF	0.70	0.10	0.50	SF	N/A	N/A	N/A	SF	0.50

Table 44: PEL summary table for the Belubula Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	1.37	2.55	0.0	0.0	3.92
SF	0.05	0.05	N/A	N/A	N/A
PEL (GL/y)	0.07	0.13	0.0	0.0	0.20

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Billabong Creek Alluvium (GS13)

The Billabong Creek Alluvium SDL resource unit is located along Billabong Creek, south-west of Wagga Wagga, between the Murray and Murrumbidgee Rivers (Figure 19). Groundwater resources in this area are relatively undeveloped. It is made up of valley fill alluvial deposits of basal sands and gravels with finer grained material overlying and interbedded, such as silty and sandy clays. The alluvial aquifer is relatively narrow and deep, with the deposit deepening from east to west (ANRA, 2010).

The hydrogeology of Billabong Creek Alluvium changes from the east to the west. To the east, the shallow alluvial aquifer is highly connected to surface water and groundwater quality is good. To the west, groundwater exists in a deeper palaeochannel and connection with surface water is low. Additionally, groundwater salinity is greater to the west (Figure 19).

The Billabong Creek Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for the Murrumbidgee Unregulated and Alluvial Water Sources. The LTAAEL under this plan for the Billabong Creek Alluvial Groundwater Source was 7.50 GL/y, which was based on the NSW risk assessment framework. This is one of the SDL resource units where the Authority adopted an existing state plan extraction limit as the SDL. Prior to adopting the state plan extraction limit, the Authority assessed the plan extraction limit against the PEL to determine if the plan limit reflected an ESLT. The assessment considered if the state extraction limit and the science underpinning it represents the most up to date scientific knowledge (i.e. a more thorough assessment than RRAM, while also being consistent with the *Water Act 2007 (Cwlth)*).

The Billabong Creek Alluvium groundwater SDL resource unit sits within the Murray Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 45: Summary table for the Billabong Creek Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Billabong Creek Alluvium (GS13)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Murray Alluvium (GW8)
GMU(s) Covered	Billabong Creek Alluvium (upstream of Mahonga)
Recharge (RRAM Step 1)*	22.0 GL/y
Recharge Input	WAVES recharge modelling
PEL**	8.13 GL/y
BDL	7.50 GL/y
SDL	7.50 GL/y
Licensed Entitlement***	7.22 GL/y
Estimated S&D Use***	0.64 GL/y
Entitlement plus S&D	7.85 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**PEL has been calculated separately for the area containing Salinity Class 1 water and the area containing the other three classes. The two areas have been set out separately below into East and West.

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Murrumbidgee Unregulated and Alluvial Water Sources (2012).

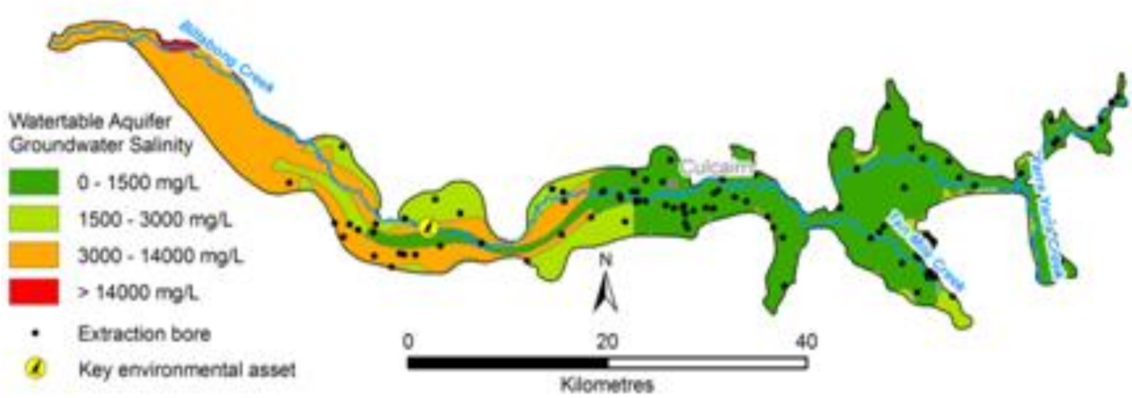


Figure 19: Billabong Creek Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome (East)

Table 46 and Table 47 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- medium risk for KEAs
- high risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a low level of uncertainty.

Table 46: RRAM summary table for the Billabong Creek Alluvium (East)

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Med	High	Low	**Risk (Y/N)**	Yes	Yes	No	**Risk to ESLT**	High
				% Area	100%	0%	0%	**Uncertainty Level**	Low
SF	0.50	0.10	0.70	**SF**	0.8	N/A	N/A	**SF**	N/A

Table 47: PEL summary table for the Billabong Creek Alluvium (East)

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	11.7	0.0	0.0	0.0	11.7
SF	0.08	N/A	N/A	N/A	N/A
PEL (GL/y)	0.93	0.0	0.0	0.0	0.93

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Recharge risk assessment method outcome (West)

Table 48 and Table 49 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a low level of uncertainty.

Table 48: RRAM summary table for the Billabong Creek Alluvium (West)

<table>
<tr><th rowspan="2">RRAM Step 2 Risks to KEA, KEF and PB</th><th rowspan="2">KEA</th><th rowspan="2">KEF</th><th rowspan="2">PB</th><th rowspan="2">RRAM Step 3 Risks to fresh water</th><th colspan="3">Salinity Class (KEO)</th><th colspan="2" rowspan="2">RRAM Step 4 Uncertainty</th></tr>
<tr><th>Class 1</th><th>Class 2</th><th>Class 3 & 4</th></tr>
<tr><td rowspan="2">Risk Ranking</td><td rowspan="2">Low</td><td rowspan="2">Low</td><td rowspan="2">Low</td><td>Risk (Y/N)</td><td>No</td><td>No</td><td>No</td><td>Risk to ESLT</td><td>Low</td></tr>
<tr><td>% Area</td><td>0%</td><td>47%</td><td>53%</td><td>Uncertainty Level</td><td>Low</td></tr>
<tr><td>SF</td><td>0.70</td><td>0.70</td><td>0.70</td><td>SF</td><td>N/A</td><td>N/A</td><td>N/A</td><td>SF</td><td>N/A</td></tr>
</table>

Table 49: PEL summary table for the Billabong Creek Alluvium (West)

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	0.0	4.85	5.39	0.04	10.3
SF	N/A	0.70	0.70	0.70	N/A
PEL	0.0	3.40	3.77	0.03	7.20

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Castlereagh Alluvium (GS14)

The Castlereagh Alluvium SDL resource unit follows the Castlereagh River north of Dubbo (Figure 20). It transitions from a single shallow unconfined aquifer in its upstream reaches to a deeper semi-confined aquifer at its downstream end. The alluvium contains basal gravels and sands and is interbedded and overlain by finer clayey sediments. Recharge occurs through diffuse rainfall and river recharge when higher flows occur. Groundwater resources in this area are relatively undeveloped.

Many of the bores in the SDL resource unit area are in close proximity to the Castlereagh River and are likely to induce stream depletion as a result of pumping, as the river is considered to be closely connected with the alluvial aquifer.

The Castlereagh Alluvium SDL resource unit was covered by the 2011 Water Sharing Plan for the Castlereagh River Unregulated and Alluvial Water Sources. The LTAAEL under this plan for the Castlereagh Alluvium Groundwater Source was 0.62 GL/y, which was based on capping at the estimated current use. This SDL resource unit was identified as a highly connected system where groundwater discharge provides base flow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion. Therefore, the MDBA capped groundwater use at the current level of development and the SDL has been set at estimated current use (the state plan extraction limit) to ensure that the KEF (i.e. base flows) is not compromised.

The Castlereagh Alluvium groundwater SDL resource unit sits within the Castlereagh Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 50: Summary table for the Castlereagh Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Castlereagh Alluvium (GS14)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground, except water contained within the unconsolidated alluvial sediments between the top of the high banks of the river
WRP Area	Macquarie–Castlereagh Alluvium (GW12)
GMU(s) Covered	Castlereagh Alluvium
Recharge (RRAM Step 1)*	12.6 GL/y
Recharge Input	WAVES recharge modelling
PEL	0.63 GL/y
BDL	0.62 GL/y
SDL**	0.62 GL/y
Licensed Entitlement***	0.58 GL/y
Measured Groundwater Use	0.54 GL/y
Estimated S&D Use***	0.08 GL/y
Entitlement plus S&D	0.66 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Castlereagh River Unregulated and Alluvial Water Sources (2011).

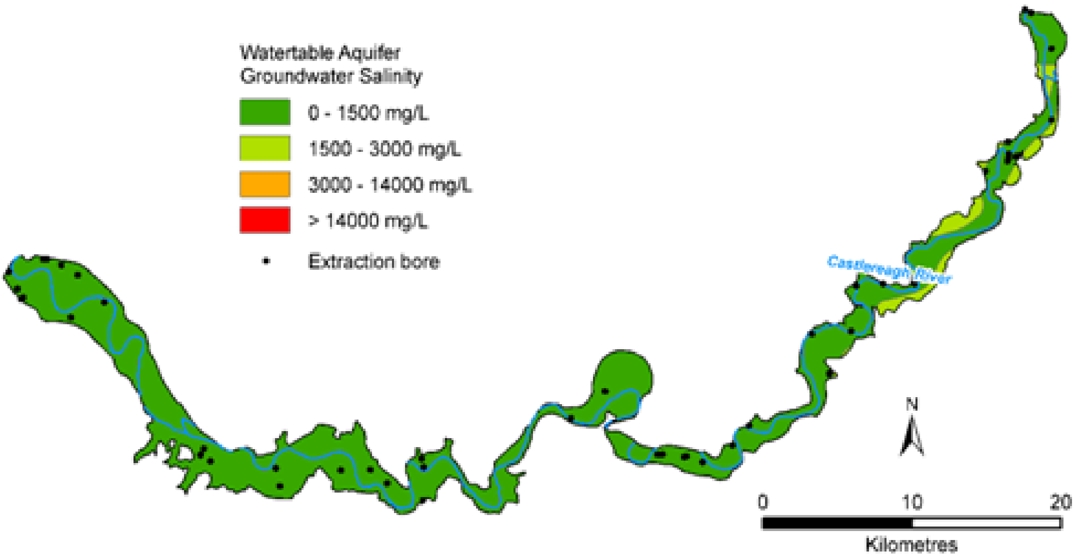


Figure 20: Castlereagh Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 51 and Table 52 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 51: RRAM summary table for the Castlereagh Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	94%	6%	0%	**Uncertainty Level**	High
SF	0.70	0.10	0.70	**SF**	N/A	N/A	N/A.	**SF**	0.50

Table 52: PEL summary table for the Castlereagh Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	11.5	1.08	0.0	0.0	12.6
SF	0.05	0.05	N/A	N/A	N/A
PEL (GL/y)	0.58	0.05	0.0	0.0	0.63

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Coolaburragundy–Talbragar Alluvium (GS15)

The Coolaburragundy–Talbragar Alluvium SDL resource unit is located along the Talbragar and Coolaburragundy Rivers to the west of Dunedoo in eastern NSW (Figure 21). These rivers are tributaries of the Macquarie River upstream of Dubbo. It transitions from a single shallow unconfined aquifer system in its upstream reaches to deeper, semi-confined aquifers at its downstream end. The alluvial sediments contain gravels and sands with finer grained clays overlying and interbedded with the more productive zones. The alluvial aquifer is thought to be closely connected with the rivers. Many of the bores are located in close proximity to the rivers and are likely to induce stream depletion as a result of pumping. Recharge is thought to occur through diffuse rainfall recharge and river recharge when higher flows occur.

The Coolaburragundy–Talbragar Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for the Macquarie-Bogan Unregulated and Alluvial Water Sources. The LTAAEL for the Coolaburragundy-Talbragar Alluvial Groundwater Source under this plan was 3.47 GL/y, which was based on capping at estimated current use. This SDL resource unit was identified as a connected system where groundwater discharge provides base flow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion. Therefore, the MDBA capped groundwater use at the current level of development and the SDL has been set at estimated current use (the state plan extraction limit) to ensure that the KEF (i.e. base flows) is not compromised.

In this SDL resource unit, the PEL was less than the BDL (i.e. estimated current use) and further investigations were carried out. It was determined that river recharge (not a component of the WAVES model) was sufficient in these systems to ensure that in capping the SDL at the BDL there will be no further impact on surface water resources beyond the level that is accounted for within the BDL. Most of this system is comprised of narrow alluvial valleys in which recharge from rivers is a significant component of the aquifer water balance.

The Coolaburragundy–Talbragar Alluvium groundwater SDL resource unit sits within the Castlereagh Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 53: Summary table for the Coolaburragundy–Talbragar Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Coolaburragundy–Talbragar Alluvium (GS15)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Macquarie–Castlereagh Alluvium (GW12)
GMU(s) Covered	Talbragar
Recharge (RRAM Step 1)*	4.25 GL/y
Recharge Input	WAVES recharge modelling
PEL	0.22 GL/y
BDL	3.47 GL/y
SDL**	3.47 GL/y
Licensed Entitlement******	6.03 GL/y
Measured Groundwater Use	3.40 GL/y
Estimated S&D Use******	0.07 GL/y
Entitlement plus S&D	6.10 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers) and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL set at current use (connected resources).

****All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources (2012).

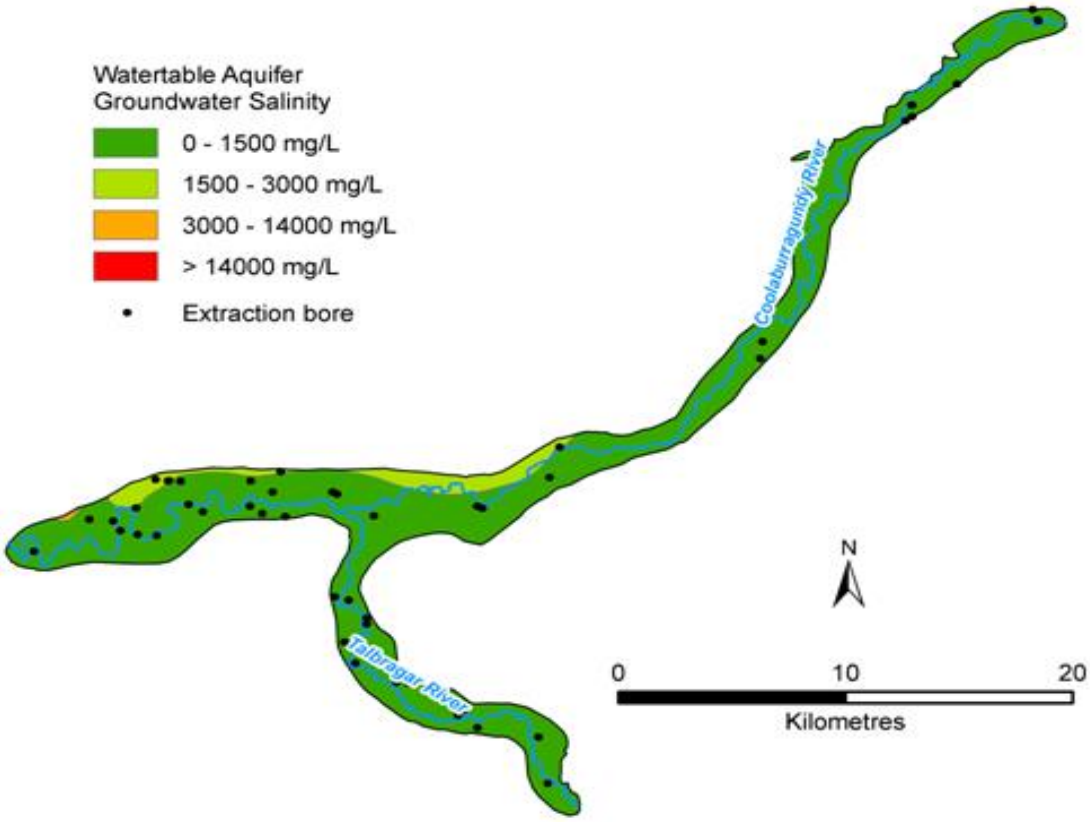


Figure 21: Coolaburragundy–Talbragar Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 54 and Table 55 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 54: RRAM summary table for the Coolaburragundy–Talbragar Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	Low	Risk (Y/N)	No	No	No	Risk to ESLT	High
				% Area	92%	8%	0%	Uncertainty Level	High
SF	0.70	0.10	0.70	SF	N/A	N/A	N/A	SF	0.50

Table 55: PEL summary table for the Coolaburragundy–Talbragar Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	4.14	0.08	0.03	0.0	4.25
SF	0.05	0.05	0.05	N/A	N/A
PEL (GL/y)	0.21	0.004	0.002	0.0	0.22

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Cudgegong Alluvium (GS16)

The Cudgegong River is a tributary of the Macquarie River upstream of Dubbo and includes the town of Mudgee (Figure 22). The Cudgegong Alluvium comprises sand and gravel lenses scattered through an alluvial body that is dominated by silt and clay.

The Cudgegong Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for the Macquarie-Bogan Unregulated and Alluvial Water Sources. The LTAAEL for the Cudgegong Alluvial Groundwater Source under this plan was 2.53 GL/y, which was based on capping at estimated current use.

This SDL resource unit was identified as a connected system where groundwater discharge provides base flow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion. Therefore, the MDBA capped groundwater use at the current level of development and the SDL has been set at estimated current use (the state plan extraction limit) to ensure that the KEF (i.e. base flows) is not compromised.

In this SDL resource unit, the PEL was less than the BDL (i.e. estimated current use) and further investigations were carried out. It was determined that river recharge (not a component of the WAVES model) was sufficient in these systems to ensure that in capping the SDL at the BDL there will be no further impact on surface water resources beyond the level that is accounted for within the BDL. Most of this system is narrow alluvial valleys in which recharge from rivers is a significant component of the aquifer water balance.

The Cudgegong Alluvium groundwater SDL resource unit sits within the Castlereagh Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 56: Summary table for the Cudgegong Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Cudgegong Alluvium (GS16)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Macquarie–Castlereagh Alluvium (GW12)
GMU(s) Covered	Cudgegong Valley Alluvium
Recharge (RRAM Step 1)*	1.38 GL/y
Recharge Input	WAVES recharge modelling
PEL	0.14 GL/y
BDL	2.53 GL/y
SDL**	2.53 GL/y
Licensed Entitlement***	13.8 GL/y
Measured Groundwater Use	2.50 GL/y
Estimated S&D Use***	0.03 GL/y
Entitlement plus S&D	13.8 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources (2012).

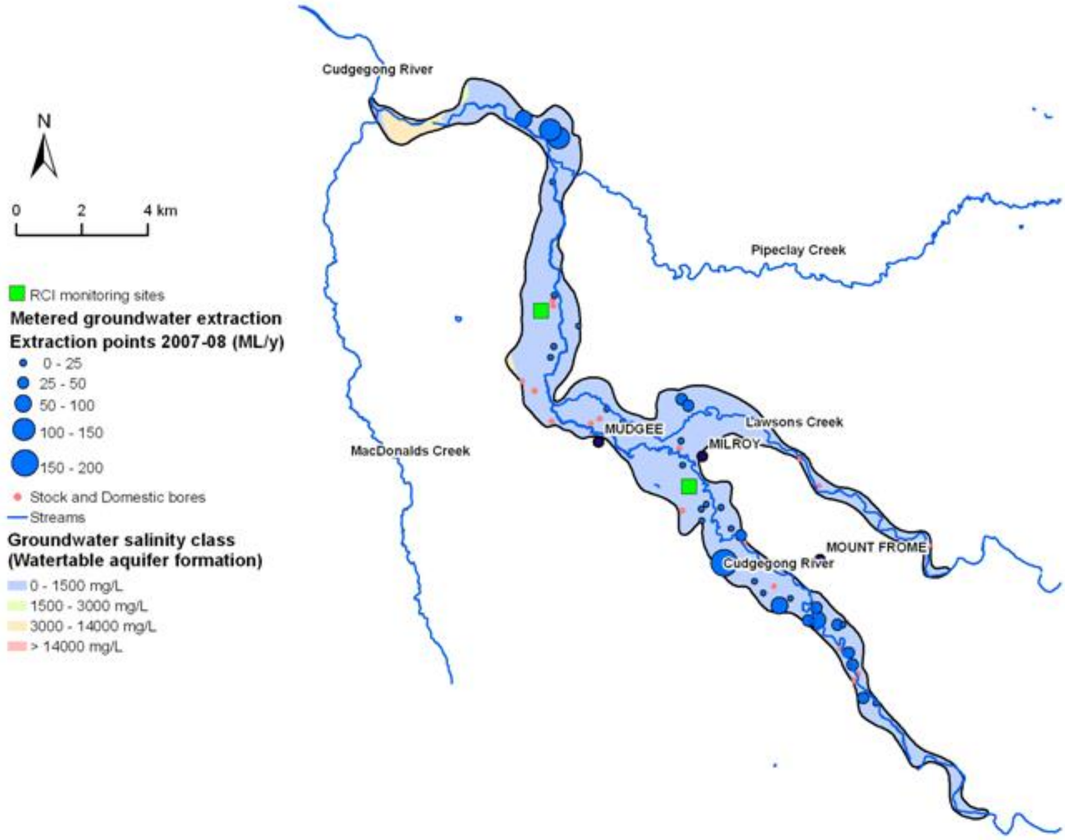


Figure 22: Cudgegong Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 57 and Table 58 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- medium risk for the productive base
- as having no risk to the key environmental outcome
- as having a low level of uncertainty.

Table 57: RRAM summary table for the Cudgegong Alluvium

<table>
<tr><th rowspan="2">RRAM Step 2 Risks to KEA, KEF and PB</th><th rowspan="2">KEA</th><th rowspan="2">KEF</th><th rowspan="2">PB</th><th rowspan="2">RRAM Step 3 Risks to fresh water</th><th colspan="3">Salinity Class (KEO)</th><th rowspan="2" colspan="2">RRAM Step 4 Uncertainty</th></tr>
<tr><th>Class 1</th><th>Class 2</th><th>Class 3 & 4</th></tr>
<tr><td rowspan="2">Risk Ranking</td><td rowspan="2">Low</td><td rowspan="2">High</td><td rowspan="2">Med</td><td>Risk (Y/N)</td><td>No</td><td>No</td><td>No</td><td>Risk to ESLT</td><td>High</td></tr>
<tr><td>% Area</td><td>97%</td><td>0%</td><td>3%</td><td>Uncertainty Level</td><td>Low</td></tr>
<tr><td>SF</td><td>0.70</td><td>0.10</td><td>0.50</td><td>SF</td><td>N/A</td><td>N/A</td><td>N/A</td><td>SF</td><td>N/A</td></tr>
</table>

Table 58: PEL summary table for the Cudgegong Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	1.35	0.0	0.03	0.0	1.38
SF	0.10	N/A	0.10	N/A	N/A
PEL (GL/y)	0.14	0.0	0.003	0.0	0.14

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Gunnedah–Oxley Basin MDB (GS17)

The Gunnedah–Oxley Basin MDB SDL resource unit is located in eastern NSW, and spans from Dubbo to the Queensland border (Figure 23). The area is made up of the Permian and Triassic rocks associated with the Gunnedah Basin (part of the larger Sydney–Bowen Structural Basin) and the overlying younger Jurassic and Cretaceous rocks associated with the Oxley Basin. The deposits are predominantly marine and terrestrial and are fine to coarse grained. The Oxley Basin contains a series of sandstone and shale units which are essentially a continuation of the formations of the Great Artesian Basin (GAB), separated due to hydrogeological discontinuities between the two. The Gunnedah and Oxley Basins are extensive, lying at depth underneath other SDL resource units; however, their outcrop is limited to regions in the Namoi, Gwydir and Macquarie–Castlereagh surface water catchments.

The Gunnedah–Oxley Basin MDB SDL resource unit was covered by the 2012 Water Sharing Plan for the NSW Murray–Darling Basin Porous Rock Groundwater Sources. The LTAAEL for the Gunnedah–Oxley Basin MDB Groundwater Source was 199.9 GL/y, plus an allowance to use 0.002% of the storage volume. There is currently a low level of groundwater use, relative to the size of the resource, however, use will increase with the expected development of the coal and coal-seam gas industry. In determining the SDL for SDL resource units where the state plan limit is greater than the level of entitlement, the MDBA did not adopt the state extraction limits as the SDLs and carried out its own assessment. The SDL for this resource unit is 114.5 GL/y, which is based on the RRAM and the unassigned groundwater assessment.

When the Basin Plan was being finalised in 2012, concerns were raised by the NSW in relation to the groundwater SDLs in the Murray–Darling Basin Porous Rock WRP area, which includes the Gunnedah–Oxley Basin MDB SDL resource unit. In response, the Basin Plan included a requirement for a review of the SDL and BDL to be conducted within two years after the commencement of the Basin Plan (by November 2014).

As per the provisions of the Basin Plan, a review panel was assembled to undertake the review. Also, to ensure the most up to date information was available to the review panels, MDBA in partnership with NSW appointed a consultant to bring together and synthesise the relevant information for the review. The review report and associated synthesis reports have been published on the MDBA website.

The review panel recommended that:

1. the SDL is varied to take account of the agreed area for the WRP in line with the current MDBA calculation and applied sustainability factors;

2. the MDBA consider varying the Unassigned Water Factor for a SDL resource unit to a value to be determined once assurances have been made by NSW that they can demonstrate that the resource will be managed via State policies and plans in such a way that impacts are limited to acceptable levels. These assurances would need to be explicit and would include

specification of the assets to be protected within Schedule 3 of the relevant NSW WSP, an agreement on the criteria that would be used to define acceptable impacts and monitoring, compliance and review processes.

The Authority accepted these recommendations and amended the SDL for the Gunnedah-Oxley Basin MDB SDL resource unit to 127.5 GL/y in July 2018.

The Gunnedah-Oxley Basin MDB SDL resource unit sits within the NSW Murray–Darling Basin Porous Rock WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 59: Summary table for the Gunnedah–Oxley Basin MDB

Summary characteristic	Name / description / volume
SDL resource unit	Gunnedah–Oxley Basin (GS17)
Groundwater covered	All groundwater contained within: a) all rocks of Permian, Triassic, Jurassic, Cretaceous and Cenozoic age within the outcropped and buried areas; and b) all unconsolidated alluvial sediments within the outcropped areas; c) excluding groundwater in the following SDL resource units: Liverpool Ranges Basalt MDB, Warrumbungle Basalt, Castlereagh Alluvium, Upper Macquarie Alluvium, NSW GAB Surat Shallow, Lower Namoi Alluvium, Upper Namoi Alluvium, Upper Namoi Tributary Alluvium and Lower Gwydir Alluvium
WRP Area	NSW Murray–Darling Basin Porous Rock (GW6)
GMU(s) Covered	Gunnedah Basin and Oxley Basin
Recharge (RRAM Step 1)*	a) 624.7 GL/y b) 686.3 GL/y****
Recharge Input	WAVES recharge modelling
PEL	a) 31.2 GL/y b) 360.3 GL/y
BDL	22.1 GL/y
SDL**	127.5 GL/y
Licensed Entitlement***	a) 16.3 GL/y b) 0 GL/y
Measured Groundwater Use	No metered use

Summary characteristic	Name / description / volume
Estimated S&D Use* **	a) 5.80 GL/y b) 0 GL/y
Entitlement plus S&D	a) 22.1 GL/y b) 0 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration. The unallocated portion of the outcrop recharge was assumed to be recharge to the deep resource.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Murray–Darling Basin Porous Rock Groundwater Sources (2012).

****Recharge to the deep part of the Gunnedah–Oxley Basin SDL resource unit is calculated by adding the total recharge to the Gunnedah–Oxley Basin and Liverpool Range Basalt shallow aquifers minus the SDL for these units.

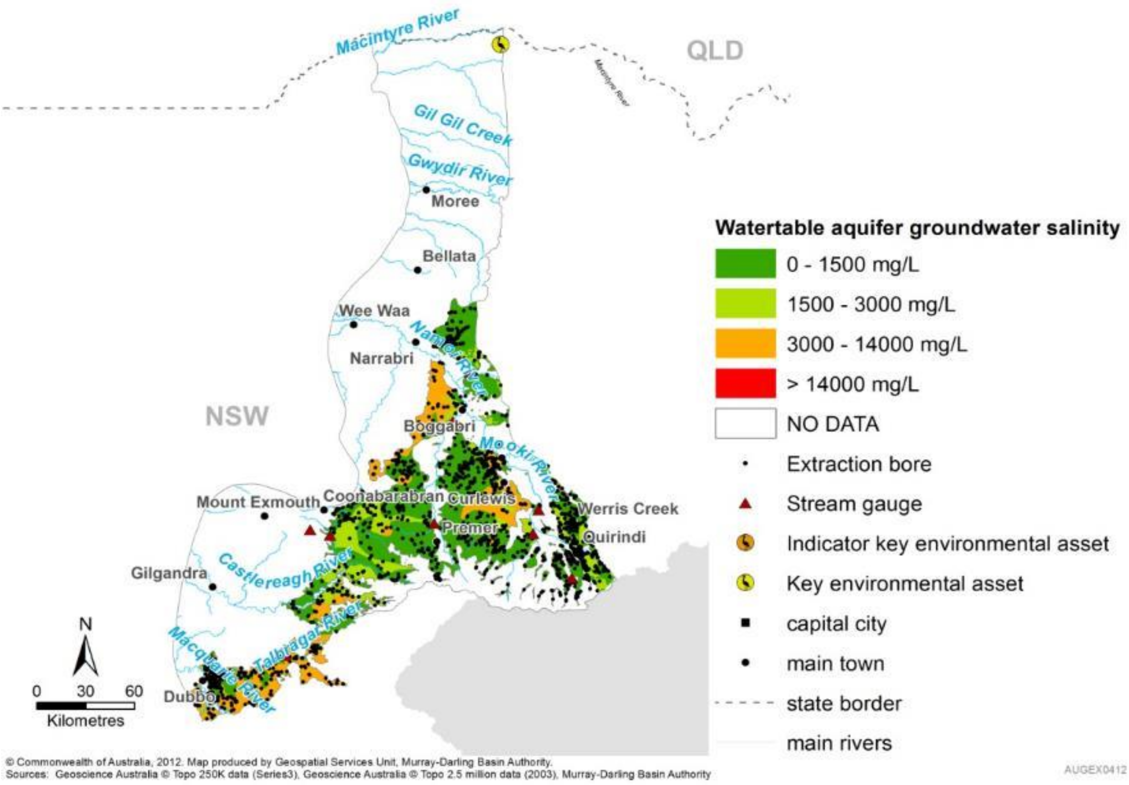


Figure 23: Gunnedah–Oxley SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).
The MDBA does not have salinity data for the buried part of the Gunnedah–Oxley Basin.

Recharge risk assessment method outcome

Table 60 and Table 61 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate for the *outcrop portion* of the SDL resource unit. In summary, the risks were identified as:

- low risk for KEAs
- high risk for KEFs
- medium risk for the productive base
- as having a risk to the key environmental outcome
- as having a high level of uncertainty.

Table 60: RRAM summary table for the Gunnedah–Oxley Basin MDB (outcrop)

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	Med	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	37%	27%	34%	**Uncertainty Level**	High
SF	0.70	0.10	0.50	**SF**	N/A	N/A	N/A	**SF**	0.50

Table 61: PEL summary table for the Gunnedah–Oxley Basin MDB (outcrop)

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	438.7	63.9	122.0	0.0	624.7
SF	0.05	0.05	0.05	N/A	N/A
PEL (GL/y)	21.9	3.20	6.10	0.0	31.2

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Table 62 and Table 63 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate for the *deep portion* of the SDL resource unit. In summary, the risks were identified as:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 62: RRAM summary table for the Gunnedah–Oxley Basin MDB (deep)

RRAM Step 2 Risks to KEA, KEF and PB	**KEA**	**KEF**	**PB**	**RRAM Step 3 Risks to fresh water**	**Salinity Class (KEO)**			**RRAM Step 4 Uncertainty**	
					Class 1	**Class 2**	**Class 3 & 4**		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	Low
				% Area	N/A	N/A	N/A	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	N/A	N/A	N/A	**SF**	0.75

Table 63: PEL summary table for the Gunnedah–Oxley Basin MDB (deep)

Measurement	**Total**
Recharge (GL/y)	686.3
SF	0.53
PEL (GL/y)	360.3

Note: The salinity data was not present to allow the recharge to be grouped into the salinity classes.

Inverell Basalt (GS18)

The Inverell Basalt SDL resource unit is in north-east NSW and spans the Gwydir and Border Rivers regions (Figure 24). Groundwater extraction is primarily focussed around Inverell. Inverell Basalt is a fractured rock aquifer predominantly comprised of alkaline olivine basalt and weathered volcanoclastic rocks, with an approximate maximum thickness of 80 m (Geoscience Australia, 2010). The aquifer has relatively good groundwater quality and low yields; averaging between 1 to 2 L/sec. Recharge occurs mainly on hilltops and slopes with discharge areas at the break-of-slope and as base flow to streams and valley floors (CSIRO, 2007a).

The Inverell Basalt SDL resource unit was covered by the 2011 Water Sharing Plan for the NSW Murray—Darling Basin Fractured Rock Groundwater Sources. The LTAAEL under this plan for the Inverell Basalt was 25.8 ML/y, which was based on the NSW risk assessment framework. The MDBA assessed this SDL resource unit as a highly connected system where groundwater discharge provides base flow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion. Therefore, SDL has been set at estimated current use (4.15 GL/y) to ensure that the KEF (i.e. base flows) is not compromised.

The Inverell Basalt SDL resource unit sits within the NSW Murray–Darling Basin Fractured Rock WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 64: Summary table for the Inverell Basalt

Summary characteristic	Name / description / volume
SDL resource unit	Inverell Basalt (GS18)
Groundwater covered	All groundwater contained within all basalt of Cenozoic age and all unconsolidated alluvial sediments
WRP Area	NSW Murray–Darling Basin Fractured Rock (GW11)
GMU(s) Covered	Inverell Basalt
Recharge (RRAM Step 1)*	110.5 GL/y
Recharge Input	WAVES recharge modelling
PEL	5.52 GL/y
BDL	4.15 GL/y
SDL**	4.15 GL/y
Licensed Entitlement***	3.08 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	1.07 GL/y
Entitlement plus S&D	4.15 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources (2012).

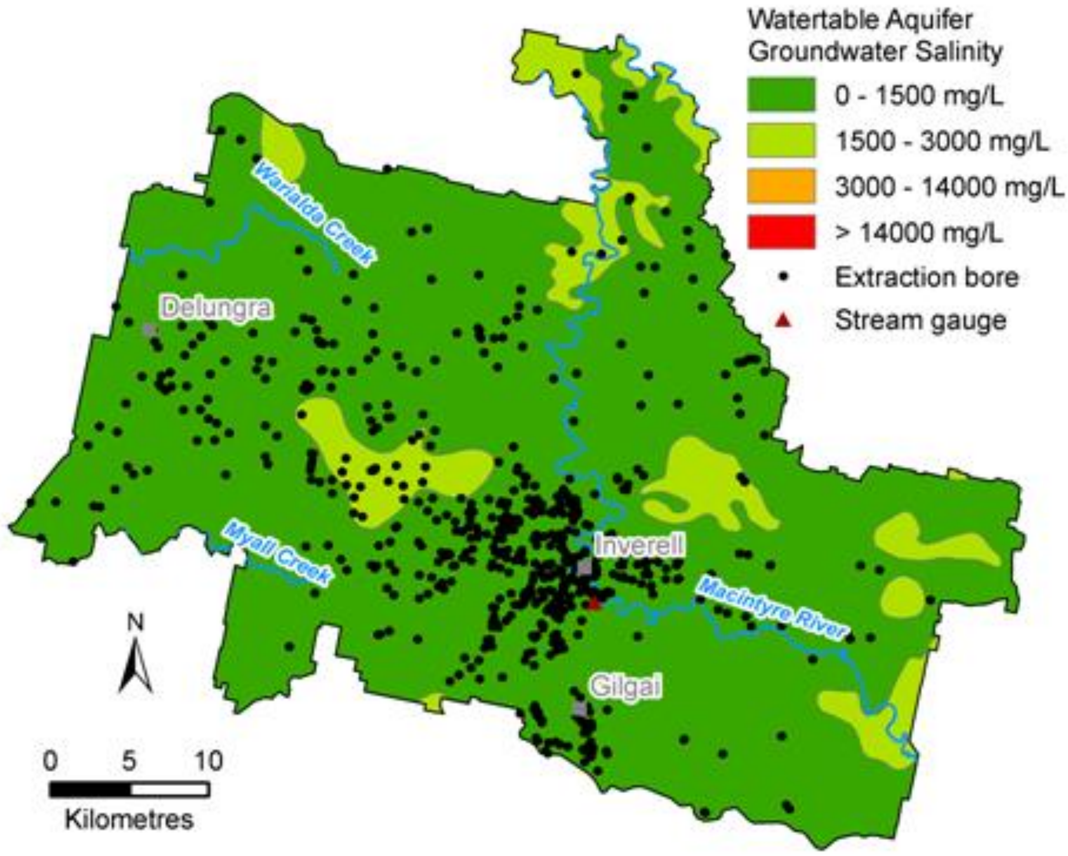


Figure 24: Inverell Basalt SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 65 and Table 66 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- medium risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 65: RRAM summary table for the Inverell Basalt

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	Med	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	90%	10%	0%	**Uncertainty Level**	High
SF	0.70	0.10	0.50	**SF**	N/A	N/A	N/A	**SF**	0.50

Table 66: PEL summary table for the Inverell Basalt

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	100.3	10.2	0.0	0.0	110.5
SF	0.05	0.05	N/A	N/A	N/A
PEL (GL/y)	5.01	0.51	0.0	0.0	5.52

*Recharge per salinity class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Kanmantoo Fold Belt MDB (GS19)

The Kanmantoo Fold Belt MDB SDL resource unit is located in western NSW, either side of the Darling River with Broken Hill located to the south west (Figure 25). Groundwater resources in this area are relatively undeveloped. Groundwater is mainly contained within the faults, fractures and shear zones of the fractured rock aquifer. Permeability and porosity of these rocks is typically low, resulting in low yields. Unregulated tributaries of the Darling River recharge the aquifer during flood events.

The Kanmantoo Fold Belt SDL resource unit was covered by the 2012 Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources. The LTAAEL under this plan for the Kanmantoo Fold Belt was 178.6 ML/y, which was based on the NSW risk assessment framework. In determining the SDL for SDL resource units where the state plan limit is greater than the level of entitlement, the MDBA did not adopt the state extraction limits as the SDLs, and carried out its own assessment. The SDL for this resource unit is 18.7 GL/y, which is based on the RRAM and the unassigned groundwater assessment.

The Kanmantoo Fold Belt MDB SDL resource unit sits within the NSW Murray–Darling Basin Fractured Rock WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 67: Summary table for the Kanmantoo Fold Belt MDB

Summary characteristic	Name / description / volume
SDL resource unit	Kanmantoo Fold Belt MDB (GS19)
Groundwater covered	All groundwater, excluding groundwater in the following SDL resource units: Western Porous Rock, Upper Darling Alluvium, Lower Darling Alluvium, Lower Murrumbidgee Shallow Alluvium, Lower Murrumbidgee Deep Alluvium, Lower Lachlan Alluvium
WRP Area	NSW Murray–Darling Basin Fractured Rock (GW11)
GMU(s) Covered	Kanmantoo Fold Belt
Recharge (RRAM Step 1)*	91.6 GL/y
Recharge Input	WAVES recharge modelling
PEL	48.1 GL/y
BDL	8.91 GL/y
SDL**	18.7 GL/y
Licensed Entitlement***	0.76 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	8.15 GL/y
Entitlement plus S&D	8.91 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources (2012).

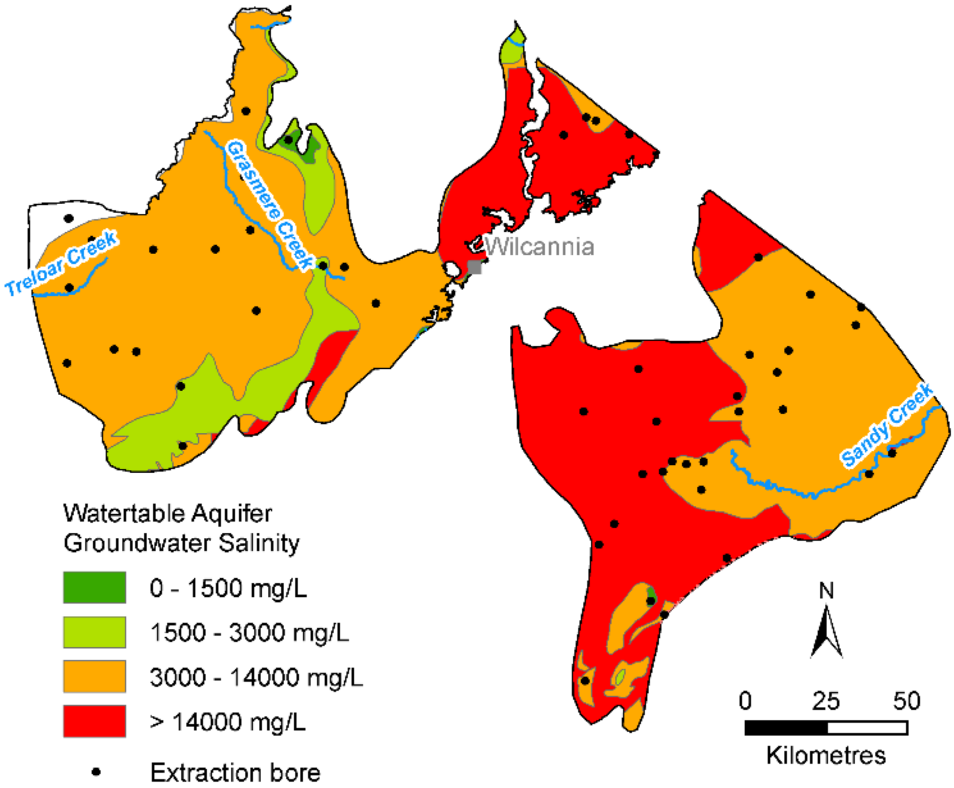


Figure 25: Kanmantoo Fold Belt SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 68 and Table 69 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 68: RRAM summary table for the Kanmantoo Fold Belt

RRAM Step 2 Risks to KEA, KEF and PB	**KEA**	**KEF**	**PB**	**RRAM Step 3 Risks to fresh water**	**Salinity Class (KEO)**			**RRAM Step 4 Uncertainty**	
					Class 1	**Class 2**	**Class 3 & 4**		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	Low
				% Area	0.4%	7.3%	92%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	N/A	N/A	N/A	**SF**	0.75

Table 69: PEL summary table for the Kanmantoo Fold Belt

Salinity	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Total**
Recharge (GL/y)*	0.34	6.19	55.9	29.2	91.6
SF	0.53	0.53	0.53	0.53	N/A
PEL (GL/y)	0.18	3.25	29.3	15.3	48.0

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Lachlan Fold Belt MDB (GS20)

In draft versions of the Basin Plan there were five SDL resource units for the Lachlan Fold Belt (Murray, Murrumbidgee, Lachlan, Macquarie–Castlereagh and Western). These five units were later merged to align with the NSW planning boundary for the Lachlan Fold Belt (Figure 26)

The outcome of the risk assessment for the five previous SDL resource units was not the same (i.e. different risks were identified). Of the five groundwater sub-units within this SDL resource unit, all systems were assessed as having a high risk to the KEF due to the presence of unregulated rivers. However, the Authority assessed that there was less risk to the ESLT characteristics due to the hydrogeological characteristics of these systems. The connectivity to surface water in these systems relies on faults and fractures in the geological strata and this results in variable connections to surface water. Consequently, the Authority considered that these systems were best addressed through the application of unassigned water assessment to set the SDL.

The Lachlan Fold Belt MDB SDL resource unit was covered by the 2012 Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources. The LTAAEL under this plan, for the Lachlan Fold Belt was 821.3 GL/y, which was based on the NSW risk assessment framework. The MDBA has a policy not to adopt the plan extraction limit as SDL for the SDL resource units where the state plan limit is greater than the level of entitlement. Accordingly, the MDBA did not adopt the plan extraction limit as the SDL for this SDL resource unit. Using the RRAM and the unassigned groundwater assessment, the MDBA set the SDL at 259.0 GL.

The Lachlan Fold Belt MDB SDL resource unit sits within the NSW Murray–Darling Basin Fractured Rock WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 70: Summary table for the Lachlan Fold Belt MDB

Summary characteristic	Name / description / volume
SDL resource unit	Lachlan Fold Belt MDB (GS20)
Groundwater covered	All groundwater, excluding groundwater contained in the following SDL resource units: Gunnedah–Oxley Basin MDB, Sydney Basin MDB, Oaklands Basin, Upper Darling Alluvium, Billabong Creek Alluvium, Lower Murray Shallow Alluvium, Lower Murray Deep Alluvium, Upper Murray Alluvium, Lake George Alluvium, Lower Murrumbidgee Shallow Alluvium, Lower Murrumbidgee Deep Alluvium, Mid-Murrumbidgee Alluvium, Belubula Alluvium, Upper Lachlan Alluvium, Orange Basalt, Liverpool Range Basalt MDB, Warrumbungle Basalt, Bell Valley Alluvium, Castlereagh Alluvium, Coolaburragundy–Talbragar Alluvium, Cudgegong Alluvium, Lower Macquarie Alluvium, Upper Macquarie Alluvium, Lower Namoi Alluvium, Upper Namoi Alluvium and Lower Gwydir Alluvium
WRP Area	NSW Murray–Darling Basin Fractured Rock (GW11)
GMU(s) Covered	Lachlan Fold Belt
Recharge (RRAM Step 1)*	8003.2 GL/y
Recharge Input	WAVES recharge modelling
PEL	400.1 GL/y
BDL	142.4 GL/y
SDL**	259.0 GL/y
Licensed Entitlement***	72.6 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	69.8 GL/y
Entitlement plus S&D	142.4 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

** SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources (2012).

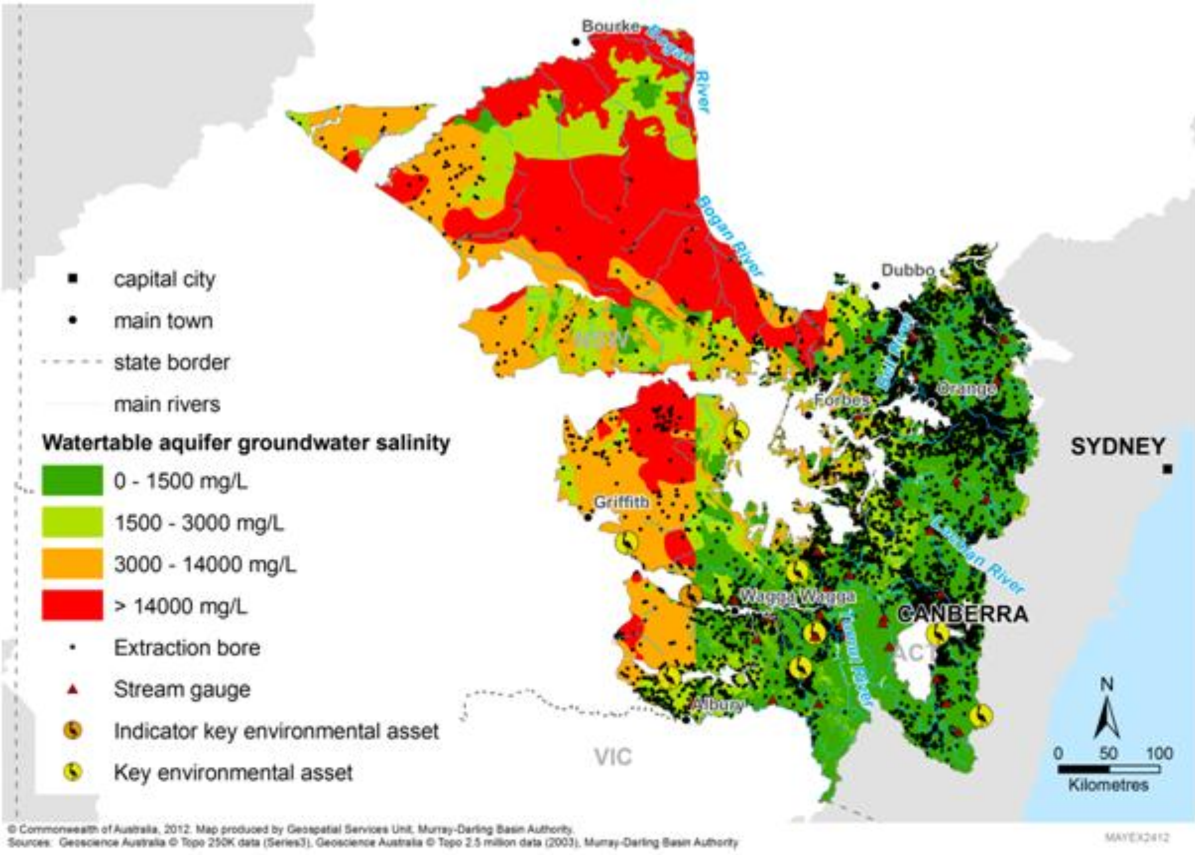


Figure 26: Lachlan Fold Belt MDB SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 71 and Table 72 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- high risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 71: RRAM summary table for the Lachlan Fold Belt

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	High	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	64%	15%	21%	**Uncertainty Level**	High
SF	0.70	0.10	0.10	**SF**	N/A	N/A	N/A	**SF**	0.50

Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater.

Table 72: PEL summary table for the Lachlan Fold Belt

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	5097.5	1198.1	876.8	830.8	8003.2
SF	0.05	0.05	0.05	0.05	N/A
PEL (GL/y)	254.9	59.9	43.8	41.5	400.1

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Lake George Alluvium (GS21)

The Lake George Alluvium SDL resource unit is located adjacent to Lake George in south-east NSW roughly along the Turallo and Butmaroo Creek drainage lines, north-east of Canberra (Figure 27). The alluvial deposit consists of basal sands and gravels which are overlain by and are interbedded with, clayey sediments which occur in two separate palaeochannels (Hydroilex, 2005). The aquifer is used for town water supply and irrigation.

The Lake George Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for the Murrumbidgee Unregulated and Alluvial Water Sources. The LTAAEL for the Lake George Alluvium (Bungendore Alluvial Groundwater Source) was 1.27 GL/y, which was based on the NSW risk assessment framework.

The Lake George Alluvium groundwater SDL resource unit is within the Murrumbidgee Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 73: Summary table for the Lake George Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Lake George Alluvium (GS21)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Murrumbidgee Alluvium (GW9)
GMU(s) Covered	Bungendore Alluvium
Recharge (RRAM Step 1)*	2.05 GL/y
Recharge Input	WAVES recharge modelling
PEL	1.08 GL/y
BDL	1.27 GL/y
SDL**	1.27 GL/y
Licensed Entitlement***	1.22 GL/y
Measured Groundwater Use	1.10 GL/y
Estimated S&D Use***	0.02 GL/y
Entitlement plus S&D	1.24 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL set at the NSW plan limit, as the PEL is close to the plan limit and the risks have been identified as low (existing planning arrangements).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Murrumbidgee Unregulated and Alluvial Water Sources (2012).

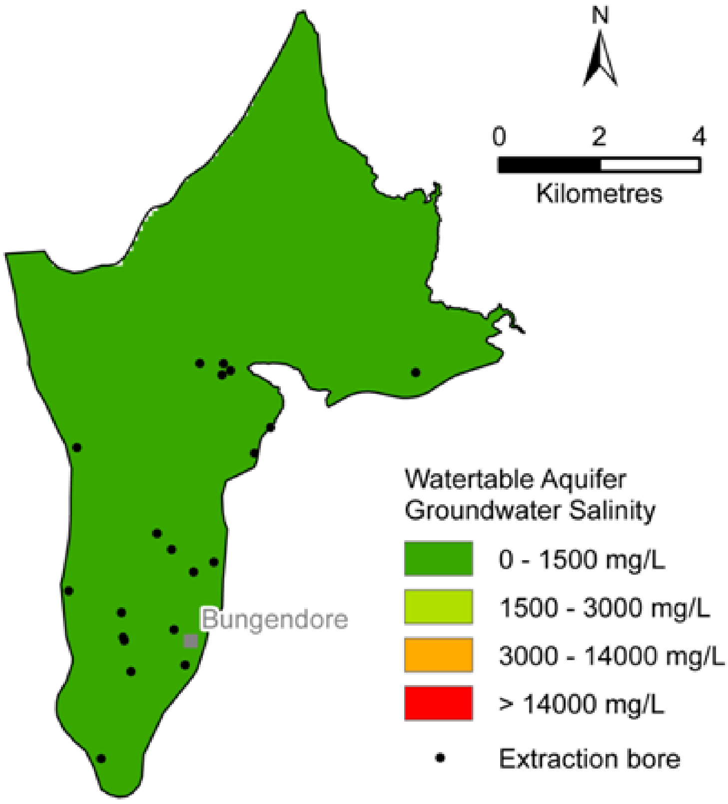


Figure 27: Lake George Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 74 and Table 75 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 74: RRAM summary table for the Lake George Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	Low
				% Area	100%	0%	0%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	N/A	N/A	N/A	**SF**	0.75

Table 75: PEL summary table for the Lake George Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	2.05	0.0	0.0	0.0	2.05
SF	0.53	0.53	0.53	0.53	N/A
PEL (GL/y)	1.08	0.0	0.0	0.0	1.08

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Liverpool Ranges Basalt MDB (GS22)

The Liverpool Ranges Basalt MDB SDL resource unit is on the eastern boundary of the Basin in NSW, with the town of Quirindi in the north-east of the SDL resource unit (Figure 28). The Liverpool Ranges Basalt MDB SDL area is comprised of multiple Tertiary basalt flows with intervening sediments and ash fall material, overlying Jurassic quartz sandstones and shale. There is no apparent eruption centre and it is likely that the basalt came from numerous basalt dykes which fed small vents. Development in the SDL resource unit is relatively low and groundwater is used mostly for S&D purposes.

The Liverpool Ranges Basalt MDB SDL resource unit was covered by the 2012 Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources. The LTAAEL under this plan for the Liverpool Ranges Basalt was 19.1 GL/y, which was based on the NSW risk assessment framework. The MDBA has a policy not to adopt the plan extraction limit as SDL for the SDL resource units where the state plan limit is greater than the level of entitlement. Accordingly, the MDBA did not adopt the plan extraction limit as the SDL for this SDL resource unit. Using the RRAM and the unassigned groundwater assessment, the MDBA set the SDL at 2.16 GL/y.

The Liverpool Ranges Basalt MDB SDL resource unit sits within the NSW Murray–Darling Basin Fractured Rock WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 76: Summary table for the Liverpool Ranges Basalt MDB

Summary characteristic	Name / description / volume
SDL resource unit	Liverpool Ranges Basalt MDB (GS22)
Groundwater covered	All groundwater contained within all basalt of Cenozoic age and all unconsolidated alluvial sediments
WRP Area	NSW Murray–Darling Basin Fractured Rock (GW11)
GMU(s) Covered	Liverpool Ranges Basalt
Recharge (RRAM Step 1)*	88.1 GL/y
Recharge Input	WAVES recharge modelling
PEL	4.41 GL/y
BDL	2.16 GL/y
SDL**	2.16 GL/y
Licensed Entitlement***	0.33 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	1.83 GL/y
Entitlement plus S&D	2.16 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Murray–Darling Basin Porous Rock Groundwater Sources (2012).

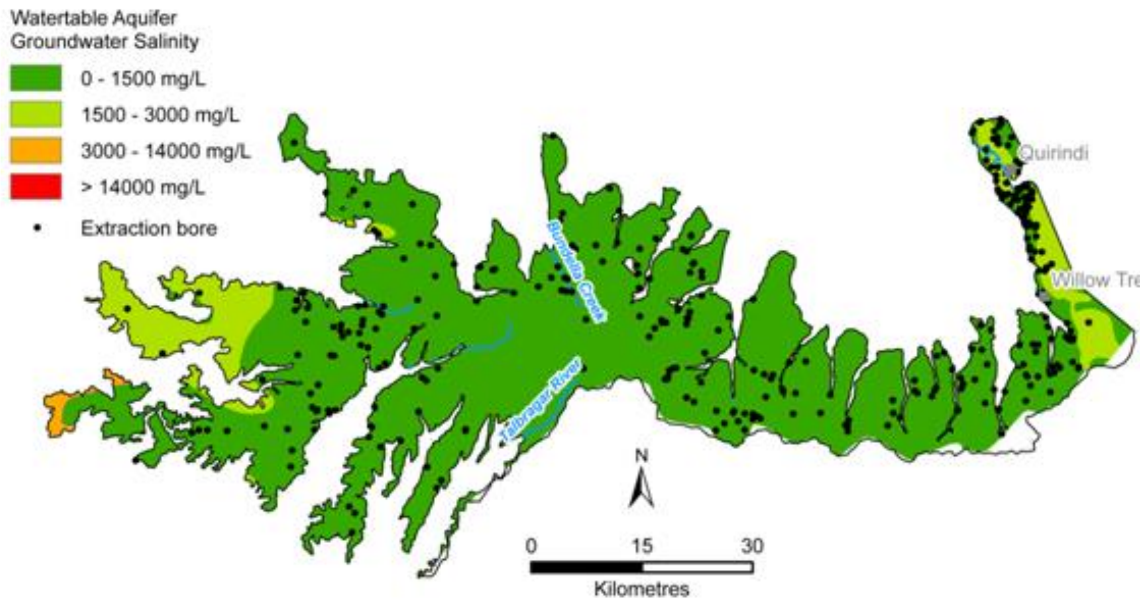


Figure 28: Liverpool Ranges Basalt SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 77 and Table 78 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- medium risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 77: RRAM summary table for the Liverpool Ranges Basalt

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	Med	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	88%	10%	2%	**Uncertainty Level**	High
SF	0.70	0.10	0.50	**SF**	N/A	N/A	N/A	**SF**	0.50

Table 78: PEL summary table for the Liverpool Ranges Basalt

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	70.1	16.8	1.21	0.0	88.1
SF	0.05	0.05	0.05	N/A	N/A
PEL (GL/y)	3.50	0.84	0.06	0.0	4.40

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Lower Darling Alluvium (GS23)

The Lower Darling Alluvium SDL resource unit is located along the Darling River downstream of the Menindee Lakes (Figure 29). It incorporates the more recently deposited alluvial sediments similar to those found in the Murray trench that contain groundwater of variable quality. The water in the Lower Darling Alluvial Groundwater Source is generally saline (5,000 to 50,000 EC), except for narrow and shallow lenses of relative freshwater (between 200 and 2,800 EC) occurring within 500 m of the Darling River. Groundwater resources in this area are relatively undeveloped. The Darling Anabranch is not a part of this resource unit. This SDL resource unit only includes the alluvial aquifer adjacent to the Lower Darling River, which ranges in width from two to five kilometres from the river channel (CSIRO, 2008a).

The Lower Darling Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for the Lower Murray–Darling Unregulated and Alluvial Water Sources. The LTAAEL under this plan for the Lower Darling Alluvium was 2.23 GL/y, which was based on capping at the estimated current use. This has been adopted as the SDL.

The Lower Darling Alluvium groundwater SDL resource unit sits within the Darling Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 79: Summary table for the Lower Darling Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Lower Darling Alluvium (GS23)
Groundwater covered	All groundwater contained within alluvial sediments of Quaternary age below the surface of the ground
WRP Area	Darling Alluvium (GW7)
GMU(s) Covered	Lower Darling Alluvium
Recharge (RRAM Step 1)*	6.75 GL/y
Recharge Input	WAVES recharge modelling
PEL	3.41 GL/y
BDL	2.23 GL/y
SDL**	2.23 GL/y
Licensed Entitlement***	1.49 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.74 GL/y
Entitlement plus S&D	2.23 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Lower Murray–Darling Unregulated and Alluvial Water Sources (2012).

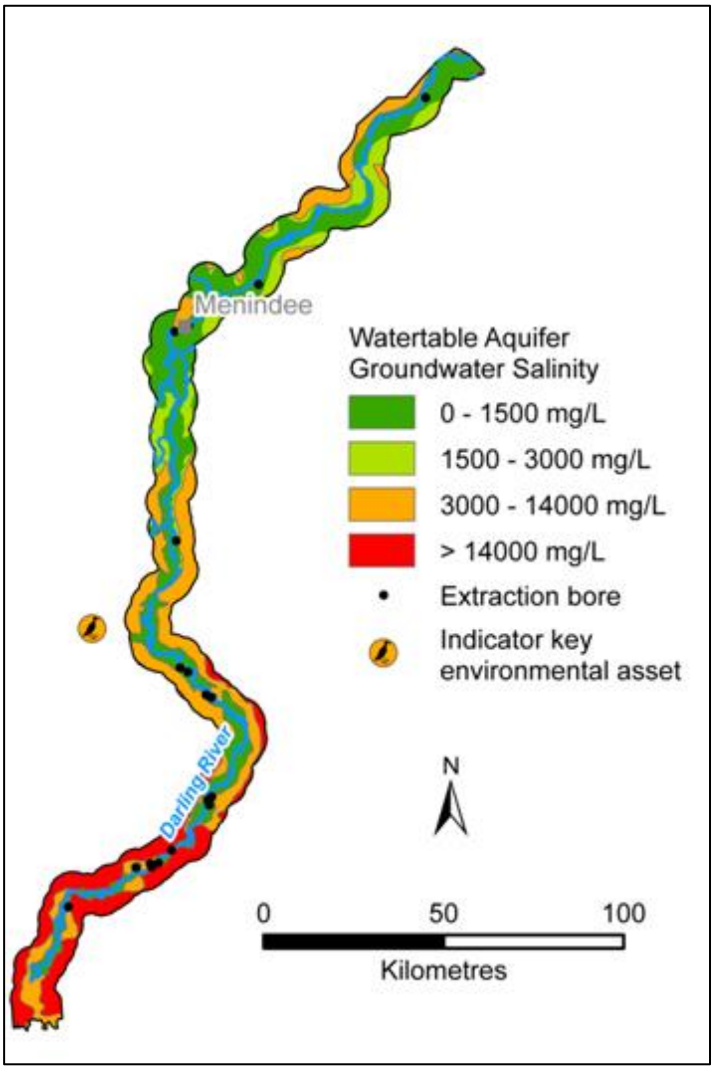


Figure 29: Lower Darling Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from as having a low level of uncertainty.

Recharge risk assessment method outcome

Table 80 and Table 81 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a high level of uncertainty.

Table 80: RRAM summary table for the Lower Darling Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	**KEA**	**KEF**	**PB**	**RRAM Step 3 Risks to fresh water**	**Salinity Class (KEO)**			**RRAM Step 4 Uncertainty**	
					Class 1	**Class 2**	**Class 3 & 4**		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	Yes	Yes	No	**Risk to ESLT**	Low
				% Area	44%	12%	44%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	0.80	0.90	N/A	**SF**	0.75

Table 81: PEL summary table for the Lower Darling Alluvium

Salinity	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Total**
Recharge (GL/y)*	1.28	0.18	2.39	2.90	6.75
SF	0.42	0.47	0.53	0.53	N/A
PEL (GL/y)	0.54	0.09	1.26	1.52	3.41

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Lower Gwydir Alluvium (GS24)

The Lower Gwydir Alluvium is located on the floodplains of the Gwydir River, both upstream and downstream of Moree (Figure 30). The Lower Gwydir numerical model covers the majority of the SDL resource unit and a larger area to the west.

The Lower Gwydir Alluvium is made up of Cenozoic alluvial sediments extending west from Biniguy for approximately 90 km. These sediments form an extensive alluvial fan deposited by the Gwydir River and its tributaries, comprised of clay, silt, sand and gravel. The water-bearing sands and gravels within the alluvial sediments of the Lower Gwydir Alluvium are generally divided into two main aquifer systems; a shallow aquifer system up to approximately 30 m deep, and a deep aquifer system up to a maximum of approximately 90 m deep (NSW DPI, 2017).

The Lower Gwydir Alluvium numerical model incorporates these two layers (CSIRO, 2007a). The upper layer represents the unconfined Narrabri Formation aquifer, the lower layer represents the Gunnedah Formation. Approximately 40 percent of extraction occurs from the shallow aquifer and the remaining 60 percent occurs from the deeper aquifer.

The Lower Gwydir Alluvium SDL resource unit was covered by the 2006 Water Sharing Plan for the Lower Gwydir Groundwater Source. The LTAAEL under this plan was 32.3 GL/y (not including S&D). This limit was established through the Achieving Sustainable Groundwater Entitlements (ASGE) program, which had a staged reduction process and reduced groundwater use to the LTAAEL by 30 June 2016. Due to this process, the Lower Gwydir Alluvium SDL resource unit was placed in the “existing reduction program” category of the Groundwater Assessment framework.

This is one of the SDL resource units where the Authority adopted an existing state plan limit as the SDL. Prior to adopting the state extraction limit the Authority assessed the plan extraction limit against the PEL to determine if the plan limit reflected an ESLT. The assessment considered if the state extraction limit and the science underpinning it represented the most up to date scientific knowledge, i.e. a more thorough assessment than RRAM, while also being consistent with the *Water Act 2007 (Cwlth)*.

The Lower Darling Alluvium groundwater SDL resource unit sits within the Gwydir Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 82: Summary table for the Lower Gwydir

Summary characteristic	Name / description / volume
SDL resource unit	Lower Gwydir Alluvium (GS24)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Gwydir Alluvium (GW15)
GMU(s) Covered	Lower Gwydir Alluvium
Annual Groundwater Recharge*	47.1 GL/y
Recharge Input	Numerical Model
PEL**	33.0 GL/y
BDL	33.0 GL/y
SDL***	33.0 GL/y
Licensed Entitlement****	32.4 GL/y
Measured Groundwater Use****	33.0 GL/y
Estimated S&D Use****	0.61 GL/y
Entitlement plus S&D	33.0 GL/y

*The results of the Lower Gwydir Alluvium numerical modelling used for the Murray–Darling Basin Sustainable Yields Project have been used to estimate recharge (CSIRO, 2007a). The model includes recharge via dryland rainfall, irrigation, river leakage and lateral flow.

**The PEL has been determined using the results from the groundwater model.

***SDL set at the ASGE reduction program limit plus S&D. This limit was supported by the Basin Plan groundwater model.

****All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Lower Gwydir Groundwater Source (2006). Updated S&D data was provided by the NSW Government on 10 February 2011.

Table 83: Summary of the groundwater and surface water fluxes derived from the numerical model and identified GDEs for Lower Gwydir

Summary characteristic	Volume / name
Groundwater Discharge to Streams*	3.40 GL/y
Stream Leakage to Groundwater*	21.7 GL/y
Impact of Groundwater Extraction on Stream flow**	24.1 GL/y
Groundwater Dependent KEA	None

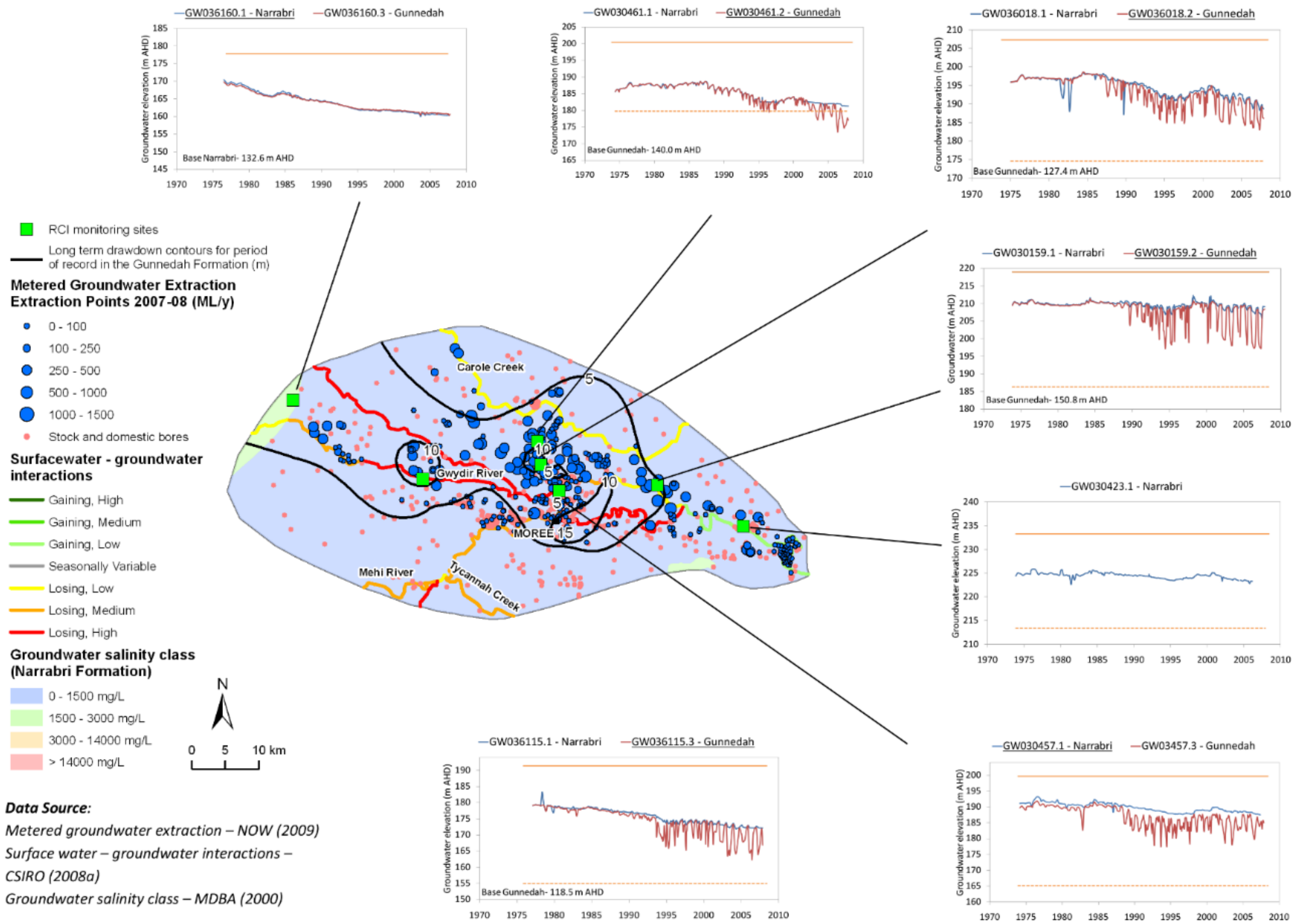
*Derived from the model results for Scenario 2 (i.e. groundwater take at the current level of entitlements).

**Derived by comparing river loss under the current levels of entitlement (Scenario 2) and the no groundwater extraction scenario (Scenario 1).

Recharge risk assessment method outcome

Although the RRAM was not applied in this SDL resource unit due to the availability of the groundwater model, the risk rankings were determined to be:

- low risk for KEAs (none identified as groundwater dependent)
- medium risk for KEFs (given there is approximately 75 percent groundwater and surface water connectivity and the rivers are regulated)
- low risk for the productive base
- a risk to the key environmental outcome
- low level of uncertainty as there is a groundwater model for this area.



Ground Surface

Base of Narrabri Formation

Groundwater elevation (m AHD) Narrabri Formation

Groundwater elevation (m AHD) Gunnedah Formation

Underlined Bore ID represents key hydrograph at nested site

(The Narrabri Formation is the uppermost aquifer of the alluvial sequence and extends to depths of 10–30 m bgl)

(The Gunnedah Formation underlies the Narrabri and has an average thickness of approximately 45 m)

Monitoring Points	Feature
GW036160.1	In the vicinity of the Gwydir Wetlands which reside in the adjacent SDL Area.
GW030461.2 GW036018.2 GW036115.3	Productive base, Salinity
GW030423.1 GW030159.1 GW036115.1 GW030457.1	Connectivity

Figure 30: Lower Gwydir Alluvium resource unit map

Hydrogeology and water sharing arrangements

- The region's primary groundwater resource is in the alluvial aquifers associated with the main rivers and prior channels of the western floodplain. Groundwater from these aquifers supplies irrigation, Stock, Domestic and town water. The aquifers form a three-layered system composed of the Cubbaroo Formation, overlain by the Gunnedah Formation and, in turn, by the Narrabri Formation.
- The Cubbaroo Formation is restricted to the deepest parts of the alluvial sequence and comprises coarse-grained palaeochannels.
- The Gunnedah Formation extends across the region and is slightly finer grained than the Cubbaroo Formation. Groundwater within the Lower Gwydir SDL resource unit is largely extracted from the Gunnedah Formation.
- The Narrabri Formation is composed of shallow alluvial fan sediments deposited by creeks draining the adjacent highlands. Groundwater is contained in small discontinuous sand lenses and varies in quality and yield.
- Recharge to the alluvial aquifers occurs via rainfall infiltration, flooding events and irrigation.
- Streams are in direct hydraulic connection with groundwater. Nearly all reaches in the Lower Gwydir are losing and range from the 'low losing' reaches of Gil Gil and Carole creeks to the 'high losing' reaches of the Gwydir River and Gingham Channel near Moree. The 'high losing' reaches are associated with a high hydraulic conductivity zone (5 to 50 m/day). Most other reaches fall into the 'medium losing' category. There is a single gaining reach of the Gwydir River at the eastern edge of the Narrabri Formation.
- Existing water sharing arrangements are detailed in the Water Sharing Plan for the Lower Gwydir Groundwater Source 2003 (July 2007). Arrangements include:
  - Water quality degradation is deemed unacceptable if groundwater salinity increases to beyond beneficial use class threshold; and
  - Performance indicators are listed (but not specified) relating to changes in: climate adjusted levels, levels adjacent to groundwater dependent ecosystems, groundwater quality, socio-economic benefits, and structural integrity of the aquifer etc.

Resource condition analysis

- Selection of key monitoring sites:
  - should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should be able to monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
  - Features requiring priority in the Lower Gwydir Alluvium include surface-groundwater interaction throughout the catchment, groundwater dependent environmental assets, the productive base of the resource in major zones of extraction and water quality.
- Analysis of historical data:
  - Evidence of water level declines since the start of monitoring, particularly in the central extraction zone (e.g. GW036018, GW030461) and in the vicinity of the Gwydir Wetlands (GW036160). The extent to which this is caused by extraction or climate is important to ascertain.
  - The threat to remaining storage is mostly low, with current water levels above a 20 % decline in aquifer saturated thickness from pre-development levels. However water level declines will be inducing more leakage from surface water resources.
  - Water quality data is sparse.

Lower Lachlan Alluvium (GS25)

The Lower Lachlan Alluvium SDL resource unit is located downstream of Lake Cargelligo, extending to the western boundary of the Lachlan Region (Figure 31). The aquifers of the Lower Lachlan consist of unconsolidated alluvial sediments that form a broad alluvial fan. The sediments are divided into the shallow Shepparton Formation unconfined aquifer and the underlying leaky confined aquifers in the Calivil Formation and Renmark Group (CSIRO, 2008b). Groundwater is extracted from all the aquifers; however, the lower two are used more extensively. The Lachlan River and various anabranches, including Willandra Creek, are the principal sources of aquifer recharge.

Groundwater extraction commenced in the 1860s for town water supply development and remained at low levels until the 1960s. Large-scale development for irrigation commenced in the early 1990s and increased steadily to current levels of more than 120.0 GL/y. Water levels monitored near extraction bores indicate that groundwater levels have declined significantly since extraction commenced and are continuing to decline.

The Lower Lachlan Alluvium SDL resource unit was covered by the 2008 Water Sharing Plan for the Lower Lachlan Groundwater Source. The LTAAEL under this plan was 108.0 GL/y (not including S&D). This limit was established through the Achieving Sustainable Groundwater Entitlements (ASGE) program, which had a staged reduction process and reduced groundwater use to the LTAAEL by 30 June 2017. Due to this process, the Lower Lachlan Alluvium SDL resource unit was placed in the “existing reduction program” category of the Groundwater Assessment framework.

The Lower Lachlan Alluvium groundwater SDL resource unit sits within the Lachlan Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 84: Summary table for the Lower Lachlan Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Lower Lachlan Alluvium (GS25)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Lachlan Alluvium (GW10)
GMU(s) Covered	Lower Lachlan Alluvium (downstream of Lake Cargelligo)
Annual Groundwater Recharge	120.0 GL/y
Recharge Input	Numerical Model
PEL**	35.0 GL/y
BDL***	123.4 GL/y
SDL****	117.0 GL/y
Licensed Entitlement*****	108.0 GL/y
Measured Groundwater Use*****	122.9 GL/y
Estimated S&D Use*****	9.00 GL/y
Entitlement plus S&D	117.0 GL/y

*The results of the Lower Lachlan Alluvium numerical modelling used for the Murray–Darling Basin Sustainable Yields Project have been used to estimate recharge (CSIRO, 2008b). The model includes recharge via dryland rainfall, irrigation, river leakage and lateral flow.

**The PEL has been determined using the results from the groundwater model.

***The BDL is the interim plan limit (including the remaining supplementary entitlements) as at 31 December 2014.

****SDL set at the ASGE reduction program limit plus S&D. The SDL recognised that the ASGE program was a ten year reduction process that had not concluded at that time and the outcomes not yet realised. The Authority is committed to working with the NSW Government to review the SDL as the outcomes of the ASGE program are realised and new knowledge becomes available.

*****All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Lower Lachlan Groundwater Source (2008). Updated S&D data was provided by the NSW Government on
10 February 2011.

Table 85: Summary of the groundwater and surface water fluxes derived from the numerical model and identified GDEs for Lower Lachlan

Summary characteristic	Volume / name
Groundwater Discharge to Streams*	0.50 GL/y
Stream Leakage to Groundwater*	31.0 GL/y
Impact of Groundwater Extraction on Stream flow**	0.34 GL/y
Groundwater Dependent KEA	Booligal Wetlands

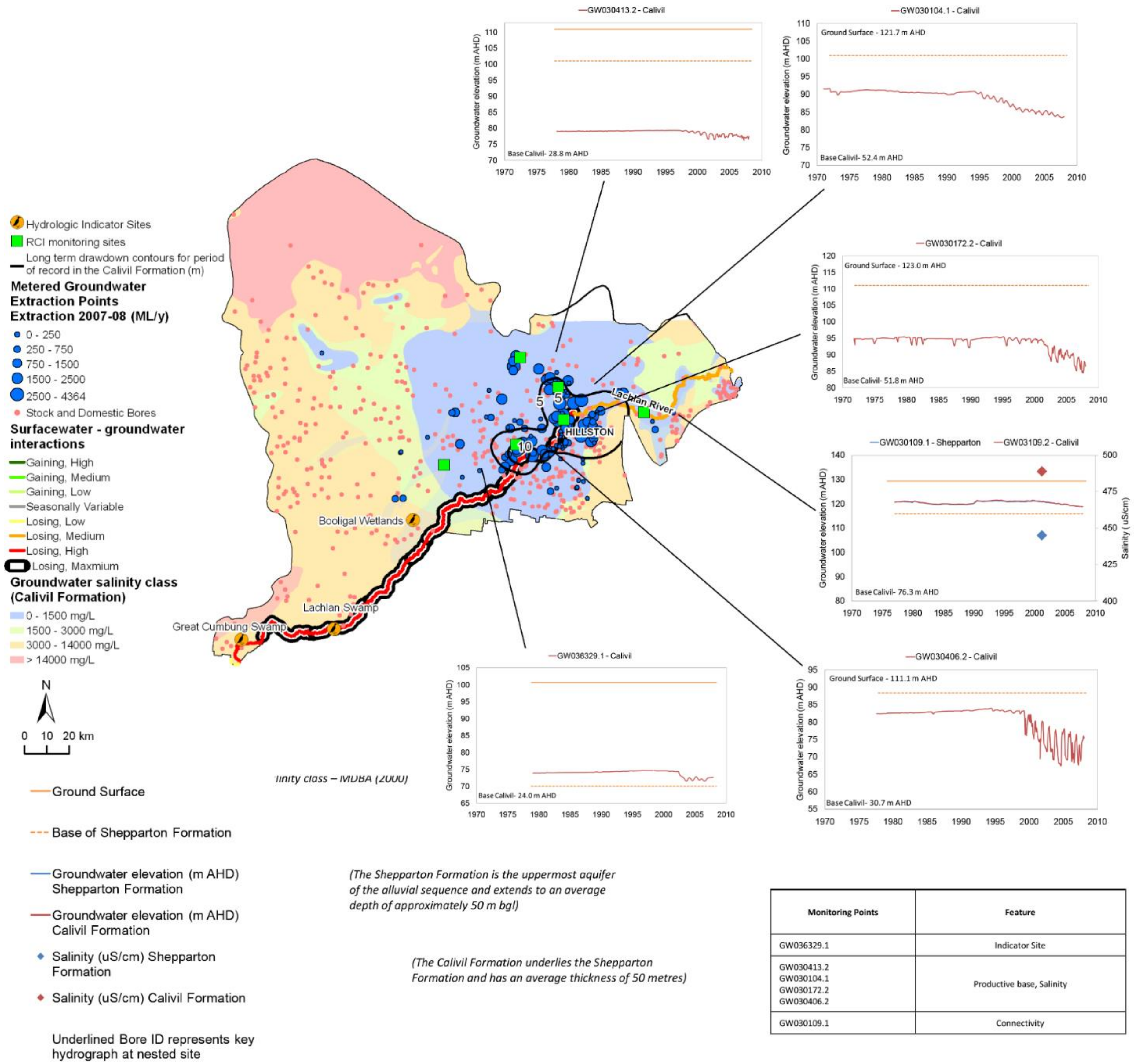
*Derived from the model results for Scenario 2 (i.e. groundwater take at the current level of entitlements).

**Derived by comparing river loss under the current levels of entitlement (Scenario 2) and the no groundwater extraction scenario (Scenario 1).

Recharge risk assessment method outcome

Although the RRAM was not applied in this SDL resource unit due to the availability of the groundwater model, the risk rankings were determined to be:

- medium risk for KEAs
- low risk for KEFs (given the lower reaches of the Lachlan River are under maximum losing conditions)
- low risk for the productive base
- a risk to the key environmental outcome
- low level of uncertainty as there is a groundwater model for this area.



Monitoring Points	Feature
GW036329.1	Indicator Site
GW030413.2 GW030104.1 GW030172.2 GW030406.2	Productive base, Salinity
GW030109.1	Connectivity

Figure 31: Lower Lachlan Alluvium SDL resource unit map

Hydrogeology and water sharing arrangements

- The aquifers of the Lower Lachlan consist of unconsolidated alluvial sediments that form a broad alluvial fan. The unconsolidated sediments are subdivided into the shallow Shepparton Formation unconfined aquifer and underlying leaky confined aquifers in the Calivil Formation and Renmark Group.
- Groundwater is abstracted from all aquifers but primarily from the lower units.
- The Lachlan River and various anabranches, including Willandra Creek (an ancestral channel) are principal sources of aquifer recharge.
- Groundwater extraction commenced in the 1860s with town water supply development and remained at low levels until the 1960s. Large-scale development for irrigation commenced in the early 1990s and increased steadily to current levels of more than 120 GL/y.
- Water level monitoring near extraction bores indicates that groundwater levels have declined significantly and continue to decline since extraction commenced.
- Existing water sharing arrangements are detailed in the Water Sharing Plan for the Lower Lachlan Groundwater Source 2003 (July 2008). Arrangements include some existing resource condition limits (RCLs):
  - Water quality degradation is deemed unacceptable if groundwater salinity increases to beyond beneficial use class thresholds (defined as < 800 for drinking water and < 1500 EC for agricultural water). Local management mechanisms may be adopted if salinities rise by more than 20% of the difference between baseline salinities and beneficial use class thresholds.
  - The average seasonally recovered water levels over a 5 year period must be maintained within 10% of the total available drawdown below the initial seasonally recovered water level at the commencement of the Plan.
  - Seasonally recovered water levels must be maintained with 20% of the total available drawdown below the initial seasonally recovered water level at the commencement of the Plan.

Resource condition analysis

- Selection of key monitoring sites:
  - should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should be able to monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
  - Features requiring priority in the Lower Lachlan Alluvium include surface-groundwater interaction in connected reaches in the east of the SDL resource unit, groundwater dependent environmental assets, the productive base of the resource in major zones of extraction, and water quality throughout.
- Analysis of historical data:
  - There is evidence of substantial drawdown in the Calivil Formation since the start of groundwater level monitoring, in the main zone of extraction with declines of greater than 10 m noted (e.g. GW030406.2)
  - The remaining storage (as shown by the aquifer saturated thickness) is generally adequate
  - Water quality data is sparse.

Lower Macquarie Alluvium (GS26)

The Lower Macquarie Alluvium is located downstream of Dubbo and includes the Macquarie and Bogan Rivers (Figure 32). The Lower Macquarie Alluvium is partially underlain by the GAB, which provides a source of groundwater in this area. While the GAB is not considered a Basin water resource under the *Water Act 2007 (Cwlth)*, many bores are screened across both the Alluvium and the GAB and hence it is difficult to differentiate extraction between the two water sources.

The Lower Macquarie Alluvium SDL resource unit incorporates a Palaeozoic basement comprised of folded metasediments. Overlying the eroded surface of the Palaeozoic rocks, are Mesozoic rocks that form the GAB intake-beds. The top of the now buried GAB sequence is a deeply weathered erosion surface that was dissected by ancient river systems (likely the predecessor of today's Macquarie River system). The erosion period lasted almost 40 million years and resulted in several deep incised valley and ridge profiles. Following the weathering period, was a period of sedimentation. This sedimentation period completely buried the valleys and ridges of the older GAB sequence with Cainozoic unconsolidated sediments. The Cainozoic alluvial sequence of the Gunnedah and Narrabri Formation comprise interbedded clay, silt, gravel and sand and form the present alluvial plains of the area (Bilge, 2007).

The Lower Macquarie Alluvium SDL resource unit was covered by the 2006 Water Sharing Plan for the Lower Macquarie Groundwater Sources. The LTAAEL under this plan was 69.3 GL/y (not including S&D). This limit was established through the Achieving Sustainable Groundwater Entitlements (ASGE) program, which had a staged reduction process and reduced groundwater use to the LTAAEL by 30 June 2016. Due to this process, the Lower Macquarie Alluvium SDL resource unit was placed in the "existing reduction program" category of the Groundwater Assessment framework.

The groundwater annual average recharge is less than SDL for this groundwater resource unit (Table 86). The initial numerical groundwater modelling carried out for the Authority indicated that the PEL was less than the BDL for this SDL resource unit and recommended further reductions in diversion limits in these systems. However, the Authority considered the additional uncertainties associated with modelling groundwater systems that are undergoing a reduction program and the resultant change in groundwater extractions. Additionally, these resource units have large groundwater storages (a minimum of 200 years at current levels of use) and there is a low risk of depleting the volume of groundwater stored in these aquifers within the period of the first Basin Plan. Given these factors the Authority considered that an approach should be adopted that allowed the NSW reduction program (ASGE) to be completed and the outcomes determined before any further changes to the SDL were considered at a later stage. For this SDL resource unit where the ASGE program was in place, the SDL in the Basin Plan has been set at the final plan limit (i.e. ASGE completion) plus S&D rights. The Authority will continue to monitor and assess the impacts of groundwater take in these systems with the aim of reviewing the plan limits on an ongoing basis.

The Lower Macquarie groundwater SDL resource unit sits within the Macquarie-Castlereagh Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 86: Summary table for the Lower Macquarie Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Lower Macquarie Alluvium (GS26)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Macquarie–Castlereagh Alluvium (GW12)
GMU(s) Covered	Lower Macquarie Alluvium (downstream of Narromine)
Annual Groundwater Recharge	62.8 GL/y
Recharge Input*	Numerical Model
PEL**	35.0 GL/y
BDL	70.7 GL/y
SDL***	70.7 GL/y
Licensed Entitlement****	69.3 GL/y
Measured Groundwater Use****	45.4 GL/y
Estimated S&D Use****	1.42 GL/y
Entitlement plus S&D	70.7 GL/y

*The results of the Lower Macquarie Alluvium numerical modelling used for the Murray–Darling Basin Sustainable Yields Project have been used to estimate recharge (CSIRO, 2008c). The model includes recharge via dryland rainfall, irrigation, river leakage and lateral flow.

**The PEL has been determined using the results from the groundwater model.

***SDL set at the ASGE reduction program limit plus S&D. The SDL recognised that the ASGE program was a ten-year reduction process that had not concluded at that time and the outcomes not yet realised. The Authority is committed to working with the NSW Government to review the SDL as the outcomes of the ASGE program are realised and new knowledge becomes available.

****All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Lower Macquarie Groundwater Source (2006). Updated S&D data was provided by the NSW Government on 10 February 2011.

Table 87: Summary of the groundwater and surface water fluxes derived from the numerical model and identified GDEs for Lower Macquarie Alluvium

Summary characteristic	Volume / name
Groundwater Discharge to Streams*	5.20 GL/y
Stream Leakage to Groundwater*	10.0 GL/y
Impact of Groundwater Extraction on Stream flow**	11.9 GL/y
Groundwater Dependent KEA	None

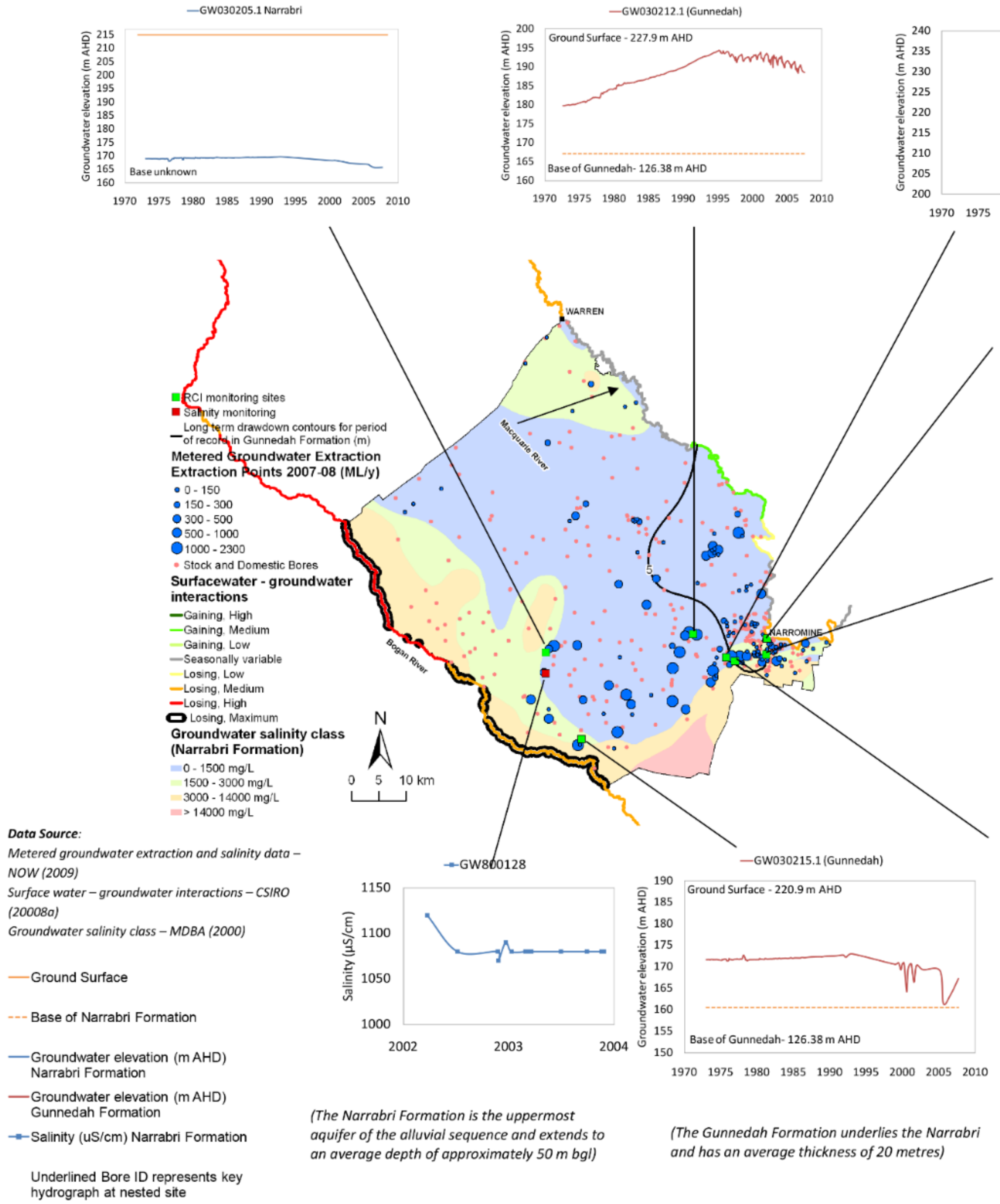
*Derived from the model results for Scenario 2 (i.e. groundwater take at the current level of entitlements).

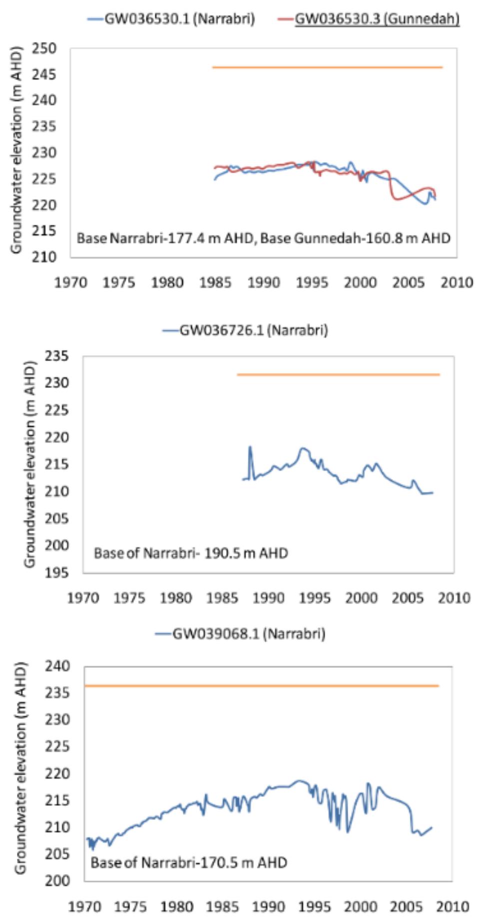
**Derived by comparing river loss under the current levels of entitlement (Scenario 2) and the no groundwater extraction scenario (Scenario 1).

Recharge risk assessment method outcome

Although the RRAM was not applied in this SDL resource unit due to the availability of the groundwater model, the risk rankings were determined to be:

- low risk for KEAs (none identified as groundwater dependent)
- low risk for KEFs
- low risk for the productive base
- a risk to the key environmental outcome
- low level of uncertainty as there is a groundwater model for this area.





Monitoring Points	Feature
GW0390205 GW800128 GW030212.1 GW030215.1 GW039068.1 GW036726.1 GW036530.3	Productive Base, Salinity
GW036535.1	Connectivity

Hydrogeology and water sharing arrangements

- The Lower Macquarie Alluvium SDL resource unit lies at the eastern end of the broad alluvial floodplain, where the Macquarie River emerges from the slightly higher relief country of the eastern valley. The primary groundwater resource in the valley is in the alluvial aquifers associated with the main rivers and prior channels of the western floodplain; groundwater from these aquifers supply irrigation, Stock, Domestic and town water supplies in the area.
- The fine-grained Gunnedah Formation extends across the region. The Narrabri Formation overlies the Gunnedah Formation and is composed of shallow alluvial fan sediments. Groundwater is contained in small discontinuous sand lenses and varies in quality and yield.
- Recharge is via rainfall infiltration, flooding events and from root zone drainage from irrigation.
- Groundwater extraction occurs largely from the deeper Gunnedah Formation
- The SDL Area is bounded by the Macquarie River to the north, and the Bogan River to the south. The Macquarie River is in direct hydraulic contact with the water table. It is losing to groundwater in the eastern section of the SDL Area where groundwater extraction is most intense. Downstream it is either seasonally varying or gaining. The water table is well below the level of the Bogan River, with an unsaturated zone below the stream.
- Existing water sharing arrangements are detailed in the Water Sharing Plan for the Lower Macquarie Groundwater Sources 2003 (October 2006). Arrangements include:
  - Water quality degradation is deemed unacceptable if salinity increases beyond beneficial use class thresholds (defined as 800 and 1500 EC). For groundwater quality of 800-1500 EC, water quality degradation is deemed unacceptable if it increases by more than 20 % of the difference between the baseline salinity and beneficial use class limit
  - The average seasonally recovered water levels over a 5 year period must be maintained within 10% of the total available drawdown below the initial seasonally recovered water level

Resource condition analysis

- Selection of key monitoring sites:
  - should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should be able to monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
  - Features requiring priority in the Lower Macquarie Alluvium include surface-groundwater interaction in zones of extraction along the Macquarie River, the productive base of the resource, and water quality throughout.
- Analysis of historical data:
  - Historical groundwater level monitoring indicates water levels rose prior to the current drought (approximately 1994/5). There has been trend of declining water levels in recent years, likely related to the expansion in extraction that accompanied the onset of drought.
  - The decline in water levels has, in places, neared the threshold set in the WSP that was based on 20% decline in aquifer saturated thicknesses from July 2002 RSWLs (GW36726.1, GW039068.1 and GW30215.1).
  - At locations where drawdown is large there is a potential risk that the semi-confined Gunnedah formation could become unconfined (e.g. GW030215.1)
  - Water quality data is sparse, however there is a risk that extraction may cause water quality decline due to induced leakage.

Figure 32: Lower Macquarie Alluvium SDL resource unit map

Lower Murray Alluvium (GS27)

The Lower Murray Alluvium SDL resource unit is located between the Murray River and Billabong Creek and includes the deeper aquifers of the Calivil Formation and Renmark Group and the Shepparton Formation sediments (Figure 33). The Calivil Formation has a high hydraulic conductivity, especially near the basin margins where alluvial fan deposits are thickest. In the west the deposits become more clay rich and also become thinner, and consequently the transmissivity decreases. The Calivil Formation outcrops in the east near Jerilderie. The Calivil Formation aquifer has the highest yields due to its transmissivity, whereas the Renmark Group is the thickest unit. Most groundwater extraction is from the Calivil Formation.

The Lower Murray Alluvium SDL resource unit was covered by the 2006 Water Sharing Plan for the Lower Murray Groundwater Source and the 2012 Water Sharing Plan for the Lower Murray Shallow Groundwater Source. The LTAAELs for these two plans were 83.7 GL/y (not including S&D), and 81.9 GL/y (including S&D), respectively. The limit for the Lower Murray Groundwater Source was established through the Achieving Sustainable Groundwater Entitlements (ASGE) program, which had a staged reduction process and reduced groundwater use to the LTAAEL by 30 June 2016. The limit for the Lower Murray Shallow Groundwater Source is based on capping the current level of development. The existing plan extraction limits have been adopted as SDLs.

The Lower Murray Alluvium groundwater SDL resource unit sits within the Murray Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 88: Summary table for the Lower Murray Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	a) Lower Murray Shallow Alluvium (GS27a) b) Lower Murray Deep Alluvium (GS27b)
Groundwater covered	a) All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground, to a depth of 20 m b) All groundwater, contained within all unconsolidated alluvial sediments deeper than 20 m below the ground surface
WRP Area	Murray Alluvium (GW8)
GMU(s) Covered	Lower Murray Alluvium (downstream of Corowa)
Recharge*	a) 337.0 GL/y b) 271.0 GL/y
Recharge Input	Numerical Model
PEL**	a) 35.5 GL/y b) 91.9 GL/y
BDL	a) 81.9 GL/y b) 88.9 GL/y
SDL***	a) 81.9 GL/y b) 88.9 GL/y
Licensed Entitlement****	a) 80.9 GL/y b) 83.7 GL/y
Measured Groundwater Use****	125.0 GL/y
Estimated S&D Use****	a) 0.99 GL/y b) 5.23 GL/y
Entitlement plus S&D	a) 81.9 GL/y b) 88.9 GL/y

*The results of the Southern Riverine Plain calibration model (1990 to 2008) were used to determine the recharge to the shallow and deep sub-units. The model includes recharge via dryland rainfall, irrigation, rivers and lateral flow.

**The PEL was determined using the results from the groundwater modelling.

***SDL set at ASGE limit plus S&D for the deep sub-unit, and NSW plan limit for the shallow sub-unit as the groundwater use represents a 'beneficial use' to control salinity (existing planning arrangements).

****All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Lower Murray Groundwater Source (2006) for the deep sub-unit, and the Water Sharing Plan for the Lower Murray Shallow Groundwater Source (2012) for the shallow sub-unit. Updated S&D data was provided by the NSW Government on 10 February 2011 for the deep sub-unit.

Table 89: Summary of the groundwater and surface water fluxes derived from the numerical model and identified GDEs for the Lower Murray Alluvium

Summary characteristic	Volume / name
Groundwater Discharge to Streams*	6.20 GL/y
Stream Leakage to Groundwater*	12.1 GL/y
Impact of Groundwater Extraction on Streamflow**	121.2 GL/y
Groundwater Dependent KEA	Koondrook–Pericoota Forest and Edward–Wakool River System (including Werai Forest)

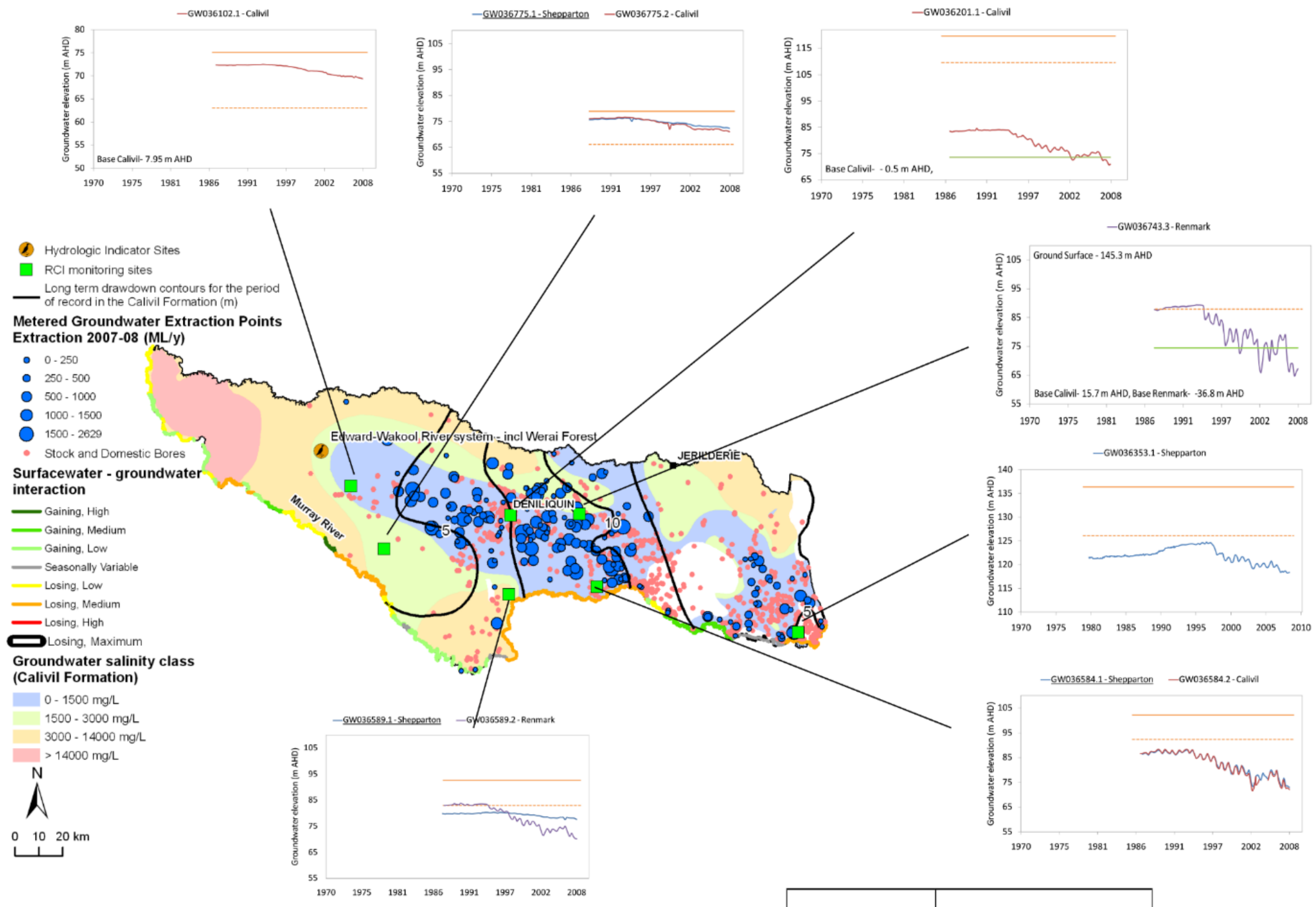
*Derived from the model results for Scenario 2 (i.e. groundwater take at the current level of entitlements).

**Derived by comparing river loss under the current levels of entitlement (Scenario 2) and the no groundwater extraction scenario (Scenario 1).

Recharge risk assessment method outcome

Although the RRAM was not applied in this SDL resource unit due to the availability of the groundwater model, the risk rankings were determined to be:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a low level of uncertainty.



Ground Surface

Base of Shepparton Formation

Groundwater elevation (m AHD) Shepparton Formation

Groundwater elevation (m AHD) Calivil Formation

Groundwater elevation (m AHD) Renmark Formation

Existing RCL levels as per current groundwater managment plans

Underlined Bore ID represents key hydrograph at nested site

Data Source:

Metered groundwater extraction – NOW (2009)

Surface water – groundwater interactions – CSIRO (2008a)

Groundwater salinity class – MDBA (2000)

(The Shepparton Formation is the uppermost aquifer of the alluvial sequence and extends to depths of 20-50 m bgl)

(The Calivil/Renmark group underlies the Shepparton Formation and extends to depths of up to 350 m bgl)

Monitoring Points	Feature
GW036102.1 GW036775.1	Indicator Site
GW036775.1 GW036201.1	Productive base, Salinity
GW036353.1 GW036584.1 GW036589.1	Connectivity

Hydrogeology and water sharing arrangements

- The Lower Murray Alluvium SDL resource unit is mainly characterised by thick sedimentary aquifers associated with Murray Basin sediments where they broaden across the Riverine Plains.
- The Renmark Group is the basal aquifer within the Riverine Plains. It is composed of alluvial sands and gravels with inter-bedded carbonaceous clay-rich units, and is hydraulically connected with the overlying Calivil Formation.
- The Calivil Formation is up to 80 m thick and consists of quartz sand and gravel – often yielding large volumes of high quality groundwater. The Calivil Formation is the primary aquifer used to provide irrigation water supply in the Lower Murray SDL resource unit.
- The Shepparton Formation overlies the Calivil Formation and usually forms the water table aquifer. It is composed of river and lake deposited sediments. The Shepparton and Calivil Formations on the Riverine Plain are loosely correlated with the Cowra and Lachlan formations respectively and are contiguous at the boundary between the Murray Uplands and the Riverine Plains.
- Groundwater in the Shepparton Formation is generally saline and there is a risk to water quality in deeper aquifers from induced leakage from shallow saline water table.
- The Murray River is in direct hydraulic connection with the groundwater. It is gaining, losing and seasonally varying throughout the SDL resource unit.
- Three key environmental assets have been identified in the SDL resource unit: the Gunbower–Koondrook–Pericoota Forests, the Edward–Wakool River System and the Barmah–Millewa Forest.
- Existing water sharing arrangements are detailed in the Water Sharing Plan for the Lower Murray Groundwater Source (October 2006) and the Water Sharing Plan for the Lower Murray Shallow Groundwater Source (April 2012). Arrangements include:
  - Water level decline is deemed unacceptable if the water levels drop below specified trigger levels, or the average water level decline exceeds 1.65 m from 2006 levels.
  - Water quality degradation is deemed unacceptable if the baseline salinity exceeds 650 EC and there is an increase in salinity of either 20% or more, or 500 EC or more
  - Land subsidence or aquifer compaction is deemed unacceptable.

Resource condition analysis

- Selection of key monitoring sites:
  - should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should be able to monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
  - Features requiring priority in the Lower Murray Alluvium SDL resource unit, include surface-groundwater interaction, groundwater dependent environmental assets, the productive base of the resource in major zones of extraction, and water quality throughout.
- Analysis of historical data:
  - Evidence of substantial drawdown from predevelopment levels in the central zone of extraction with declines of greater than 10 m noted in the Calivil Formation (e.g. GW036201, GW036743). Water levels have also declined significantly in the Shepparton formation – e.g. at GW036584. The extent to which this is caused by extraction or climate is important to ascertain.
  - Water levels are below the base of the Shepparton Formation in some locations (GW036353.1, GW036584.1, GW036589.1)
  - In places the water level declines exceed the 1.65 m threshold specified in the WSP
  - Water quality data is sparse.

Figure 33: Lower Murray Alluvium SDL resource unit map

Lower Murrumbidgee Alluvium (GS28)

The Lower Murrumbidgee Alluvium SDL resource unit is located downstream of Narrandera and extends west to the western boundary of the Murrumbidgee Region (Figure 34). The area contains three main aquifers: the shallow Shepparton Formation, and the deeper Calivil Formation and Renmark Group. The Calivil Formation provides most of the available fresh groundwater.

The Lower Murrumbidgee Alluvium SDL resource unit was covered by the 2006 Water Sharing Plan for the Lower Murrumbidgee Groundwater Sources. The LTAAEL under this plan for the deep source (Calivil/Renmark) was 270.0 GL/y and for the shallow source was 10.0 GL/y (not including S&D). This limit was established through the Achieving Sustainable Groundwater Entitlements (ASGE) program, which had a staged reduction process and reduced groundwater use to the LTAAEL by 30 June 2016. Due to this process, the Lower Murrumbidgee Alluvium SDL resource unit was placed in the “existing reduction program” category of the Groundwater Assessment framework.

The Lower Murrumbidgee groundwater SDL resource unit sits within the Murrumbidgee Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 90: Summary table for the Lower Murrumbidgee Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	a) Lower Murrumbidgee Shallow Alluvium (GS28a) b) Lower Murrumbidgee Deep Alluvium (GS28b)
Groundwater covered	a) All groundwater contained within the alluvial sediments to a depth of 40 m or to the bottom of the Shepparton Formation, whichever is the deeper b) All groundwater contained within the Calivil Formation and Renmark Group unconsolidated alluvial sediments greater than a depth of 40 m
WRP Area	Murrumbidgee Alluvium (GW9)
GMU(s) Covered	Lower Murrumbidgee Alluvium (downstream of Narrandera)
Recharge*	438.0 GL/y
Recharge Input	Numerical Model
PEL**	327.0 GL/y
BDL	a) 26.9 GL/y b) 273.6 GL/y
SDL***	a) 26.9 GL/y b) 273.6 GL/y
Licensed Entitlement****	a) 16.0 GL/y b) 270.0 GL/y
Measured Groundwater Use****	323.5 GL/y
Estimated S&D Use****	a) 10.9 GL/y b) 3.63 GL/y
Entitlement plus S&D	a) 26.9 GL/y b) 273.6 GL/y

*The results of the Lower Murrumbidgee Alluvium numerical modelling (2004-05 level of extraction) have been used to estimate recharge (CSIRO, 2008e). The model includes recharge via dryland rainfall, irrigation, rivers and lateral flow.

**The PEL was determined using the results from the groundwater modelling.

***SDL set at ASGE reduction program limit plus S&D, and water used for salinity control.

****All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Lower Murrumbidgee Groundwater Sources (2006), and from updated S&D data provided by the NSW Government on 25 October 2011. An extra 6.0 GL/y was also added to the shallow sub-zone to account for groundwater used for water table control, as advised by the NSW Government on 25 October 2011.

Table 91: Summary of the groundwater and surface water fluxes derived from the numerical model and identified GDEs for the Lower Murrumbidgee Alluvium

Summary characteristic	Volume / name
Groundwater Discharge to Streams*	1.50 GL/y
Stream Leakage to Groundwater*	99.0 GL/y
Impact of Groundwater Extraction on Streamflow**	40.0 GL/y
Groundwater Dependent KEA	Lower Murrumbidgee River Floodplain, Great Cumbung Swamp and Fivebough–Tuckerbil Ramsar Site

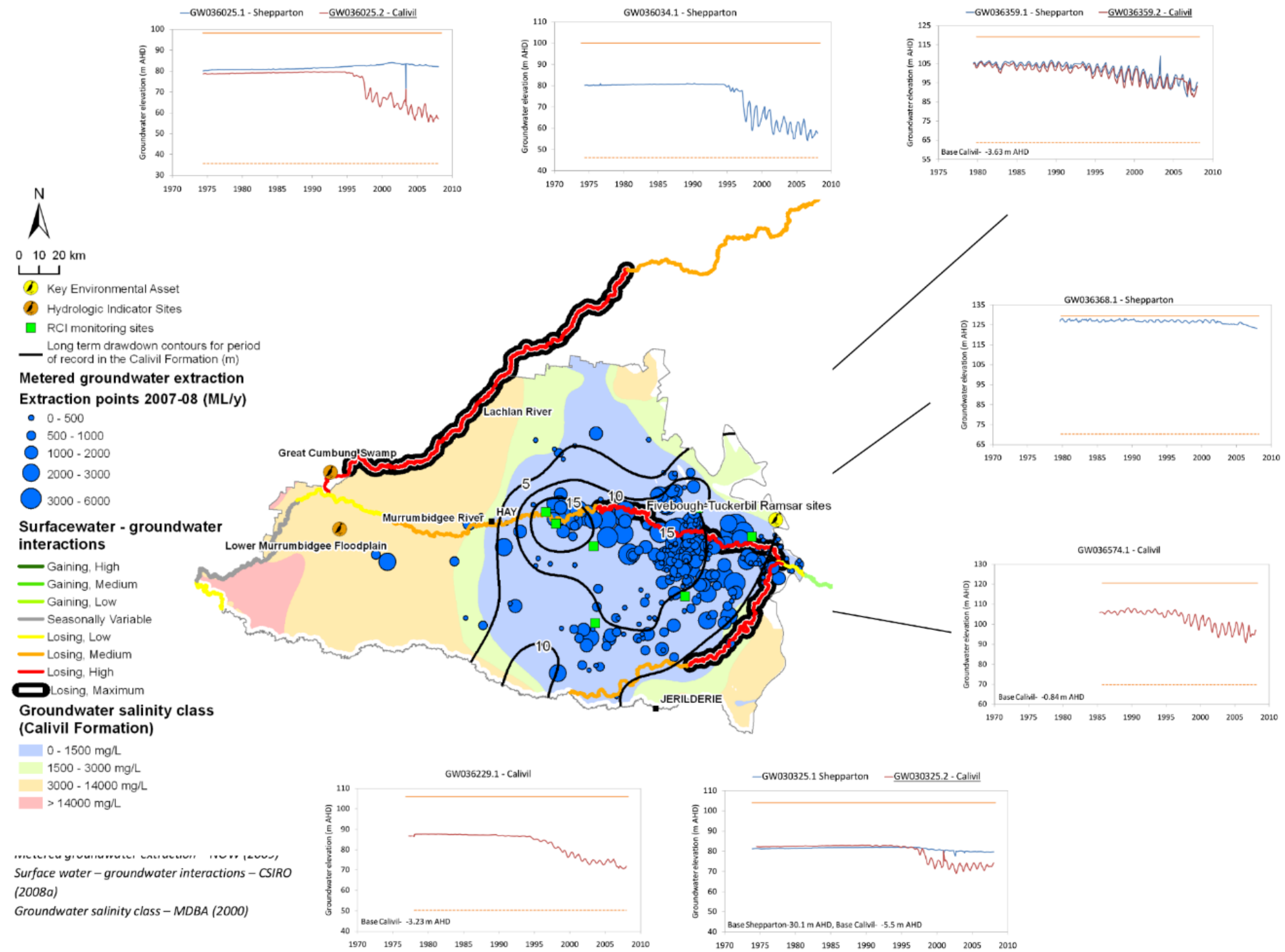
*Derived from the model results for Scenario 2 (i.e. groundwater take at the current level of entitlements).

**Derived by comparing river loss under the current levels of entitlement (Scenario 2) and the no groundwater extraction scenario (Scenario 1).

Recharge risk assessment method outcome

Although the RRAM was not applied in this SDL resource unit due to the availability of the groundwater model, the risk rankings were determined to be:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a low level of uncertainty.



Ground Surface

Base of Shepparton Formation

Groundwater elevation (m AHD) Shepparton Formation

Groundwater elevation (m AHD) Calivil Formation

Underlined Bore ID represents key hydrograph at nested site

(The Shepparton Formation is the uppermost aquifer of the alluvial sequence and extends to an average depth of approximately 65 m bgl)

(The Calivil Formation underlies the Shepparton and has an average thickness of approximately 80 m)

Monitoring Points	Feature
GW036368.1	Indicator Site
GW036025.2 GW036229.1 GW030325.2 GW036574.1 GW036359.2	Productive base, Salinity
GW036034.1 GW036368.1	Connectivity

Hydrogeology and water sharing arrangements

- The aquifers of the Lower Murrumbidgee Alluvium consist of unconsolidated alluvial fan sediments that broaden at the point where the Murrumbidgee River emerges onto the riverine plain near Narrandera.
- The sediments are subdivided into a broad and highly heterogeneous Shepparton Formation unconfined aquifer and underlying leaky confined aquifers in the Calivil Formation and Renmark Group.
- Groundwater is abstracted from all aquifers, but primarily from the Calivil formation.
- The main sources of recharge are the river, infiltration of irrigation accessions and rainfall.
- There is a regional flux of groundwater from east to west.
- Large-scale extraction for irrigation commenced in the late 1980s and has increased steadily to current levels of more than 300 GL/y/year.
- Most extraction occurs from the Calivil formation and occurs in the zone of good quality groundwater (< 1500 mg/L). It is apparent that the impacts associated with extraction (e.g. drawdown) are more localised than the extent of this zone.
- Current groundwater management arrangements are detailed in the Water Sharing Plan for the Lower Murrumbidgee Groundwater Sources 2003 (updated October 2006)
  - Water quality degradation is deemed unacceptable if groundwater salinity increases to beyond beneficial use class thresholds
  - Performance indicators are listed (but not specified) relating to changes in: climate adjusted levels, levels adjacent to groundwater dependent ecosystems, groundwater quality, socio-economic benefits, and structural integrity of the aquifer etc.

Resource condition analysis

- Selection of key monitoring sites:
  - should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should be able to monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
  - Features requiring priority in the Mid Murrumbidgee Alluvium include surface-groundwater interaction where streams are in close connection with the aquifer, groundwater dependent environmental assets, the productive base of the resource in major zones of extraction, areas at risk of subsidence, and water quality throughout.
- Analysis of historical data:
  - There is evidence of substantial drawdown in the Calivil Formation since the start of monitoring, with up to 20 m drawdown in parts of the region (e.g. GW036025.2, GW036034.1) and greater than 5 m throughout much of the productive zone.
  - Groundwater levels have also declined in the vicinity of the Fivebough–Tuckerbil Ramsar site (GW36580.1).
  - Despite the drawdown there is generally still sufficient storage available in terms of aquifer saturated thickness due to the extensive thickness of the aquifers within the SDL resource unit. However at locations where drawdown is large there is a potential risk that the semi-confined Calivil formation could become unconfined (e.g. GW036034.1, GW036025.2)
  - Water quality data is sparse.

Figure 34: Lower Murrumbidgee Alluvium SDL resource unit map

Lower Namoi Alluvium (GS29)

The Lower Namoi Alluvium SDL resource unit is located downstream of Narrabri on the Namoi River (

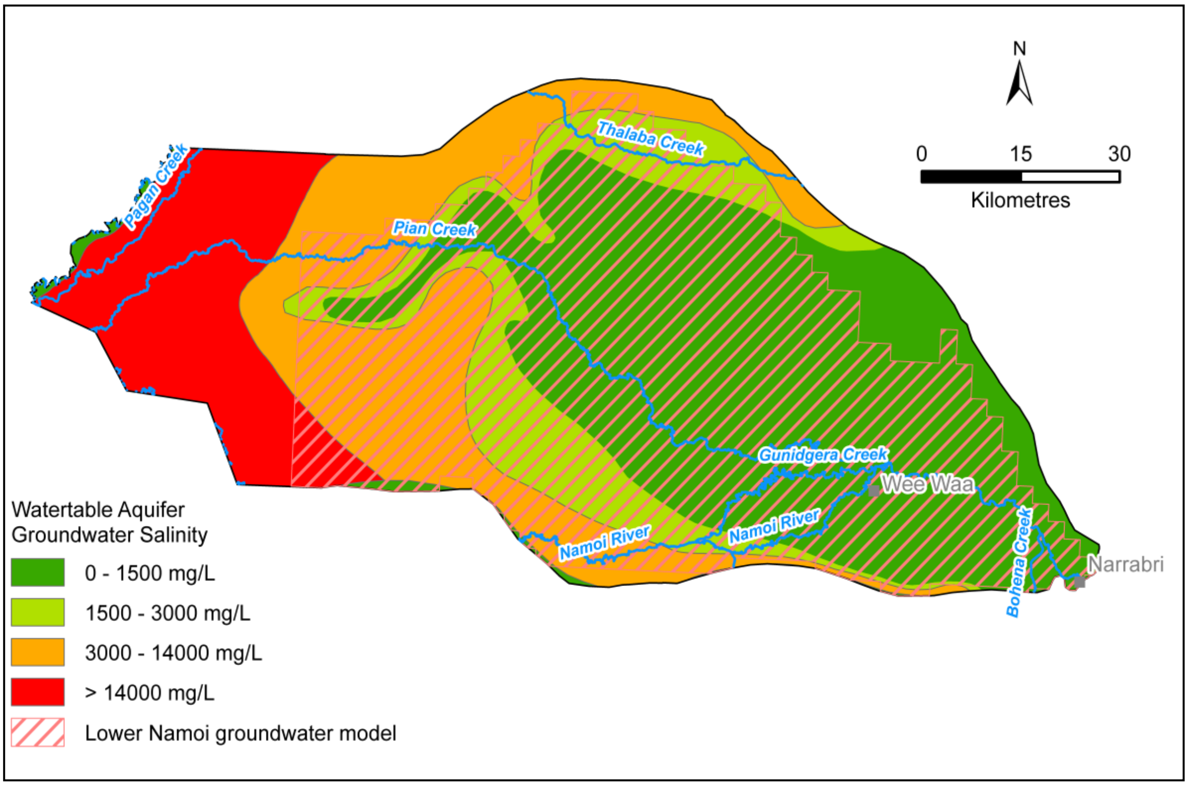


Figure 35Figure 35 and Figure 36). The area contains three main aquifers: the unconfined Narrabri Formation, the semi-confined Gunnedah Formation and the confined Cubbaroo Formation. The upper aquifers are laterally extensive, whereas the Cubbaroo Formation is a palaeochannel facies with limited extent.

The Lower Namoi Alluvium SDL resource unit was covered by the 2006 Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources. The LTAAEL under this plan for the Lower Namoi Alluvial Water Source was 86.0 GL/y (not including S&D). This limit was established through the Achieving Sustainable Groundwater Entitlements (ASGE) program, which had a staged reduction process and reduced groundwater use to the LTAAEL by 30 June 2017. Due to this process, the Lower Namoi Alluvium SDL resource unit was placed in the "existing reduction program" category of the Groundwater Assessment framework.

The groundwater annual average recharge is less than SDL for this groundwater resource unit (Table 92). The numerical groundwater modelling carried out for the Authority indicated that the PEL was less than the BDL for this SDL resource unit and recommended further reductions in diversion limits in these systems. However, the Authority considered the additional uncertainties associated with modelling groundwater systems that are undergoing a reduction program and the resultant change in groundwater extractions. Additionally, these resource units have large groundwater storages (a minimum of 200 years at current levels of use) and there is a low risk of depleting the volume of groundwater stored in these aquifers within the period of the first Basin Plan. The large storages also suggest that the overall risk to the resource is relatively low for the period of the first Basin Plan. Given these factors the Authority considered that an approach should be adopted that allowed the reduction program to be completed and the outcomes determined before any further changes to the SDL were considered at a later stage. For this SDL resource unit where the ASGE program was taking place, the SDL in the Basin Plan has been set at the final plan limit (i.e. ASGE completion) plus S&D rights. The Authority will continue to monitor and assess the impacts of groundwater take in these systems with the aim of reviewing the plan limits on an ongoing basis.

The Lower Namoi Alluvium groundwater SDL resource unit sits within the Namoi Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 92: Summary table for the Lower Namoi Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Lower Namoi (GS29)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Namoi Alluvium (GW14)
GMU(s) Covered	Lower Namoi Alluvium
Recharge (RRAM Step 1)*	68.2 GL/y
Recharge Input	Numerical Model
PEL**	74.6 GL/y
BDL	88.3 GL/y
SDL***	88.3 GL/y
Licensed Entitlement****	86.0 GL/y
Measured Groundwater Use****	99.8 GL/y
Estimated S&D Use****	2.25 GL/y
Entitlement plus S&D	88.3 GL/y

*The results of the Lower Namoi Alluvium numerical modelling (2004-05 level of extraction) have been used to estimate recharge (CSIRO, 2007b). The model includes recharge via dryland rainfall, irrigation, rivers, creeks, flooding and lateral flow.

**The PEL was determined using the results from the groundwater model (70.0 GL/y) and the RRAM for the area outside the model domain (4.61 GL/y).

***SDL set at ASGE reduction program limit plus S&D. The SDL recognised that the ASGE program was a ten-year reduction process that had not concluded at that time and the outcomes not yet realised. The Authority is committed to working with the NSW Government to review the SDL as the outcomes of the ASGE program are realised and new knowledge becomes available.

****All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources (2006), and from updated S&D data provided by the NSW Government on 10 February 2011.

Table 93: Summary of the groundwater and surface water fluxes derived from the numerical model and identified GDEs for the Lower Namoi Alluvium

Summary characteristic	Volume / name
Groundwater Discharge to Streams*	0.60 GL/y
Stream Leakage to Groundwater*	40.0 GL/y
Impact of Groundwater Extraction on Streamflow**	38.0 GL/y
Groundwater Dependent KEA	None

*Derived from the model results for Scenario 2 (i.e. groundwater take at the current level of entitlements).

**Derived by comparing river loss under the current levels of entitlement (Scenario 2) and the no groundwater extraction scenario (Scenario 1).

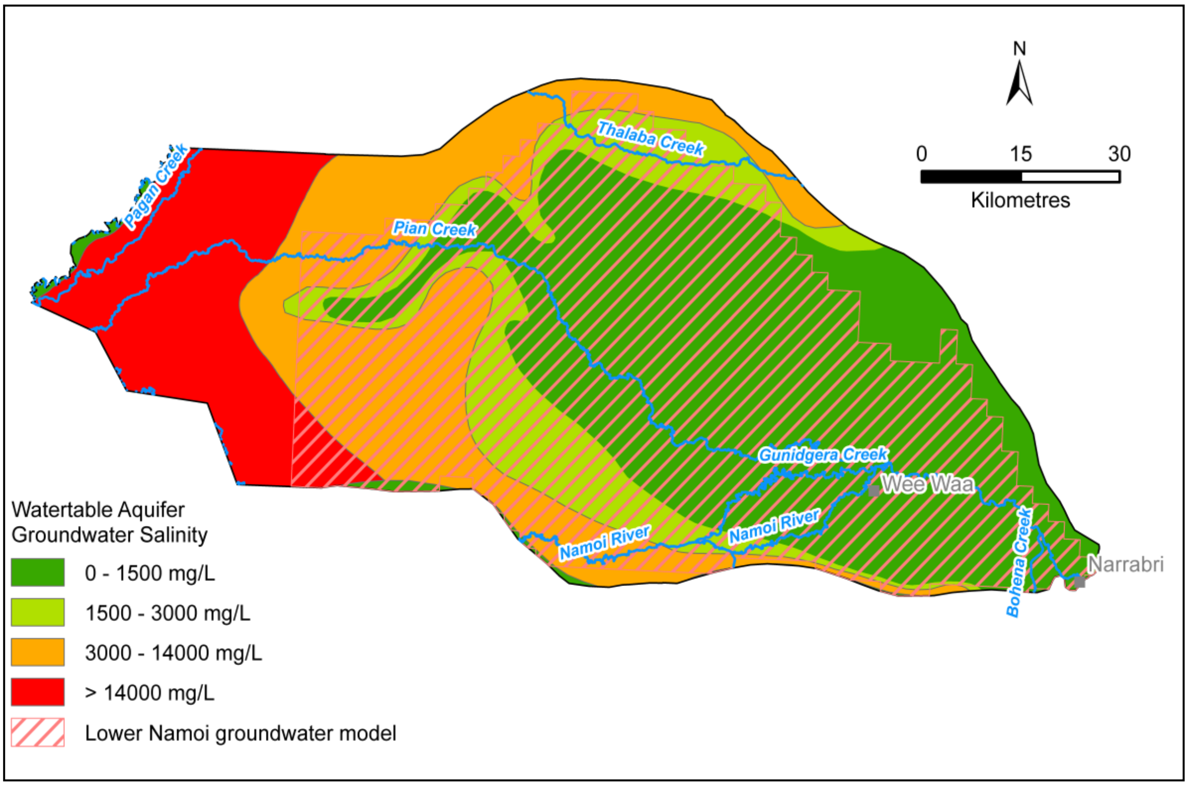


Figure 35: Lower Namoi Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 94 and Table 95 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a low level of uncertainty.

Table 94: RRAM summary table for the Lower Namoi Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	Yes	Yes	No	**Risk to ESLT**	Low
				% Area	48%	14%	38%	**Uncertainty Level**	Low
SF	0.70	0.70	0.70	**SF**	0.80	0.90	N/A	**SF**	N/A

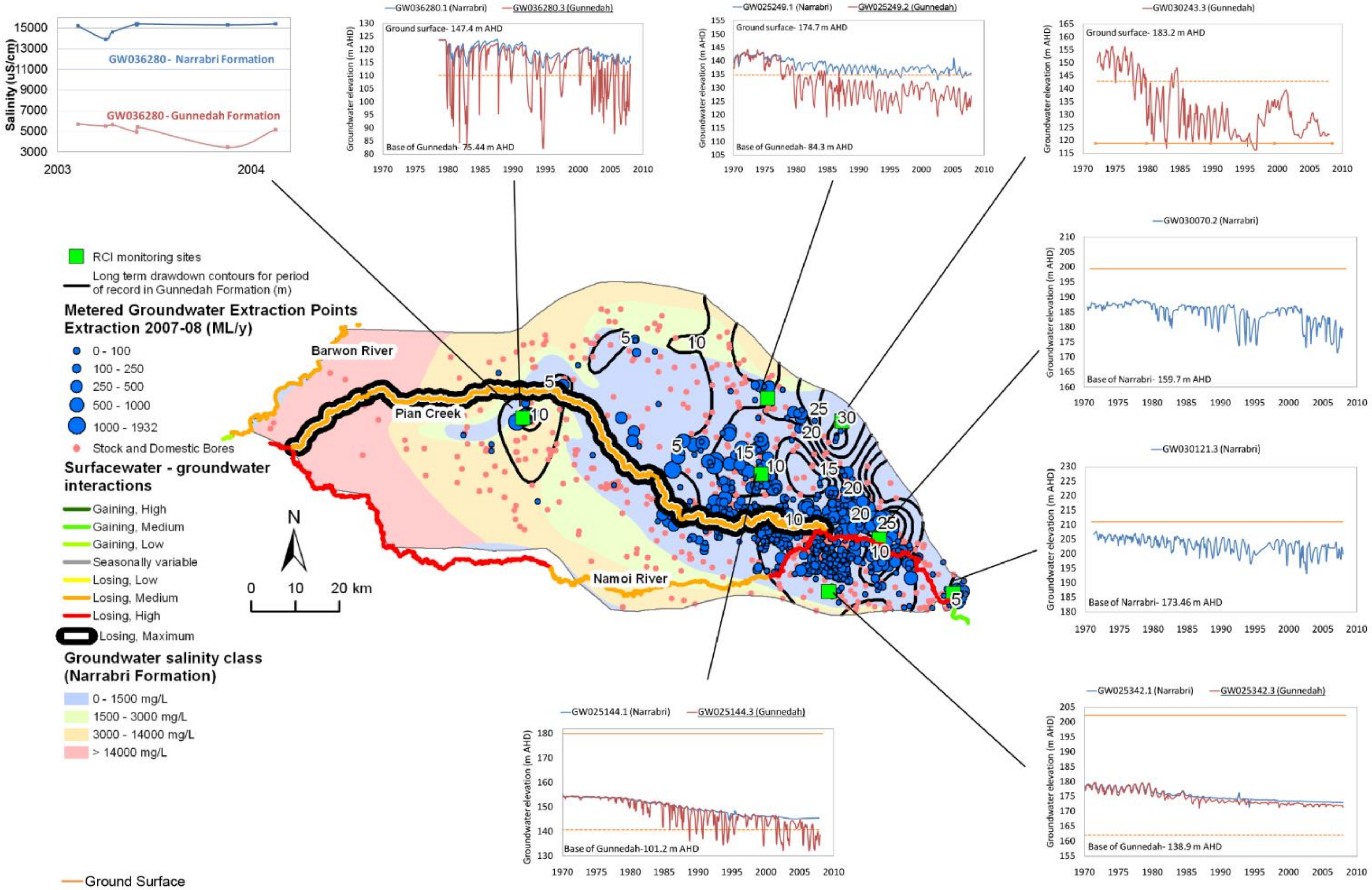
Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater.

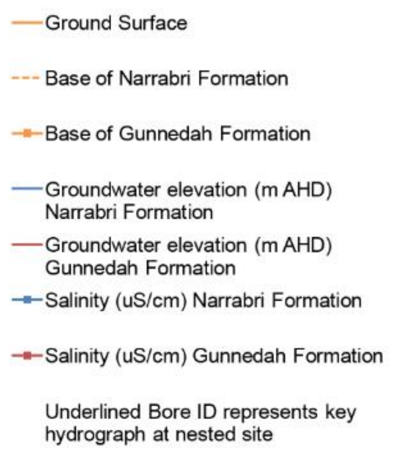
Table 95: PEL summary table for the Lower Namoi Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge to non-modelled zones 6, 7, 9, 10 (GL/y)*	1.20	0.37	2.10	3.20	6.87
SF	0.56	0.63	0.70	0.70	N/A
PEL (GL/y)**	0.67	0.23	1.47	2.24	4.61

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

**PEL is for the non-modelled portion of the SDL resource unit (30% of the total).





(The Narrabri Formation is the uppermost aquifer of the alluvial sequence and extends to an average depth of approximately 40 m bgl)

(The Gunnedah Formation underlies the Narrabri and has an average thickness of 40 metres)

Data Source:

Metered groundwater extraction and salinity data – NOW (2009)
Surface water – groundwater interactions – CSIRO (2008a)
Groundwater salinity class – MDBA (2000)

Monitoring Points	Feature
GW030070.2 GW030121.3	Connectivity
GW036280.3 GW025249.1 GW030243.3 GW025144.3 GW025342.3	Productive base, Salinity

Hydrogeology and water sharing arrangements

- The aquifer system of the Lower Namoi Valley comprises unconsolidated sediments of inter-bedded clays, sands and gravels associated with the Namoi River and its tributaries
- There are two alluvial aquifer systems identified with most areas of the Lower Namoi: the shallow Narrabri Formation and the deeper Gunnedah Formation. An aquifer called the Cubbaroo Formation underlies the Gunnedah Formation
- There is no difference discernible between the aquifer systems and they act as a single aquifer in some areas to the east
- Recharge to the groundwater system on the alluvial plain is primarily via leakage from the stream channel under normal flows, leakage from overbank flooding and infiltration from rainfall. There is a downward movement of groundwater from the Narrabri to the Gunnedah Formation in the eastern parts of the plain and the direction is reversed at the western margin.
- The rivers are in direct hydraulic contact with the water table at the eastern margin of the plain. An unsaturated zone develops further west where the water table falls well below the streams and surface water leaks to the underlying aquifer
- Most extraction occurs from the Gunnedah Formation, within the zone of low groundwater (TDS < 1500 mg/L).
- Existing water sharing arrangements are detailed in the Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources 2003. Arrangements include:
  - Water quality degradation is deemed unacceptable if groundwater salinity increases to beyond beneficial use class thresholds
  - Acceptable and unacceptable water level declines are not specified.

Resource condition analysis

- Selection of key monitoring sites:
  - should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should be able to monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
  - Features requiring priority in the Lower Namoi Alluvium include surface-groundwater interaction in the east of the catchment where streams are highly connected, the productive base of the resource in major zones of extraction, and water quality throughout.
- Analysis of historical data:
  - There is evidence of substantial drawdown in the Gunnedah Formation since the start of monitoring in the early 1970s, particularly to the north of the river in the major extraction zones (e.g. bores GW025144, GW030243, GW025249)
  - The remaining storage within the Narrabri Formation appears to be limited in places as shown by the aquifer saturated thickness and in some cases has become unsaturated (GW025144, GW030243, GW025249).
  - Water quality data is sparse, but is shown in the west of the region by bore GW36280.

Figure 36: Detailed Lower Namoi Alluvium SDL resource unit map

Manilla Alluvium (GS30)

The Manilla Alluvium SDL resource unit is located in the Namoi River Catchment (Figure 37). The area is associated with Yarramanbully Creek, Manilla River and Namoi River, and includes the town of Manilla.

The Manilla Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources. The LTAAEL for the water source was 1.23 GL/y, which was based on capping groundwater use at the current level of development.

This SDL resource unit was identified as a connected system where groundwater discharge provides base flow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion. Therefore, the MDBA capped groundwater use at the current level of development and SDL has been set at estimated current use (the state plan extraction limit) to ensure that the KEF (i.e. base flows) is not compromised.

The Manilla Alluvium groundwater SDL resource unit sits within the Namoi Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 96: Summary table for the Manilla Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Manilla Alluvium (GS30)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Namoi Alluvium (GW14)
GMU(s) Covered	Miscellaneous Alluvium of Barwon Region
Recharge*	12.6 GL/y
Recharge Input	WAVES recharge modelling
PEL	0.63 GL/y
BDL	1.23 GL/y
SDL**	1.23 GL/y
Licensed Entitlement***	3.65 GL/y
Measured Groundwater Use***	1.21 GL/y
Estimated S&D Use***	0.02 GL/y
Entitlement plus S&D	3.67 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources (2012).

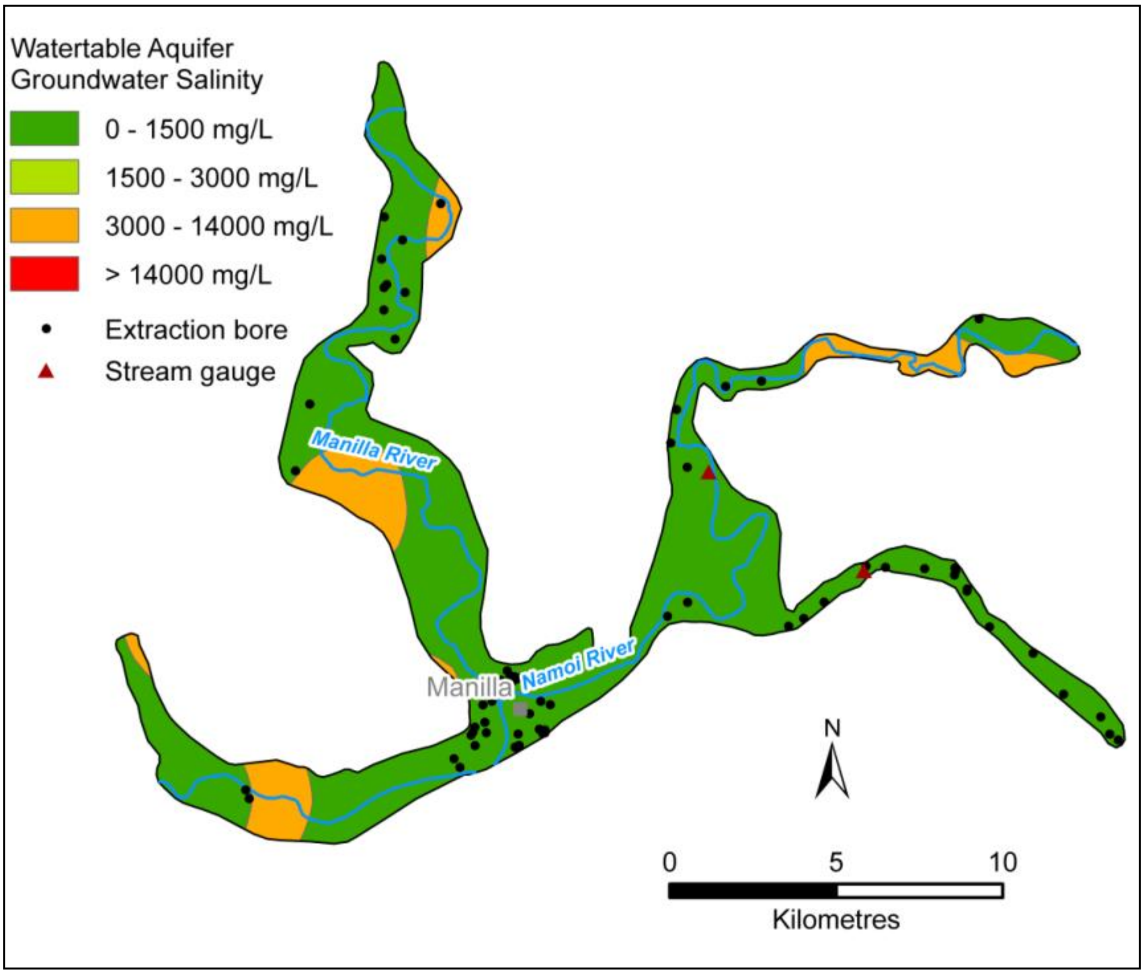


Figure 37: Manilla Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 97 and Table 98 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- high risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 97: RRAM summary table for the Manilla Alluvium

<table>
<tr><th rowspan="2">RRAM Step 2 Risks to KEA, KEF and PB</th><th rowspan="2">KEA</th><th rowspan="2">KEF</th><th rowspan="2">PB</th><th rowspan="2">RRAM Step 3 Risks to fresh water</th><th colspan="3">Salinity Class (KEO)</th><th rowspan="2" colspan="2">RRAM Step 4 Uncertainty</th></tr>
<tr><th>Class 1</th><th>Class 2</th><th>Class 3 & 4</th></tr>
<tr><td rowspan="2">Risk Ranking</td><td rowspan="2">Low</td><td rowspan="2">High</td><td rowspan="2">High</td><td>Risk (Y/N)</td><td>No</td><td>No</td><td>No</td><td>Risk to ESLT</td><td>High</td></tr>
<tr><td>% Area</td><td>85%</td><td>0%</td><td>15%</td><td>Uncertainty Level</td><td>High</td></tr>
<tr><td>SF</td><td>0.70</td><td>0.10</td><td>0.10</td><td>SF</td><td>N/A</td><td>N/A</td><td>N/A</td><td>SF</td><td>0.50</td></tr>
</table>

Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater.

Table 98: PEL summary table for the Manilla Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	11.0	0.0	1.58	0.0	12.6
SF	0.05	N/A	0.05	N/A	N/A
PEL (GL/y)	0.55	0.0	0.08	0.0	0.63

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Mid-Murrumbidgee Alluvium (GS31)

The Mid-Murrumbidgee Alluvium SDL resource unit is a relatively narrow alluvial system associated with the Murrumbidgee River and major tributaries between Gundagai and Narrandera (Figure 38 and Figure 39). The area contains two main aquifers, the Cowra Formation and the basal Lachlan Formation, which overlie a paleo-valley of weathered bedrock. The Lachlan Formation provides the majority of groundwater due to the higher hydraulic conductivity compared to the Cowra Formation.

The Mid-Murrumbidgee Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for the Murrumbidgee Unregulated and Alluvial Water Sources. The LTAAEL for the water sources that make up this SDL resource unit was 53.5 GL/y, which was based on capping groundwater use at the current level of development. This SDL resource unit was identified as a connected system where groundwater discharge provides base flow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion. Therefore, the MDBA capped groundwater use at the current level of development and SDL has been set at estimated current use (the state plan extraction limit) to ensure that the KEF (i.e. base flows) is not compromised.

The Mid-Murrumbidgee Alluvium SDL resource unit sits within the Murrumbidgee Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 99: Summary table for the Mid-Murrumbidgee Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Mid-Murrumbidgee Alluvium (GS31)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Murrumbidgee Alluvium (GW9)
GMU(s) Covered	Mid-Murrumbidgee Alluvium (upstream of Narrandera)
Recharge (RRAM Step 1)*	73.2 GL/y
Recharge Input	Numerical Model
PEL**	52.8 GL/y
BDL	53.5 GL/y
SDL***	53.5 GL/y
Licensed Entitlement****	80.0 GL/y
Measured Groundwater Use****	52.7 GL/y
Estimated S&D Use****	0.80 GL/y
Entitlement plus S&D	80.8 GL/y

*Recharge derived from the results of the Mid-Murrumbidgee Alluvium groundwater modelling using the PEL scenario. Recharge inputs include rainfall, irrigation, river and flood.

**The PEL has been determined using the results from the groundwater model (52.8 GL/y) and the RRAM for the area outside the model domain (0.82 GL/y).

***SDL is set at current use (connected resources).

****All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Murrumbidgee Unregulated and Alluvial Water Sources (2012).

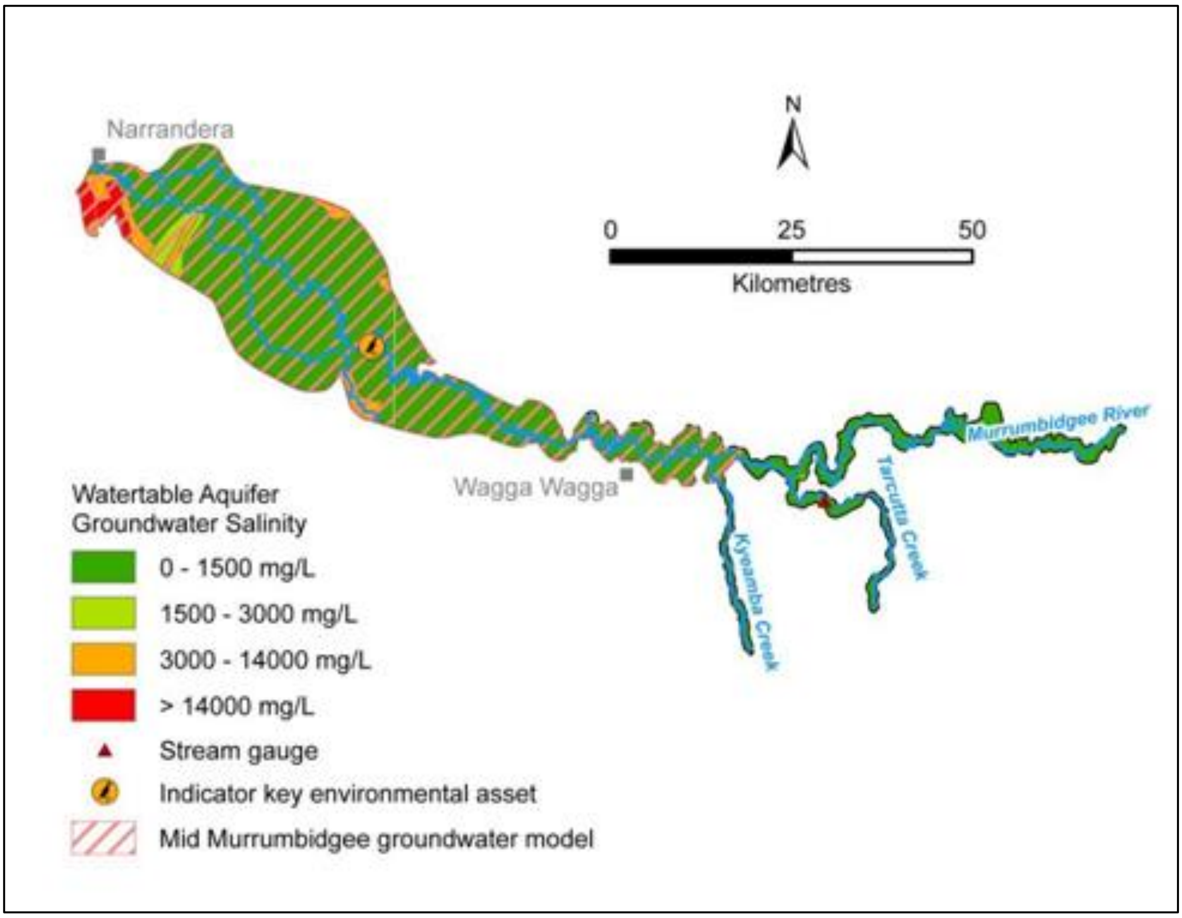


Figure 38: Mid-Murrumbidgee SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 100 and Table 101 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- high risk for KEAs
- high risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a low level of uncertainty.

Table 100: RRAM summary table for the Mid-Murrumbidgee

<table>
<tr><th rowspan="2">RRAM Step 2 Risks to KEA, KEF and PB</th><th rowspan="2">KEA</th><th rowspan="2">KEF</th><th rowspan="2">PB</th><th rowspan="2">RRAM Step 3 Risks to fresh water</th><th colspan="3">Salinity Class (KEO)</th><th colspan="2" rowspan="2">RRAM Step 4 Uncertainty</th></tr>
<tr><th>Class 1</th><th>Class 2</th><th>Class 3 & 4</th></tr>
<tr><td rowspan="2">Risk Ranking</td><td rowspan="2">High</td><td rowspan="2">High</td><td rowspan="2">Low</td><td>Risk (Y/N)</td><td>No</td><td>No</td><td>No</td><td>Risk to ESLT</td><td>High</td></tr>
<tr><td>% Area</td><td>91%</td><td>2%</td><td>7%</td><td>Uncertainty Level</td><td>Low</td></tr>
<tr><td>SF</td><td>0.10</td><td>0.10</td><td>0.70</td><td>SF</td><td>N/A</td><td>N/A</td><td>N/A</td><td>SF</td><td>N/A</td></tr>
</table>

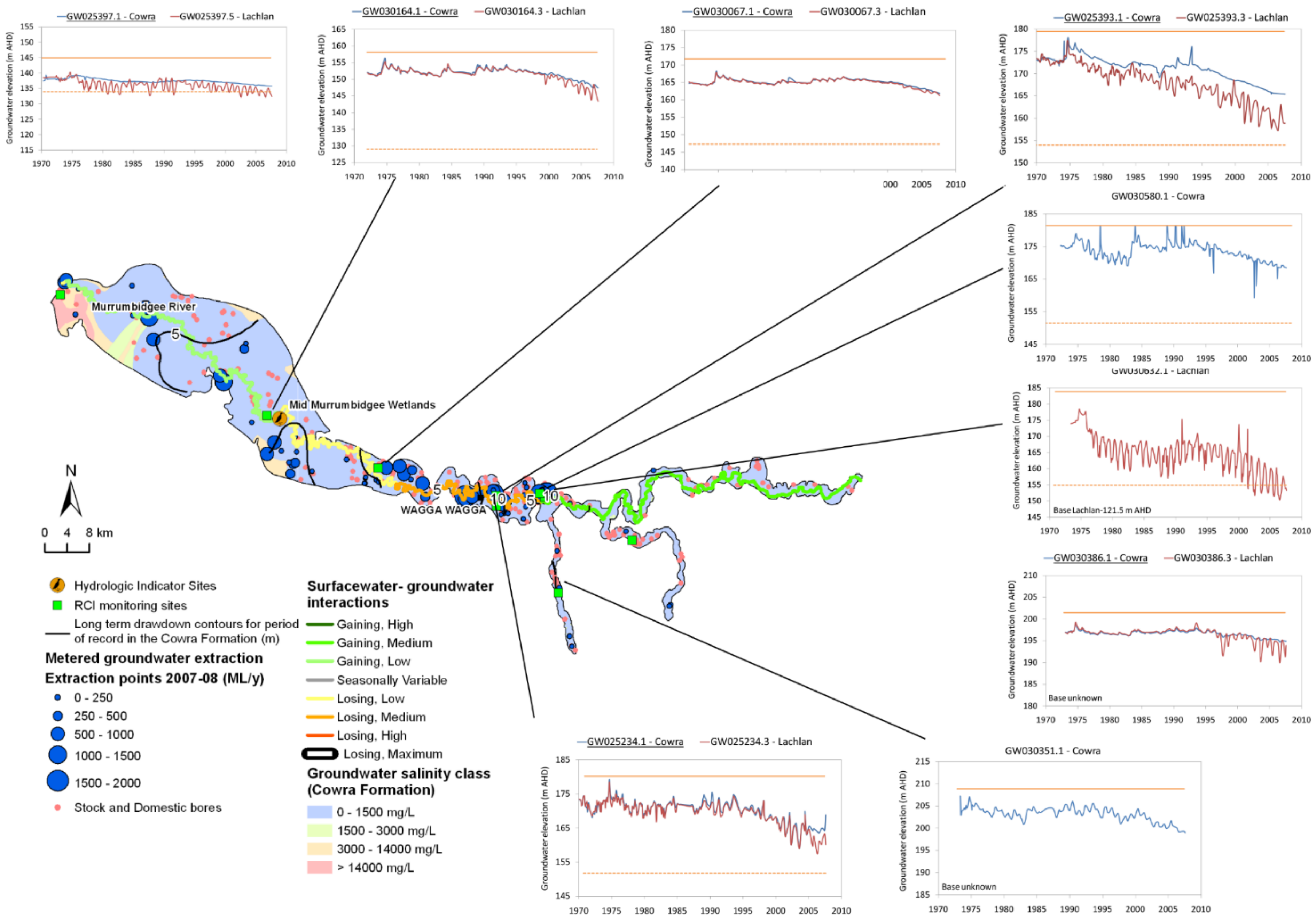
Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater.

Table 101: PEL summary table for the Mid-Murrumbidgee

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	8.20	0.04	0.0	0.0	8.24
SF	0.10	0.10	N/A	N/A	N/A
PEL (GL/y)**	0.82	0.004	0.0	0.0	0.82

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

**PEL is for the non-modelled portion of the SDL resource unit (14% of the total).



Ground Surface

Base of Cowra Formation

Groundwater elevation (m AHD) Cowra Formation

Groundwater elevation (m AHD) Lachlan Formation

Underlined Bore ID represents key hydrograph at nested site

(The Cowra Formation is the uppermost aquifer of the alluvial sequence and extends to an average depth of approximately 25 m bgl)

(The Lachlan Formation underlies the Cowra and has an average thickness of 50 metres)

Data Source:

Metered groundwater extraction – NOW (2009)

Surface water – groundwater interactions – CSIRO (2008a)

Groundwater salinity class – MDBA (2000)

Monitoring Points	Feature
GW030164.1	Indicator Site
GW025234.3 GW025393.3 GW030362.1 GW025397.5	Productive base, Salinity
GW030351.1 GW030386.1 GW025393.1 GW030580.1 GW030067.1 GW025397.1	Connectivity

Hydrogeology and water sharing arrangements

- The Mid-Murrumbidgee Alluvium SDL resource unit consists of alluvium filling a deep 'V' shaped valley in the weathered basement. It is divided into two main geological layers: the upper unconfined Cowra Formation and the lower confined Lachlan Formation.
- The Cowra Formation consists of unconsolidated sand, gravel, silt and clay. It has a maximum thickness of 80 m.
- The Lachlan Formation also has a maximum thickness of approximately 80 m and is made up of well sorted, clean quartz sand and gravel. The deeper Lachlan Formation forms the main productive aquifer
- Most extraction occurs from the Lachlan Formation. Close to half of all groundwater extraction is for town water supply from bore fields located in close proximity to Wagga Wagga. Irrigation development since the late 1990s has led to a significant increase in usage.
- The influence of the current dry conditions, lower river levels and development of the groundwater resource has seen a change in the relationship between the Murrumbidgee River and the groundwater system. There are indications that groundwater levels in the Cowra aquifer that were previously above the river height are now below the base of the river, suggesting a change in the relationship between the two systems
- Groundwater salinity in the Lachlan formation generally ranges from 150 to 950 EC becoming more saline with distance from the river. The Cowra formation is more saline and can be significantly greater than 1000µS/cm where the aquifer is isolated from the river.
- The Mid Murrumbidgee alluvium is part of the Murrumbidgee Unregulated and Alluvial Water Sharing Plan administered under the *Water Management Act 2000*.

Resource condition analysis

- Selection of key monitoring sites:
  - should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should be able to monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
  - Features requiring priority in the Mid Murrumbidgee Alluvium include surface-groundwater interaction throughout the catchment, groundwater dependent environmental assets, the productive base of the resource in major zones of extraction (particularly near town water supply bore fields), and water quality throughout.
- Analysis of historical data:
  - Evidence of substantial drawdown in the Lachlan Formation since the start of groundwater level monitoring, in the western, and central areas of Wagga Wagga and in the Gumly Gumly area with declines of greater than 10 m noted (e.g. GW025393, GW030632, GW025234)
  - The remaining storage within the Cowra Formation appears to be limited in places (as shown by the aquifer saturated thickness) with potential for the semi-confined Lachlan Formation becoming unconfined (e.g. GW025397, GW025393, GW025234, GW025393, GW030632)
- Water quality data is sparse.

Figure 39: Detailed Mid-Murrimbidgee SDL resource unit map

NSW Border Rivers Alluvium (GS32)

The NSW Border Rivers Alluvium SDL resource unit is located within the topographic depressions of the river valley, where the parent rock has been eroded and riverine sediments deposited (Figure 40). The area incorporates two aquifers that overlie basement rock and are separated by an aquitard. The water table aquifer consists of unconsolidated clay, sand and gravel to about 10 to 30 m depth. It is unconfined and responds hydraulically to flooding. The aquitard comprises of low permeability clay layers. The deeper aquifer is semi-confined and comprises consolidated clay, sandstone and gravel up to about 50 m thick and extends to about 50 to 100 m below the ground surface (Welsh, 2007). Nested observation sites indicate that the upper and lower alluvial aquifers are in hydraulic connection.

The NSW Border Rivers Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources. The LTAAEL for the water sources that make up this SDL resource unit was 8.40 GL/y, which was based on capping groundwater use at the current level of development. This was adopted as the SDL.

The NSW Border Rivers Alluvium groundwater SDL resource unit sits within the NSW Border Rivers Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 102: Summary table for the NSW Border Rivers Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	NSW Border Rivers Alluvium (GS32)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	NSW Border Rivers Alluvium (GW18)
GMU(s) Covered	Border Rivers Alluvium
Recharge (RRAM Step 1)*	19.0 GL/y
Recharge Input	WAVES recharge modelling
PEL	4.76 GL/y
BDL	8.40 GL/y
SDL**	8.40 GL/y
Licensed Entitlement***	15.9 GL/y
Measured Groundwater Use***	8.16 GL/y
Estimated S&D Use***	0.24 GL/y
Entitlement plus S&D	16.1 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers) and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL is set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources (2012).

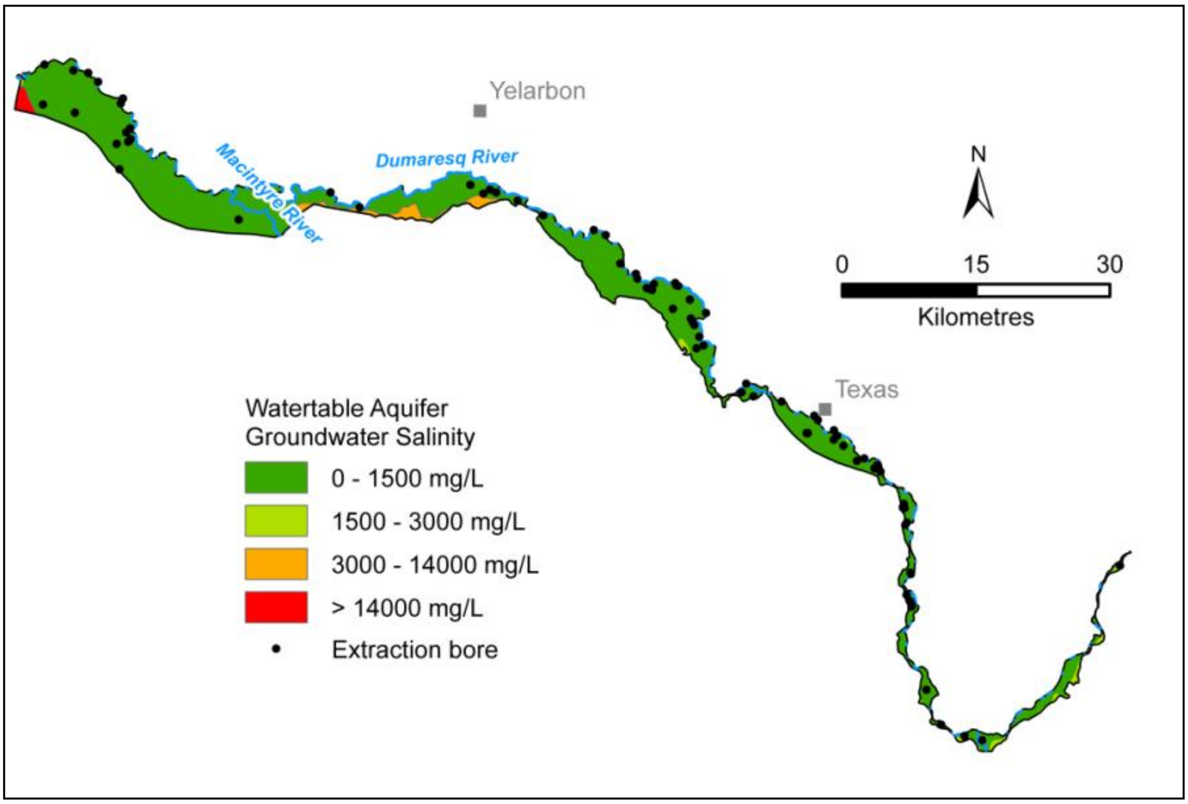


Figure 40: NSW Border Rivers Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 103 and Table 104 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- medium risk for KEFs
- medium risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 103: RRAM summary table for the NSW Border Rivers Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Med	Med	Risk (Y/N)	No	No	No	Risk to ESLT	Medium
				% Area	94%	2%	4%	Uncertainty Level	High
SF	0.70	0.50	0.50	SF	N/A	N/A	N/A	SF	0.50

Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater.

Table 104: PEL summary table for the NSW Border Rivers Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	17.6	0.87	0.56	0.01	19.0
SF	0.25	0.25	0.25	0.25	N/A
PEL (GL/y)	4.40	0.22	0.14	0.003	4.76

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

NSW Border Rivers Tributary Alluvium (GS33)

The NSW Border Rivers Tributary Alluvium SDL resource unit is located in the Border Rivers catchment in northern NSW (Figure 41). The Alluvium is associated with the lower Macintyre River, near its convergence with the Dumaresq River. The Alluvial sediments of both the Macintyre and Dumaresq Rivers upstream of the confluence are confined to narrow valleys, dominated by sandy to silty clay with minor gravels. The upper alluvial deposits are approximately 10 to 30 m thick.

The NSW Border Rivers Tributary Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources. The LTAAEL for the water sources that make up this SDL resource unit was 0.41 GL/y, which was based on capping groundwater use at the current level of development. This was adopted as the SDL.

The NSW Border Rivers Tributary Alluvium groundwater SDL resource unit sits within the NSW Border Rivers Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 105: Summary table for the NSW Border Rivers Tributary Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	NSW Border Rivers Tributary Alluvium (GS33)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	NSW Border Rivers Alluvium (GW18)
GMU(s) Covered	Miscellaneous Alluvium of Barwon Region
Recharge (RRAM Step 1)*	4.50 GL/y
Recharge Input	WAVES recharge modelling
PEL	0.22 GL/y
BDL	0.41 GL/y
SDL**	0.41 GL/y
Licensed Entitlement***	1.61 GL/y
Measured Groundwater Use***	No metered use
Estimated S&D Use***	0.13 GL/y
Entitlement plus S&D	1.74 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL is set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources (2012).

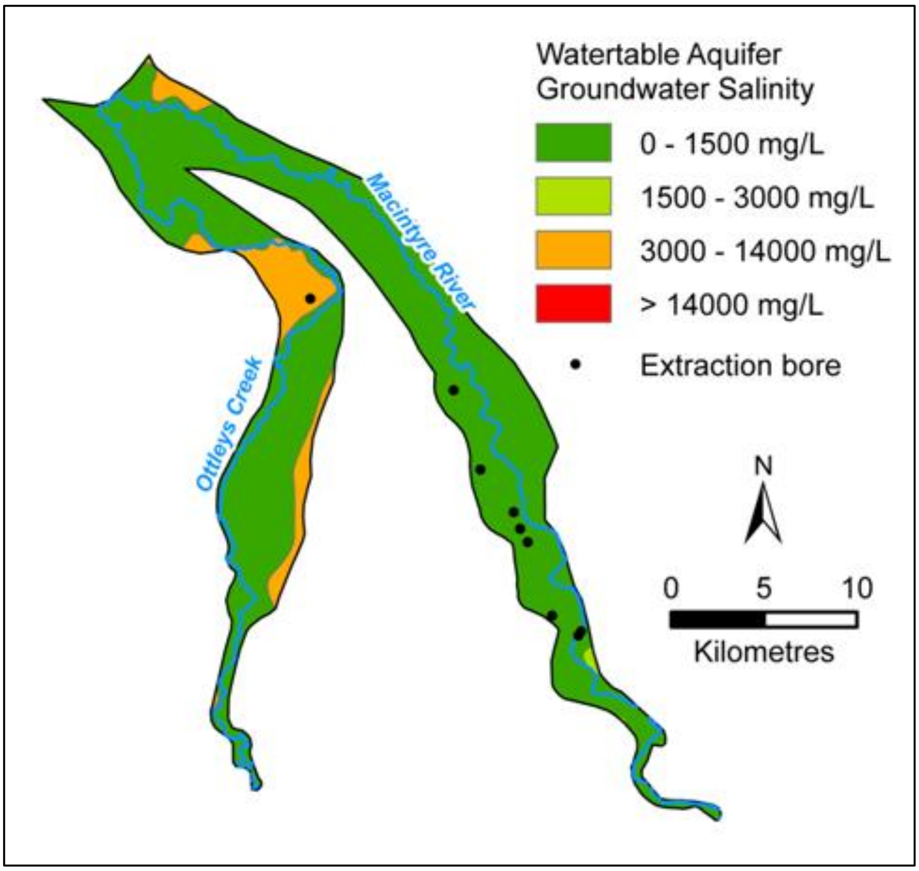


Figure 41: NSW Border Rivers Tributary Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 106 and Table 107 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 106: RRAM summary table for the NSW Border Rivers Tributary Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	**KEA**	**KEF**	**PB**	**RRAM Step 3 Risks to fresh water**	**Salinity Class (KEO)**			**RRAM Step 4 Uncertainty**	
					Class 1	**Class 2**	**Class 3 & 4**		
Risk Ranking	Low	High	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	91%	0%	9%	**Uncertainty Level**	High
SF	0.70	0.10	0.70	**SF**	N/A	N/A	N/A	**SF**	0.50

Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater.

Table 107: PEL summary table for the NSW Border Rivers Tributary Alluvium

Salinity	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Total**
Recharge (GL/y)*	4.23	0.0	0.25	0.0	4.48
SF	0.05	0.05	0.05	0.05	N/A
PEL (GL/y)	0.21	0.0	0.01	0.0	0.22

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

NSW GAB Surat Shallow (GS34)

The NSW GAB Surat Shallow SDL resource unit is located in northern NSW and incorporates the shallow Quaternary and Tertiary sediments that overly the GAB sediments on the plains of northern NSW (Figure 42). The area contains the lower reaches of the Barwon, Gwydir, Namoi and Castlereagh Rivers and the sediments of their recent and ancient pathways. Generally, the hydrogeology comprises undifferentiated alluvial deposits that have not been the focus of hydrogeological investigations. Further east the alluvial formations of the major river valleys contain coarse-grained materials, which grade laterally into the alluvial deposits of the SDL resource unit. It is assumed that this alluvium is finer grained than further east and does not contain widespread coarse deposits.

The NSW GAB Surat Shallow SDL resource unit was covered by the 2011 Water Sharing Plan for the NSW Great Artesian Basin Shallow Groundwater Sources. The LTAAEL for this water source was 143.3 GL/y, which was based on the NSW risk assessment framework. The Basin Plan set the SDL at 15.5 GL/y using the unassigned groundwater assessment (25% factor).

The NSW GAB Surat Shallow groundwater SDL resource unit sits within the Great Artesian Basin Shallow WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 108: Summary table for the NSW GAB Surat Shallow

Summary characteristic	Name / description / volume
SDL resource unit	NSW GAB Surat Shallow (GS34)
Groundwater covered	All groundwater contained within: a) all geological formations to a depth of 60 m below the surface of the ground; and b) all unconsolidated alluvial sediments; excluding groundwater contained in the following SDL resource units: Lower Namoi Alluvium and Lower Gwydir Alluvium
WRP Area	NSW Great Artesian Basin Shallow (GW13)
GMU(s) Covered	GAB Alluvial
Recharge (RRAM Step 1)*	180.2 GL/y
Recharge Input	WAVES recharge modelling
PEL	42.3 GL/y
BDL	6.57 GL/y
SDL**	15.5 GL/y
Licensed Entitlement***	5.59 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.98 GL/y
Entitlement plus S&D	6.57 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Great Artesian Basin Shallow Groundwater Sources (2011).

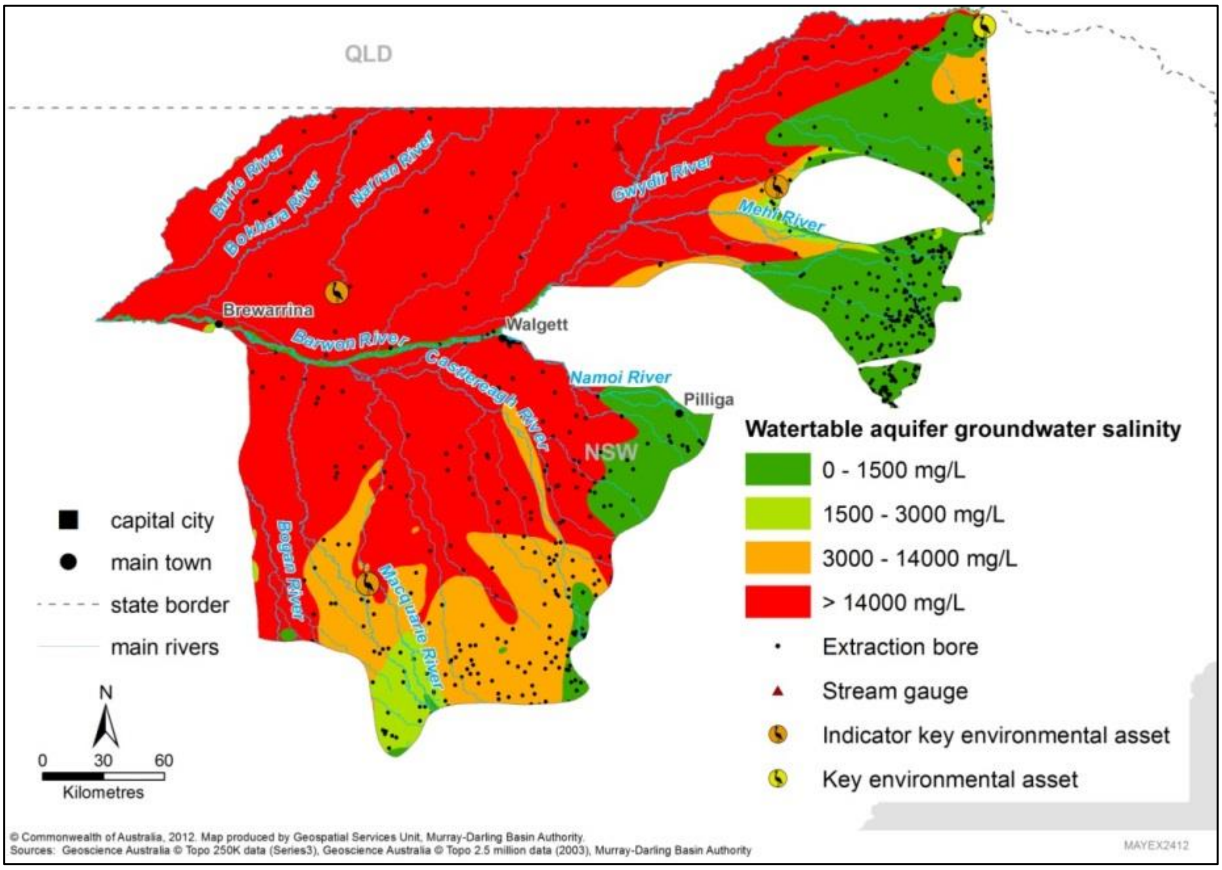


Figure 42: NSW GAB Surat Shallow SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 109 and Table 110 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- medium risk for KEAs
- medium risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a high level of uncertainty.

Table 109: RRAM summary table for the NSW GAB Surat Shallow

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Med	Med	Low	Risk (Y/N)	Yes	Yes	No	Risk to ESLT	Medium
				% Area	16%	2%	82%	Uncertainty Level	High
SF	0.50	0.50	0.70	SF	0.80	0.90	N/A	SF	0.50

Table 110: PEL summary table for the NSW GAB Surat Shallow

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	53.8	1.71	23.0	101.7	180.2
SF	0.20	0.23	0.25	0.25	N/A
PEL (GL/y)	10.8	0.39	5.74	25.4	42.3

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

NSW GAB Warrego Shallow (GS35)

The NSW GAB Warrego Shallow SDL resource unit is located in north-west NSW (Figure 43). The area includes all groundwater that lies above the GAB and is bound by the Queensland border, the Upper Darling Alluvium and the NSW GAB Shallow Surat. The area incorporates shallow Mesozoic sediments that overly the main GAB formations in the plains of north-west NSW. These are mostly shallow, deeply weathered materials with a thin layer of alluvial or windblown sediments ranging in grain size from gravels and sands to clays and extending down to 20 m depth (Quarantotto, 1986). The groundwater is primarily used for S&D purposes.

The NSW GAB Warrego Shallow SDL resource unit was covered by the 2011 Water Sharing Plan for the NSW Great Artesian Basin Shallow Groundwater Sources. The LTAAEL for this water source was 115.7 GL/y, which was based on the NSW risk assessment framework. The Basin Plan set the SDL at 33.4 GL/y using the unassigned groundwater assessment (25% factor).

The NSW GAB Warrego Shallow groundwater SDL resource unit sits within the Great Artesian Basin Shallow WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 111: Summary table for the NSW GAB Warrego Shallow

Summary characteristic	Name / description / volume
SDL resource unit	NSW GAB Warrego Shallow (GS35)
Groundwater covered	All groundwater contained within: a) all geological formations to a depth of 60 m below the surface of the ground; and b) all unconsolidated alluvial sediments; excluding groundwater contained in the following SDL resource units: Upper Darling Alluvium
WRP Area	NSW Great Artesian Basin Shallow (GW13)
GMU(s) Covered	GAB Alluvial
Recharge (RRAM Step 1)*	250.6 GL/y
Recharge Input	WAVES recharge modelling
PEL	131.6 GL/y
BDL	0.65 GL/y
SDL**	33.4 GL/y
Licensed Entitlement***	0 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.65 GL/y
Entitlement plus S&D	0.65 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Great Artesian Basin Shallow Groundwater Sources (2011).

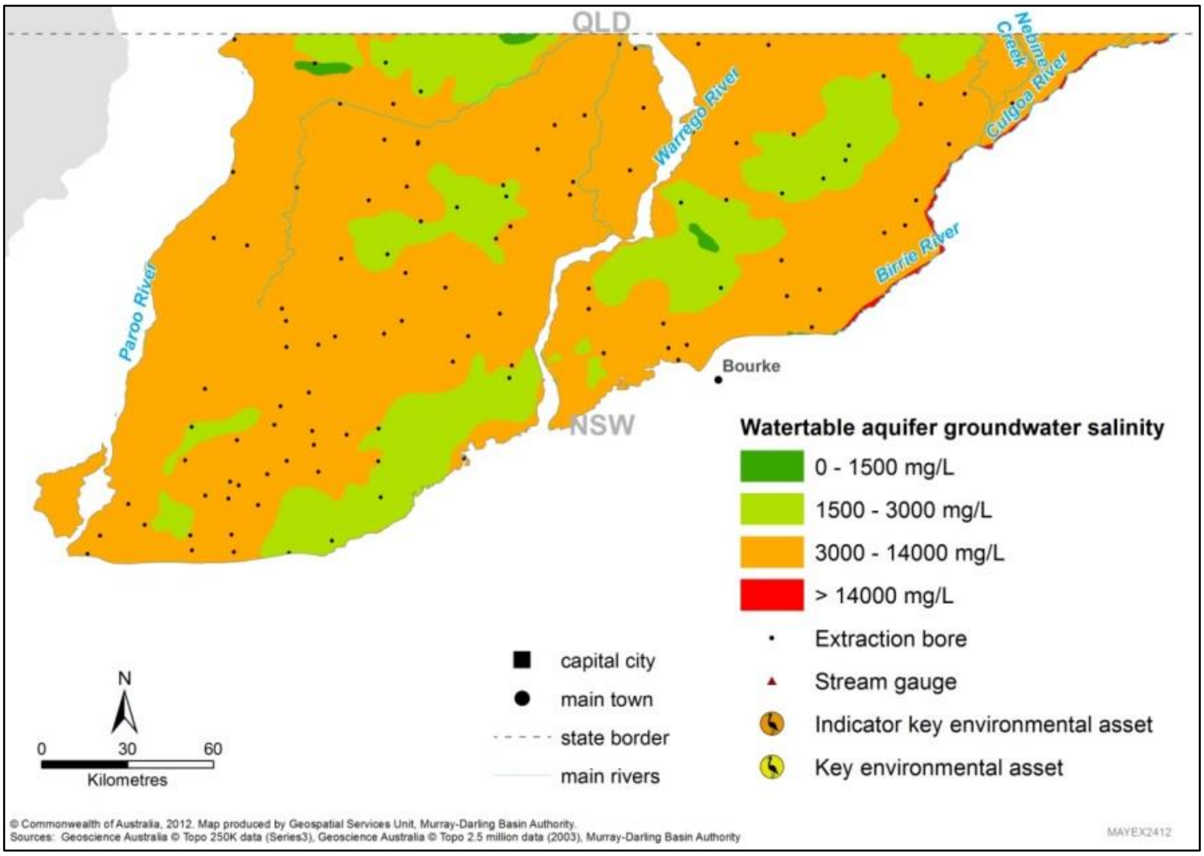


Figure 43: NSW GAB Warrego Shallow SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 112 and Table 113 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 112: RRAM summary table for the NSW GAB Warrego Shallow

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	Risk (Y/N)	No	No	No	Risk to ESLT	Low
				% Area	0%	29%	70%	Uncertainty Level	High
SF	0.70	0.70	0.70	SF	N/A	N/A	N/A	SF	0.75

Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater

Table 113: PEL summary table for the NSW GAB Warrego Shallow

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	0.79	73.6	175.9	0.25	250.5
SF	0.53	0.53	0.53	0.53	N/A
PEL (GL/y)	0.41	38.7	92.4	0.13	131.6

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

NSW GAB Central Shallow (GS36)

The NSW GAB Central Shallow SDL resource unit is located in north-west NSW (Figure 44). The area includes all groundwater that lies above the GAB between the MDB boundary and the alluvial deposits associated with the Paroo River. The area incorporates shallow Mesozoic sediments that overly the main GAB formations in the plains of north-west NSW. These are mostly shallow, deeply weathered materials with a thin layer of alluvial or windblown sediments ranging in grain size from gravels and sands to clays and extending up to 20 m (Quarantotto, 1986). The groundwater is primarily used for S&D purposes.

The NSW GAB Central Shallow SDL resource unit was covered by the 2011 Water Sharing Plan for the NSW Great Artesian Basin Shallow Groundwater Sources. The LTAAEL for this water source was 145.5 GL/y, which was based on the NSW risk assessment framework. The Basin Plan set the SDL at 8.83 GL/y using the unassigned groundwater assessment (25% factor).

The NSW GAB Central Shallow groundwater SDL resource unit sits within the Great Artesian Basin Shallow WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 114: Summary table for the NSW GAB Central Shallow

Summary characteristic	Name / description / volume
SDL resource unit	NSW GAB Central Shallow (GS36)
Groundwater covered	All groundwater contained within: a) all geological formations to a depth of 60 m below the surface of the ground; and b) all unconsolidated alluvial sediments; excluding groundwater contained in the following SDL resource units: Upper Darling Alluvium
WRP Area	NSW Great Artesian Basin Shallow (GW13)
GMU(s) Covered	GAB Alluvial
Recharge (RRAM Step 1)*	65.9 GL/y
Recharge Input	WAVES recharge modelling
PEL	34.6 GL/y
BDL	0.25 GL/y
SDL**	8.83 GL/y
Licensed Entitlement***	0.003 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.24 GL/y
Entitlement plus S&D	0.24 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Great Artesian Basin Shallow Groundwater Sources (2011).

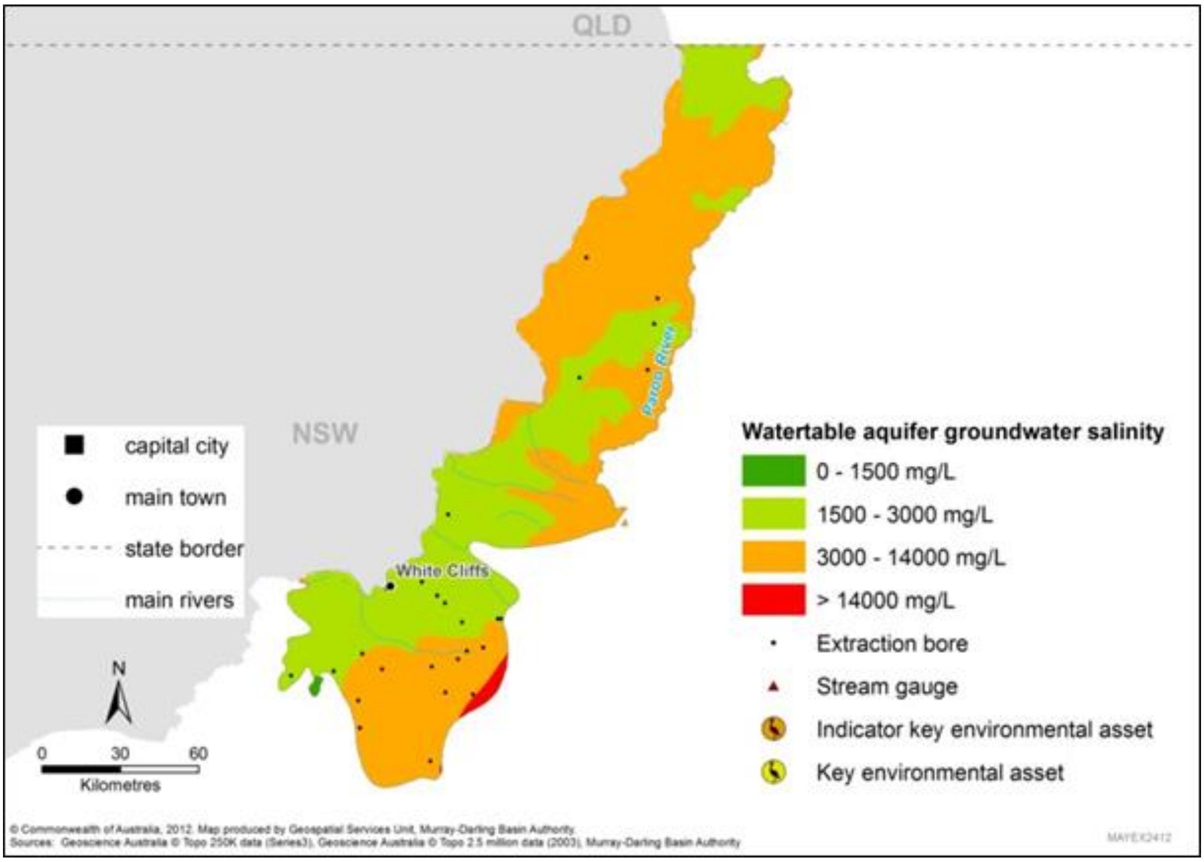


Figure 44: NSW GAB Central Shallow SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 115 and Table 116 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 115: RRAM summary table for the NSW GAB Central Shallow

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	Low
				% Area	0%	29%	70%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	N/A	N/A	N/A	**SF**	0.75

Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater.

Table 116: PEL summary table for the NSW GAB Central Shallow

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	0.21	19.4	46.3	0.06	66.0
SF	0.53	0.53	0.53	0.53	N/A
PEL (GL/y)	0.11	10.2	24.3	0.03	34.6

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

New England Fold Belt (GS37)

The New England Fold Belt SDL resource unit is located in north-east NSW and encompasses the upper reaches of the Namoi, Gwydir and Dumaresq Rivers (Figure 45). The area comprises an eroded mountain range bounded to the south and west by border thrust fault systems. The central zone consists of moderately to highly deformed Silurian to Permian rocks which increase in the degree of deformation from west to east. The basement rocks include phyllites, cherts, sediments comprising mudstones, sandstones, limestones, conglomerates and tuffs with interbedded rhyolites. The western zone of the New England Fold Belt is bounded to the east by the Great Serpentine Belt and to the west by the Hunter–Mooki Thrust Fault System.

The New England Fold Belt SDL resource unit was covered by the 2011 Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources. Buried groundwater resources are also contained within the New England Fold Belt SDL resource unit. In the case of the buried Peel Fractured Rock groundwater resource, this was covered in the 2010 Water Sharing Plan for the Peel Valley Regulated, Unregulated, Alluvium and Fractured Rock Water Sources.

The LTAAEL in the 2011 Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources was 204.8 GL/y, which was based on the NSW risk assessment framework. The MDBA has a policy not to adopt the plan extraction limit as the SDL for SDL resource units where the state plan limit is greater than the level of entitlement. Accordingly, the MDBA did not adopt the plan extraction limit as the SDL for this SDL resource unit. Using the RRAM and the unassigned groundwater assessment, the MDBA set the SDL at 55.1 GL/y.

The New England Fold Belt SDL resource unit sits within the NSW Murray–Darling Basin Fractured Rock WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 117: Summary table for the New England Fold Belt

Summary characteristic	Name / description / volume
SDL resource unit	New England Fold Belt (GS37)
Groundwater covered	All groundwater excluding groundwater contained in the following SDL resource units: Inverell Basalt, Liverpool Ranges Basalt MDB, Manilla Alluvium, Peel Valley Alluvium, Upper Namoi Alluvium, Upper Namoi Tributary Alluvium, Upper Gwydir Alluvium, NSW Border Rivers Alluvium and NSW Border Rivers Tributary Alluvium
WRP Area	NSW Murray–Darling Basin Fractured Rock (GW11)
GMU(s) Covered	New England Fold Belt
Recharge (RRAM Step 1)*	2451.5 GL/y
Recharge Input	WAVES recharge modelling
PEL	122.6 GL/y
BDL	32.9 GL/y
SDL**	55.1 GL/y
Licensed Entitlement***	7.67 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	14.5 GL/y
Entitlement plus S&D	22.2 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via baseflow and/or evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources (2011).

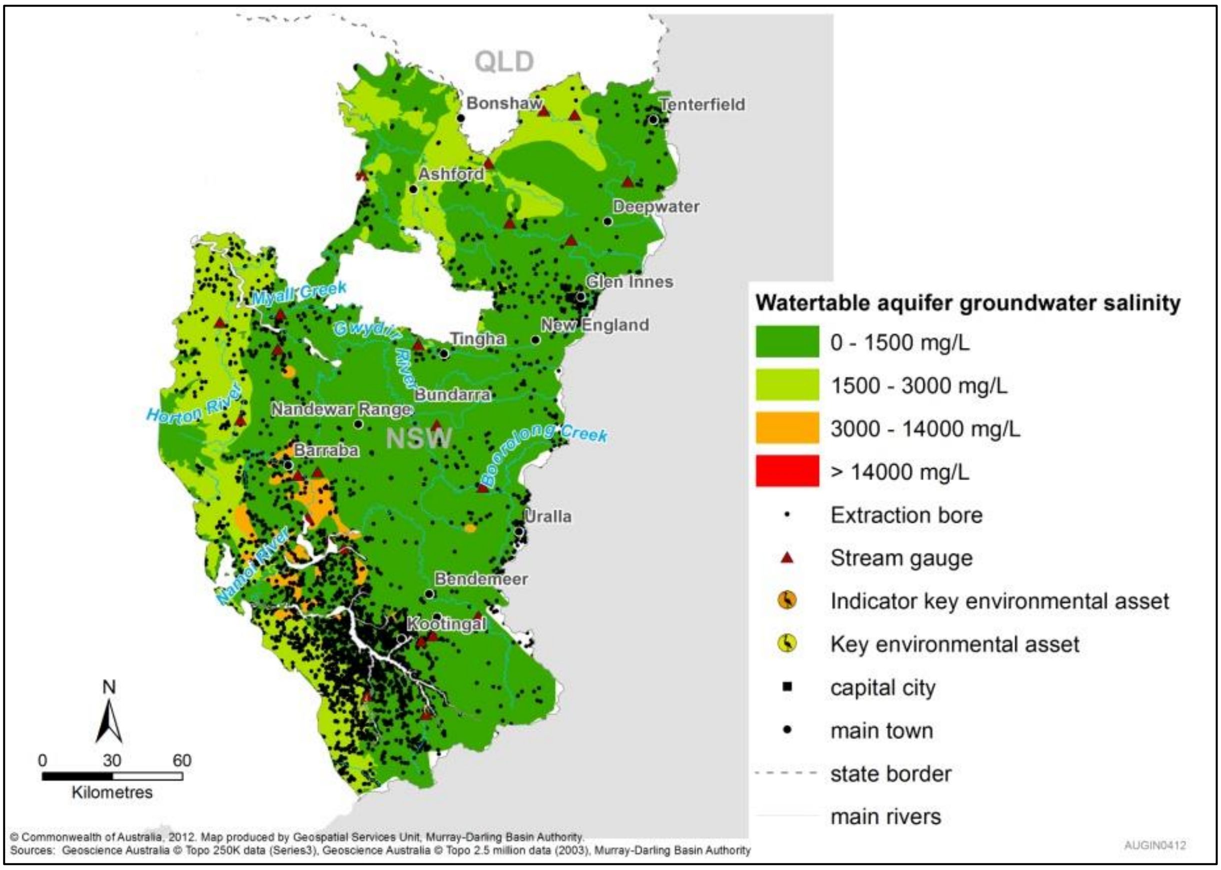


Figure 45: New England Fold Belt SDL resource unit map

Note: Some buried parts of the New England Fold Belt resource unit do not have salinity data. The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 118 and Table 119 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- medium risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 118: RRAM summary table for the New England Fold Belt

RRAM Step 2 Risks to KEA, KEF and PB	**KEA**	**KEF**	**PB**	**RRAM Step 3 Risks to fresh water**	**Salinity Class (KEO)**			**RRAM Step 4 Uncertainty**	
					Class 1	**Class 2**	**Class 3 & 4**		
Risk Ranking	Low	High	Med	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	71%	26%	3%	**Uncertainty Level**	High
SF	0.70	0.10	0.50	**SF**	N/A	N/A	N/A	**SF**	0.50

Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater.

Table 119: PEL summary table for the New England Fold Belt

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	1899.3	468.9	83.4	0.0	2451.6
SF	0.05	0.05	0.05	0.05	N/A
PEL (GL/y)	95.0	23.4	4.17	0.0	122.6

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Oaklands Basin (GS38)

The Oaklands Basin SDL resource unit straddles the Murray and Murrumbidgee Alluvium WRP areas in southern NSW (Figure 46). The resource unit subcrops over an area of 514,000 ha. It is a small Late Permian intracratonic basin containing Late Carboniferous to Triassic sediments, most notably a thick Permian Coal Measures sequence. The basin is completely buried and recharge is expected to be through vertical seepage from the overlying unconsolidated sediments. Groundwater resources in this area are undeveloped and not normally accessed for agricultural purposes, however, there is potential for extraction by the mining industry. There has been minimal exploration for coal resources in this basin and little is known regarding the regional movement of groundwater.

The Oaklands Basin SDL resource unit is buried underneath other SDL resource units and does not receive rainfall recharge. The storage volume of the resource unit is in excess of 400,000 GL and the SDL of 2.50 GL/y represents 0.0006% of the storage (i.e. the storage is 160,000 times the SDL).

The Oaklands Basin SDL resource unit was covered by the 2012 Water Sharing Plan for the NSW Murray–Darling Basin Porous Rock Groundwater Sources. The LTAAEL was 0 GL/y, however, the plan provided for 0.002% of the storage to be mined which was reported by the NSW Government to be 12.6 GL.

The Oaklands Basin SDL resource unit sits within the NSW Murray–Darling Basin Porous Rock WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 120: Summary table for the Oaklands Basin

Summary characteristic	Name / description / volume
SDL resource unit	Oaklands Basin (GS38)
Groundwater covered	All groundwater contained within all rocks of Permian and Triassic age
WRP Area	NSW Murray–Darling Basin Porous Rock (GW6)
GMU(s) Covered	Oaklands Basin
PEL	N/A
BDL	0 GL/y
SDL*	2.50 GL/y
Licensed Entitlement	N/A
Measured Groundwater Use	N/A
Estimated S&D Use	N/A
Entitlement plus S&D	N/A

*When setting the SDL for the Oaklands Basin, the MDBA considered all the available information and sought the advice of independent experts before determining the SDL. Groundwater is not currently taken from the Oaklands Basin and the SDL has been set to allow limited and sustainable development for this deep groundwater SDL resource unit.

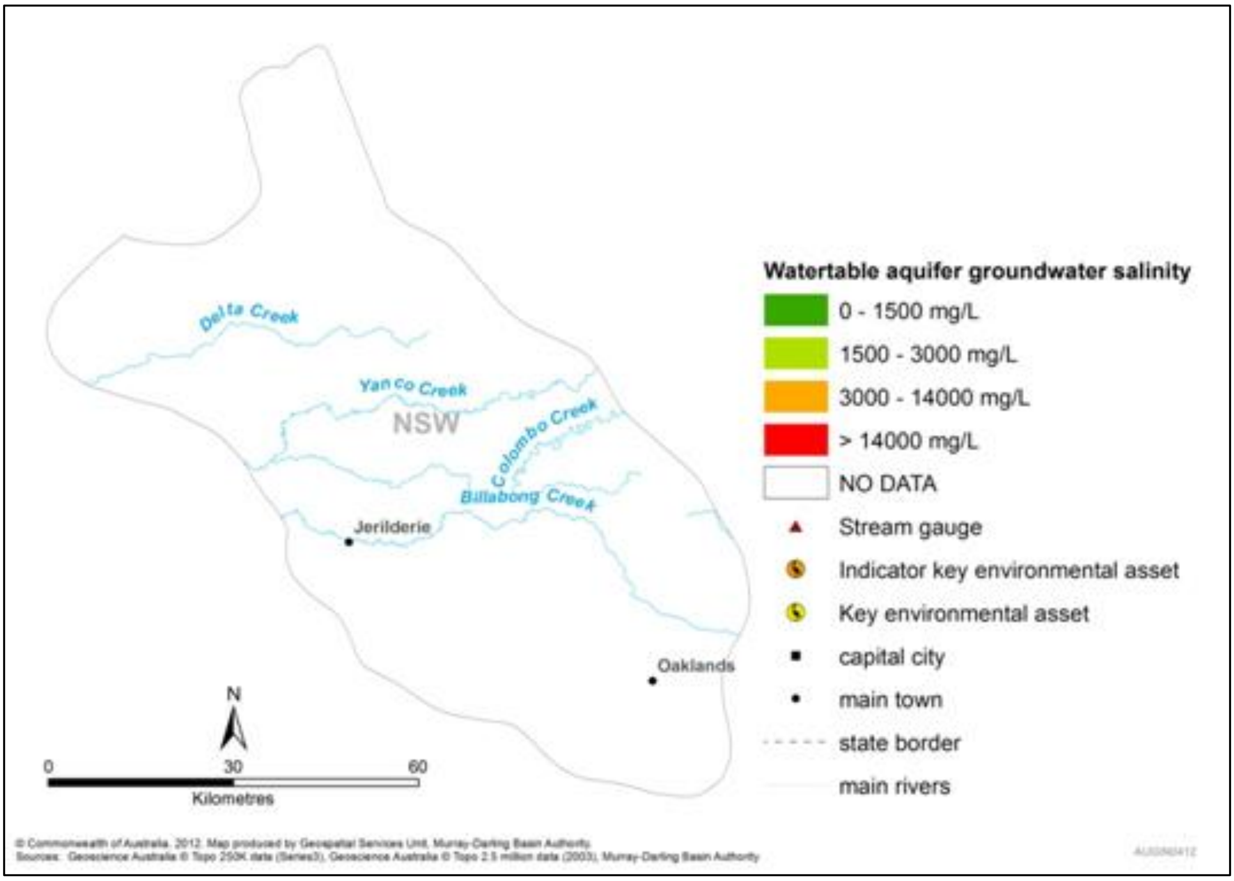


Figure 46: Oaklands Basin SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

There is no estimated recharge figure for this unit that could be applied in the RRAM to determine the PEL. However, the risk rankings have been assessed as follows:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Orange Basalt (GS39)

The Orange Basalt SDL resource unit is located in central-eastern NSW (Figure 47). It lies predominantly to the south of the large rural city of Orange. The resource unit comprises numerous basalt extrusions associated with the Canobolas Complex. The aquifer is highly variable in its permeability and water yielding capability. The area ranges from open relatively wide fractures with considerable capacity for storage and transmission of water, to areas where fractures are rare and consequently the aquifer is a poor source of water.

The Orange Basalt SDL resource unit was covered by the 2012 Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources. The LTAAEL was 16.2 GL/y for this water source, which was based on the NSW risk assessment framework. This SDL resource unit was identified as connected system where groundwater discharge provides base flow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion. Therefore, the MDBA capped groundwater use at the current level of development and the SDL has been set at estimated current use to ensure that the KEF (i.e. base flows) is not compromised.

The Orange Basalt SDL resource unit sits within the NSW Murray–Darling Basin Fractured Rock WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 121: Summary table for the Orange Basalt

Summary characteristic	Name / description / volume
SDL resource unit	Orange Basalt (GS39)
Groundwater covered	All groundwater contained within all basalt of Cenozoic age and all unconsolidated alluvial sediments
WRP Area	NSW Murray–Darling Basin Fractured Rock (GW11)
GMU(s) Covered	Orange Basalt
Recharge (RRAM Step 1)*	122.7 GL/y
Recharge Input	WAVES recharge modelling
PEL	30.7 GL/y
BDL	10.7 GL/y
SDL**	10.7 GL/y
Licensed Entitlement***	9.51 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	1.16 GL/y
Entitlement plus S&D	10.7 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL is set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources (2012).

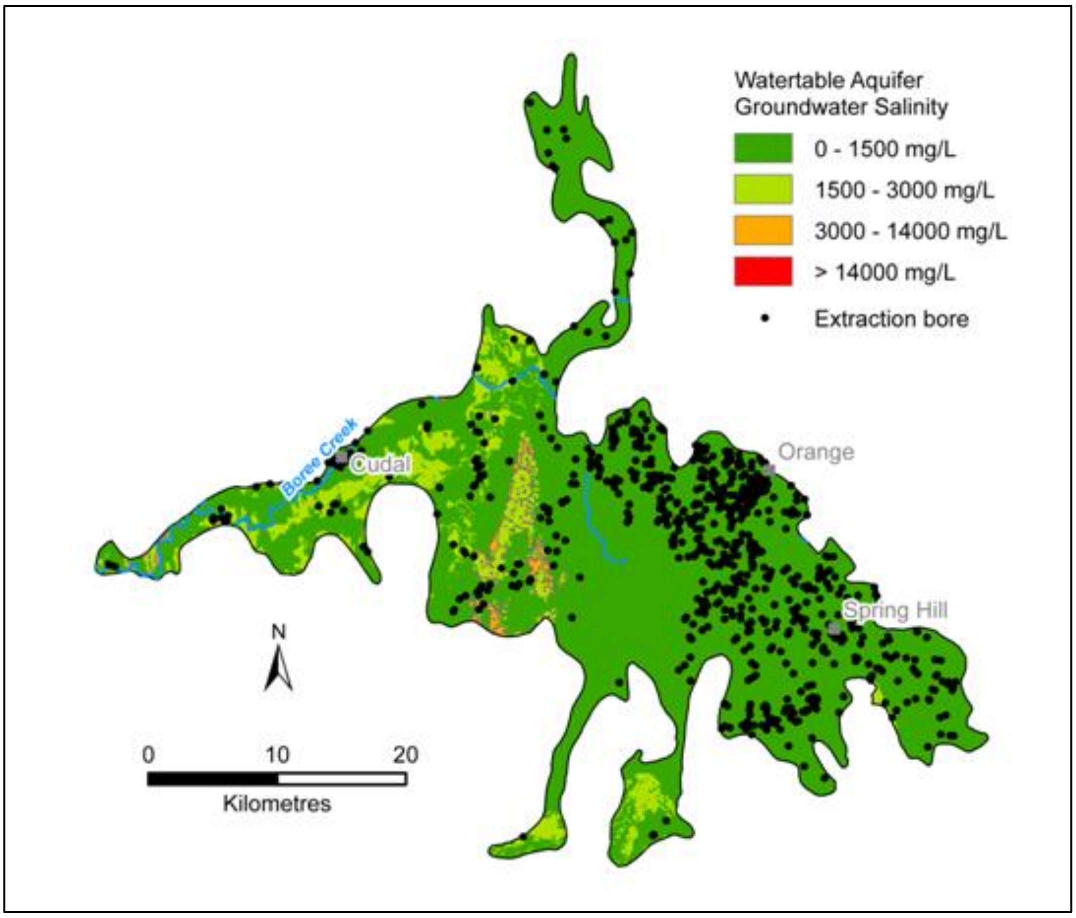


Figure 47: Orange Basalt SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 122 and Table 123 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- medium risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 122: RRAM summary table for the Orange Basalt

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Med	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	Medium
				% Area	89%	10%	1%	**Uncertainty Level**	High
SF	0.70	0.50	0.70	**SF**	N/A	N/A	N/A	**SF**	0.50

Table 123: PEL summary table for the Orange Basalt

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	107.2	13.7	1.78	0.0	122.7
SF	0.25	0.25	0.25	0.25	N/A
PEL (GL/y)	26.8	3.42	0.45	0.0	30.7

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Peel Valley Alluvium (GS40)

The Peel Valley Alluvium SDL resource unit is located in north-east NSW near Tamworth (Figure 48). The Peel River flows north-west and has a number of tributaries, including Goonoo–Goonoo Creek. The alluvial sediments of this valley consist of basal gravels and sands which are overlain and interbedded with finer grained sediments such as silty or sandy clays. The sediments are relatively shallow and thin within the narrow valleys. Recharge to the alluvial aquifer is thought to occur via two main processes, with direct diffuse rainfall recharge being thought a lesser mechanism than river recharge during high river flows. The river and the alluvial aquifer are considered to be in good connection, with groundwater extraction from near river bores likely to result in stream depletion. The alluvial aquifer is used for mostly horticultural purposes, though it has historically been used for water supply.

The Peel Valley Alluvium SDL resource unit was covered by the 2010 Water Sharing Plan for the Peel Valley Regulated, Unregulated, Alluvium and Fractured Rock Water Sources. The LTAAEL was 9.34 GL/y for this water source, which was based on capping groundwater use. This SDL resource unit was identified as a connected system where groundwater discharge provides base flow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion. Therefore, the MDBA capped groundwater use at the current level of development and the SDL has been set at estimated current use to ensure that the KEF (i.e. base flows) is not compromised.

The Peel Valley Alluvium groundwater SDL resource unit sits within the Namoi Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 124: Summary table for the Peel Valley Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Peel Valley Alluvium (GS40)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Namoi Alluvium (GW14)
GMU(s) Covered	Peel Valley Alluvium
Recharge (RRAM Step 1)	22.9 GL/y
Recharge Input	WAVES recharge modelling
PEL	1.14 GL/y
BDL	9.34 GL/y
SDL**	9.34 GL/y
Licensed Entitlement***	51.4 GL/y
Measured Groundwater Use***	9.10 GL/y
Estimated S&D Use***	0.24 GL/y
Entitlement plus S&D	51.6 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL is set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Peel Valley Regulated, Unregulated, Alluvium and Fractured Rock Water Sources (2010).

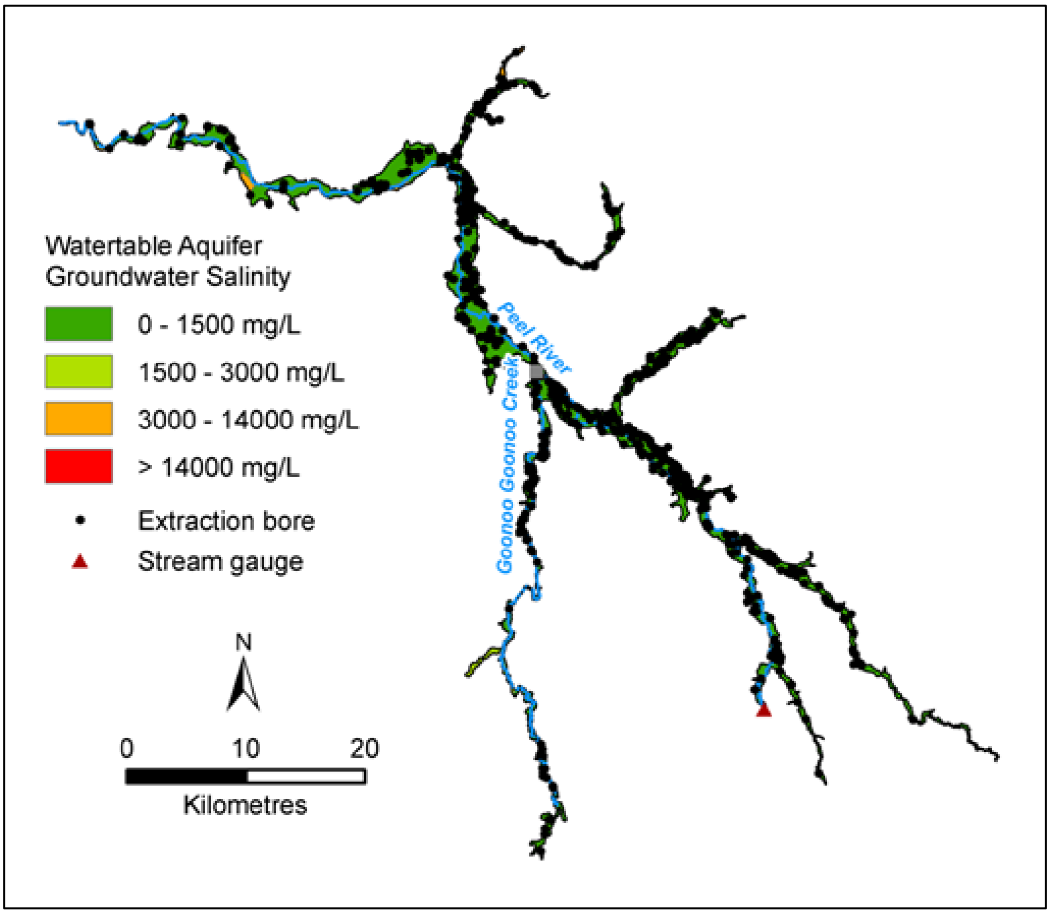


Figure 48: Peel Valley Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 125 and Table 126 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- high risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 125: RRAM summary table for the Peel Valley Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	High	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	97%	1%	2%	**Uncertainty Level**	High
SF	0.70	0.10	0.10	**SF**	N/A	N/A	N/A	**SF**	0.50

Table 126: PEL summary table for the Peel Valley Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	22.1	0.39	0.40	0.0	22.9
SF	0.05	0.05	0.05	0.05	N/A
PEL (GL/y)	1.11	0.02	0.02	0.0	1.15

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Sydney Basin MDB (GS41)

The Sydney Basin MDB SDL resource unit is located on the eastern fringe of the NSW MDB, with the majority of the Sydney Basin sitting outside of the MDB (Figure 49). The Sydney Basin contains 4,500 m of Permo–Triassic clastic sediments (Geoscience Australia, 2008b). A small part of the Sydney Basin MDB lies at depth underneath other SDL resource units; with the outcrop located in the Macquarie–Castlereagh surface water catchments. There is currently a low level of groundwater use, relative to the size of the resource.

The Sydney Basin MDB SDL resource unit was covered by the 2012 Water Sharing Plan for the NSW Murray–Darling Basin Porous Rock Groundwater Sources. The LTAAEL under this plan was 60.4 GL/y, plus an allowance to use 0.002% of the storage volume. The plan limit was based on the NSW risk assessment framework.

The Basin Plan includes a requirement for the review of the SDL and BDL for the Murray–Darling Basin Porous Rock WRP area, which includes the Sydney Basin MDB SDL resource unit, to be conducted within two years after the commencement of the Basin Plan.

A review panel was formed and recommended that:

1. the SDL is varied to take account of the agreed area for the WRP in line with the current MDBA calculation and applied sustainability factors; and

2. the MDBA consider varying the Unassigned Water Factor for a SDL resource unit to a value to be determined once assurances have been made by NSW that they can demonstrate that the resource will be managed via State policies and plans in such a way that impacts are limited to acceptable levels. These assurances would need to be explicit and would include specification of the assets to be protected within Schedule 3 of the relevant NSW WSP, an agreement on the criteria that would be used to define acceptable impacts and monitoring, compliance and review processes.

The Authority accepted these recommendations and amended the SDL for the Sydney Basin MDB SDL resource unit to 19.1 GL/y in July 2018.

The Sydney Basin MDB SDL resource unit sits within the NSW Murray–Darling Basin Porous Rock WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 127: Summary table for the Sydney Basin MDB

Summary characteristic	Name / description / volume
SDL resource unit	Sydney Basin MDB (GS41)
Groundwater covered	All groundwater contained within: a) all rocks of Permian, Triassic, Jurassic, Cretaceous and Cenozoic age within the outcropped and buried areas; and b) all unconsolidated alluvial sediments within the outcropped areas
WRP Area	NSW Murray–Darling Basin Porous Rock
GMU(s) Covered	Sydney Basin
Recharge (RRAM Step 1)*	a) 106.6 GL/y b) 102.9 GL/y****
Recharge Input	WAVES recharge modelling
PEL	a) 5.30 GL/y b) 54.0 GL/y
BDL	3.12 GL/y
SDL**	19.1 GL/y
Licensed Entitlement***	a) 2.70 GL/y b) 0 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	a) 0.50 GL/y b) 0 GL/y
Entitlement plus S&D	a) 3.10 GL/y b) 0 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration. The unallocated portion of the outcrop recharge was assumed to be recharge to the deep resource.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Murray–Darling Basin Porous Rock Groundwater Sources (2012).

****Recharge to the deep part of the Sydney Basin SDL resource unit is calculated by as residual between the recharge to the Sydney Basin shallow aquifer minus the SDL for this unit.

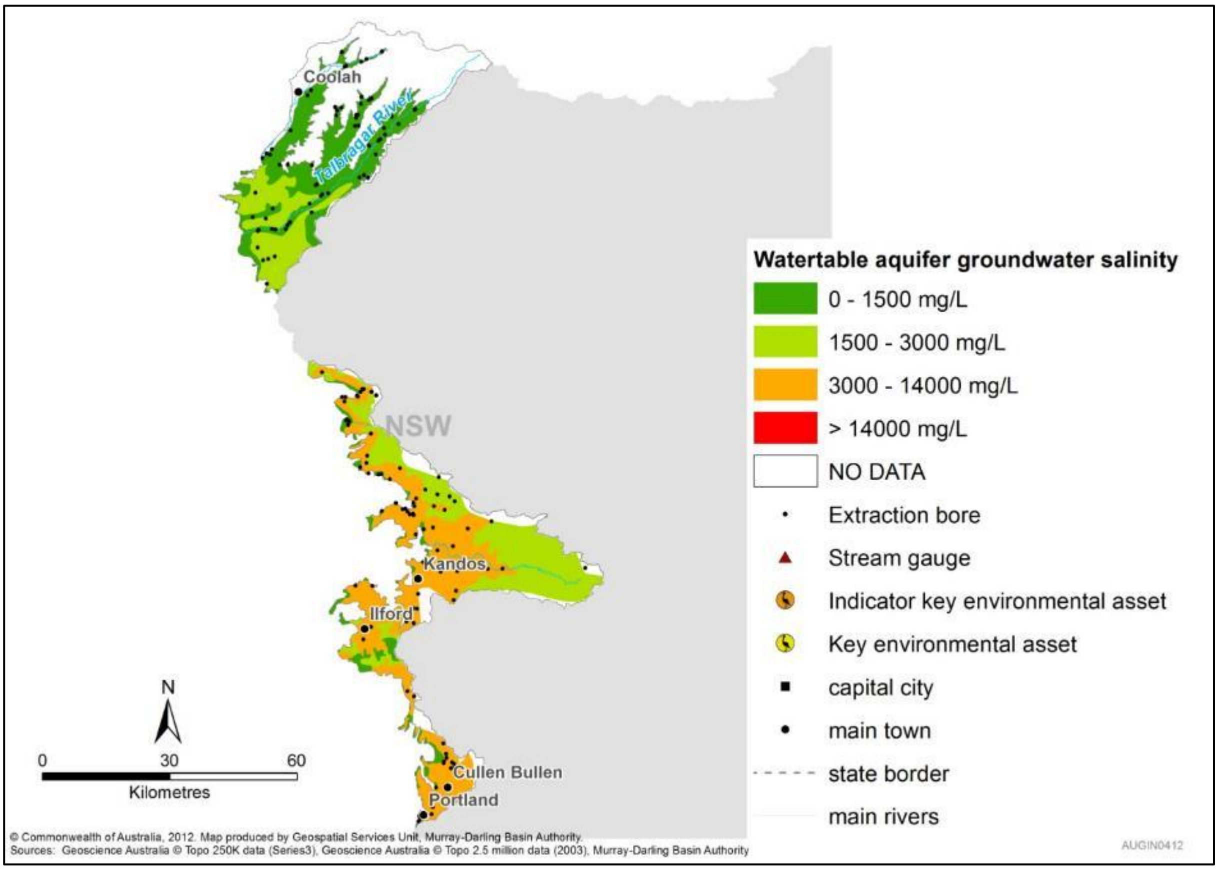


Figure 49: Sydney Basin MDB SDL resource unit map

Note: the buried part of the Sydney Basin does not have salinity data. The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 128 and Table 129 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate for the *outcrop portion* of the SDL resource unit. In summary, the risks were identified as:

- low risk for KEAs
- high risk for KEFs
- medium risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 128: RRAM summary table for the Sydney Basin MDB (outcrop)

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	Med	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	N/A	N/A	N/A	**Uncertainty Level**	High
SF	0.70	0.10	0.50	**SF**	N/A	N/A	N/A	**SF**	0.50

Table 129: PEL summary table for the Sydney Basin MDB (outcrop)

Measurement	Total
Recharge (GL/y)	106.6
SF	0.05
PEL (GL/y)	5.33

Note: The salinity data was not present to allow the recharge to be grouped into the salinity classes.

Table 130 and Table 131 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate for the *deep portion* of the SDL resource unit. In summary, the risks were identified as:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 130: RRAM summary table for the Sydney Basin MDB (deep)

<table>
<tr><th rowspan="2">RRAM Step 2
Risks to KEA, KEF and PB</th><th rowspan="2">KEA</th><th rowspan="2">KEF</th><th rowspan="2">PB</th><th rowspan="2">RRAM Step 3 Risks to fresh water</th><th colspan="3">Salinity Class (KEO)</th><th rowspan="2" colspan="2">RRAM Step 4 Uncertainty</th></tr>
<tr><th>Class 1</th><th>Class 2</th><th>Class 3 & 4</th></tr>
<tr><td rowspan="2">Risk Ranking</td><td rowspan="2">Low</td><td rowspan="2">Low</td><td rowspan="2">Low</td><td>Risk (Y/N)</td><td>No</td><td>No</td><td>No</td><td>Risk to ESLT</td><td>Low</td></tr>
<tr><td>% Area</td><td>N/A</td><td>N/A</td><td>N/A</td><td>Uncertainty Level</td><td>High</td></tr>
<tr><td>SF</td><td>0.70</td><td>0.70</td><td>0.70</td><td>SF</td><td>N/A</td><td>N/A</td><td>N/A</td><td>SF</td><td>0.75</td></tr>
</table>

Table 131: PEL summary table for the Sydney Basin MDB (deep)

Measurement	Total
Recharge (GL/y)	102.9
SF	0.53
PEL (GL/y)	54.0

Note: The salinity data was not present to allow the recharge to be grouped into the salinity classes.

Upper Darling Alluvium (GS42)

The Upper Darling Alluvium SDL resource unit is located in north-west NSW and is associated with the Paroo, Warrego and Darling (between Bourke and Wilcannia) Rivers (Figure 50). The deposits are relatively thick with deeper sediments located within the trench eroded into GAB materials. The alluvial sediments are comprised of basal sands and gravels and generally become finer closer to the surface (CSIRO, 2008a).

The aquifer is recharged predominantly through river recharge during flood events and to a limited extent through diffuse rainfall recharge.

The Darling Salt Interception Scheme exists along the Glen Villa reach of the Darling River approximately 25 km down river from Bourke. The Scheme consists of four pumping bores which remove shallow saline groundwater from the shallow aquifer and transports it to an evaporation basin some distance away from the river. The primary aim of the salt interception scheme is to reach river salinity targets at Morgan and this scheme contributes to that aim.

The Upper Darling Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for the Barwon–Darling Unregulated and Alluvial Water Sources. The LTAAEL was 19.2 GL/y, which was based on the NSW risk assessment framework. In determining the SDL for SDL resource units where the state plan limit is greater than the level of entitlement, the MDBA did not adopt the state extraction limits as the SDLs and carried out its own assessment. The SDL for this resource unit is 6.59 GL/y, which is based on the RRAM and the unassigned groundwater assessment.

The Upper Darling Alluvium groundwater SDL resource unit sits within the Namoi Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 132: Summary table for the Upper Darling Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Upper Darling Alluvium (GS42)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Darling Alluvium (GW7)
GMU(s) Covered	Upper Darling Alluvium
Recharge (RRAM Step 1)*	14.3 GL/y
Recharge Input	WAVES recharge modelling
PEL	7.48 GL/y
BDL	6.29 GL/y
SDL**	6.59 GL/y
Licensed Entitlement***	3.53 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	2.76 GL/y
Entitlement plus S&D	6.29 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration. The Upper Darling Alluvial groundwater source is recharged by rainfall and streamflow. However, a significant recharge to this system occurs from streamwater during episodic flood events.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Barwon–Darling unregulated and Alluvial Water Sources (2012).

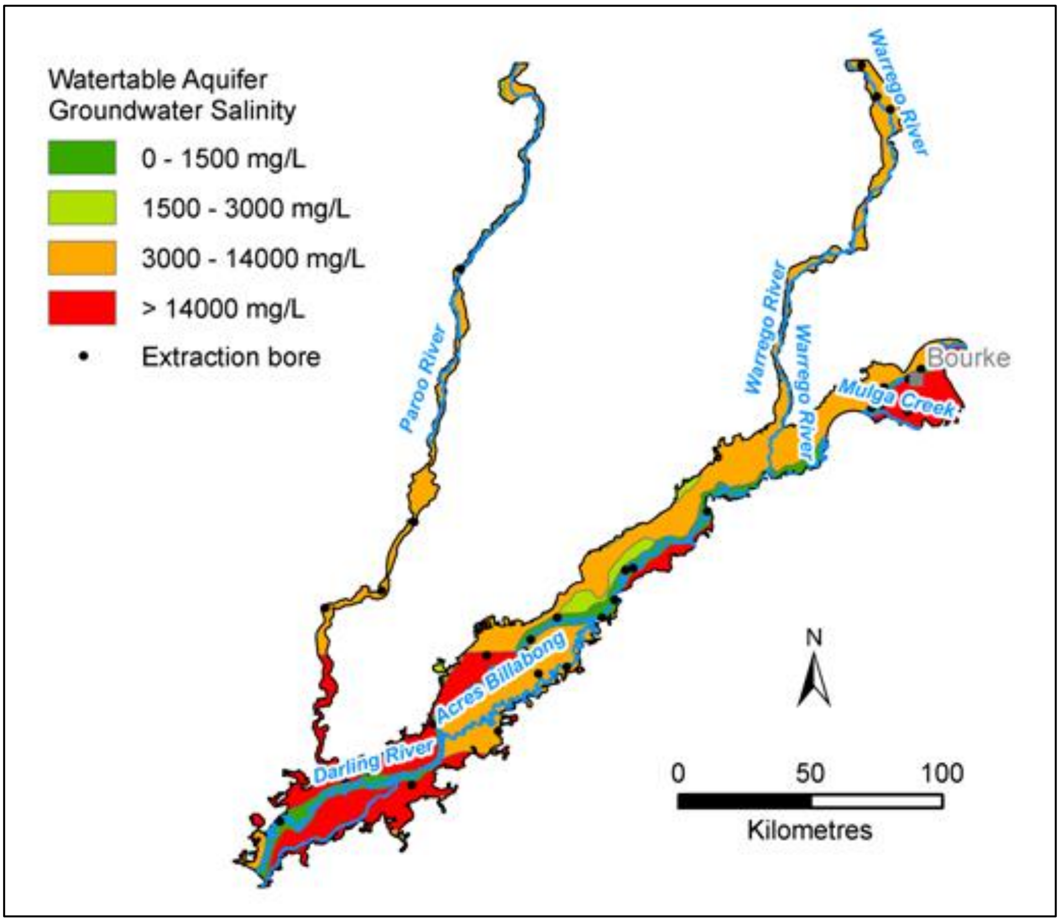


Figure 50: Upper Darling Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 133 and Table 134 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 133: RRAM summary table for the Upper Darling Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	Low
				% Area	15%	3%	82%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	N/A	N/A	N/A	**SF**	0.75

Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater.

Table 134: PEL summary table for the Upper Darling Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	0.84	1.05	8.41	3.97	14.27
SF	0.53	0.53	0.53	0.53	N/A
PEL (GL/y)	0.44	0.55	4.41	2.08	7.48

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Upper Gwydir Alluvium (GS43)

The Upper Gwydir Alluvium SDL resource unit is located in the east of the Gwydir Catchment (Figure 51). From a hydrogeological perspective, the Gwydir Catchment is divided into two main areas: the hilly highland country to the east and the broad flat alluvial plains to the west. The highland hydrogeology is dominated by a fractured rock aquifer with the resource unit comprising of the unconsolidated alluvial sediments associated with the Gwydir River in the valleys of the highlands. These alluvial deposits are limited in their extent and are not a large groundwater resource.

The Upper Gwydir Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for Gwydir Unregulated and Alluvial Water Sources. The LTAAEL under this plan for the Upper Gwydir Alluvial Water Source was 0.72 GL/y, which was based on capping at the current level of development.

The Upper Gwydir Alluvium groundwater SDL resource unit sits within the Gwydir Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 135: Summary table for the Upper Gwydir Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Upper Gwydir Alluvium (GS43)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Gwydir Alluvium (GW15)
GMU(s) Covered	Miscellaneous Alluvium of Barwon Region
Recharge (RRAM Step 1)*	7.50 GL/y
Recharge Input	WAVES recharge modelling
PEL	0.38 GL/y
BDL	0.72 GL/y
SDL**	0.72 GL/y
Licensed Entitlement***	1.25 GL/y
Measured Groundwater Use***	0.66 GL/y
Estimated S&D Use***	0.06 GL/y
Entitlement plus S&D	1.31 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL is set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Gwydir Unregulated and Alluvial Water Sources (2012).

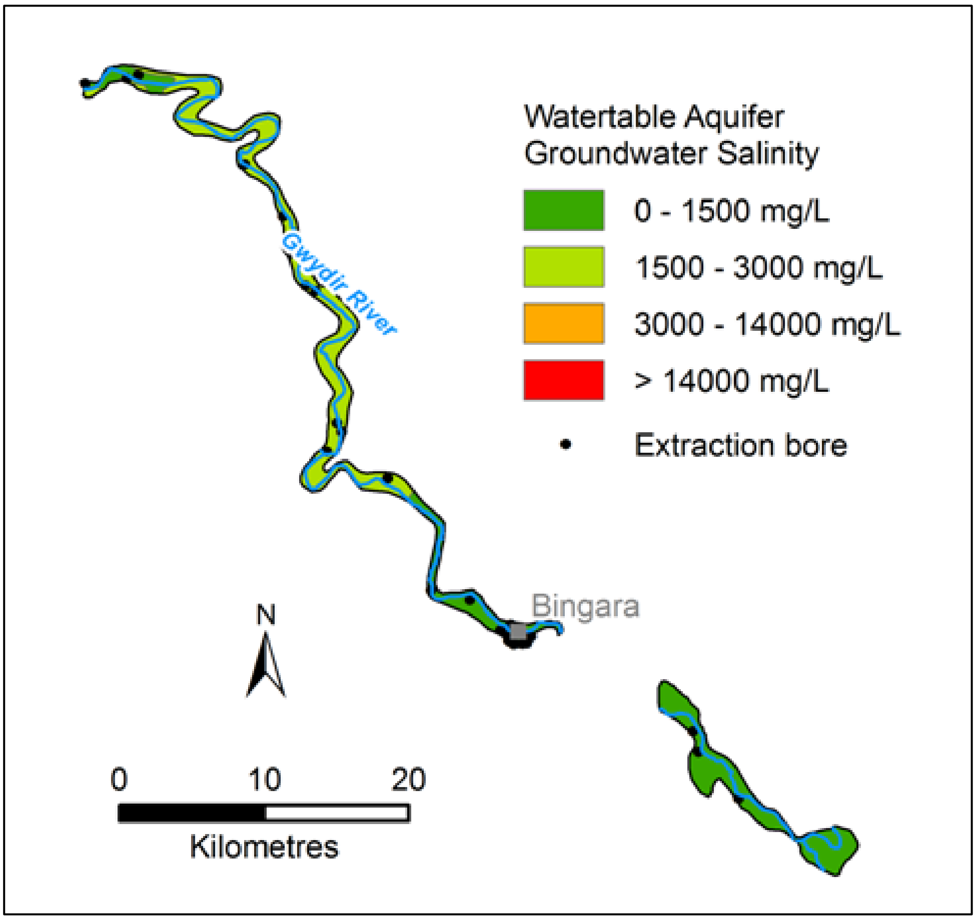


Figure 51: Upper Gwydir Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 136 and Table 137 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- high risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 136: RRAM summary table for the Upper Gwydir Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	High	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	48%	52%	0%	**Uncertainty Level**	High
SF	0.70	0.10	0.10	**SF**	N/A	N/A	N/A	**SF**	0.50

Table 137: PEL summary table for the Upper Gwydir Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	3.58	3.96	0.0	0.0	7.54
SF	0.05	0.05	N/A	N/A	N/A
PEL (GL/y)	0.18	0.20	0.0	0.0	0.38

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Upper Lachlan Alluvium (GS44)

The Upper Lachlan Alluvium SDL resource unit is located upstream of Lake Cargelligo and is associated with the Lachlan River and its tributaries (Figure 52 and Figure 53). The area is made up of valley-fill alluvial sediments and contains two main aquifers: the unconfined Cowra Formation and the semi-confined Lachlan Formation, which is a palaeochannel facies with limited extent.

The Upper Lachlan Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for Lachlan Unregulated and Alluvial Water Sources. The LTAEEEL under this plan for the Upper Lachlan Alluvial Water Source was 94.2 GL/y, which was based on capping at the current level of development. This SDL resource unit was identified as a connected system where groundwater discharge provides base flow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion. Therefore, the MDBA capped groundwater use at the current level of development and the SDL has been set at estimated current use to ensure that the KEF (i.e. base flows) is not compromised.

The Upper Lachlan Alluvium groundwater SDL resource unit sits within the Lachlan Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 138: Summary table for the Upper Lachlan Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Upper Lachlan Alluvium (GS44)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Lachlan Alluvium (GW10)
GMU(s) Covered	Upper Lachlan Alluvium (upstream of Lake Cargelligo)
Recharge (RRAM Step 1)*	186.5 GL/y
Recharge Input	Numerical Model: Upper Lachlan Groundwater Flow Model water balance summary (Bilge, 2012)
PEL	117.4 GL/y
BDL	94.2 GL/y
SDL**	94.2 GL/y
Licensed Entitlement***	186.1 GL/y
Measured Groundwater Use***	88.0 GL/y
Estimated S&D Use***	6.20 GL/y
Entitlement plus S&D	192.3 GL/y

*Groundwater recharge from the Upper Lachlan Groundwater Flow Model water balance summary for the 22-year calibration period (1986 to 2008) (Bilge, 2012).

**SDL is set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources (2012).

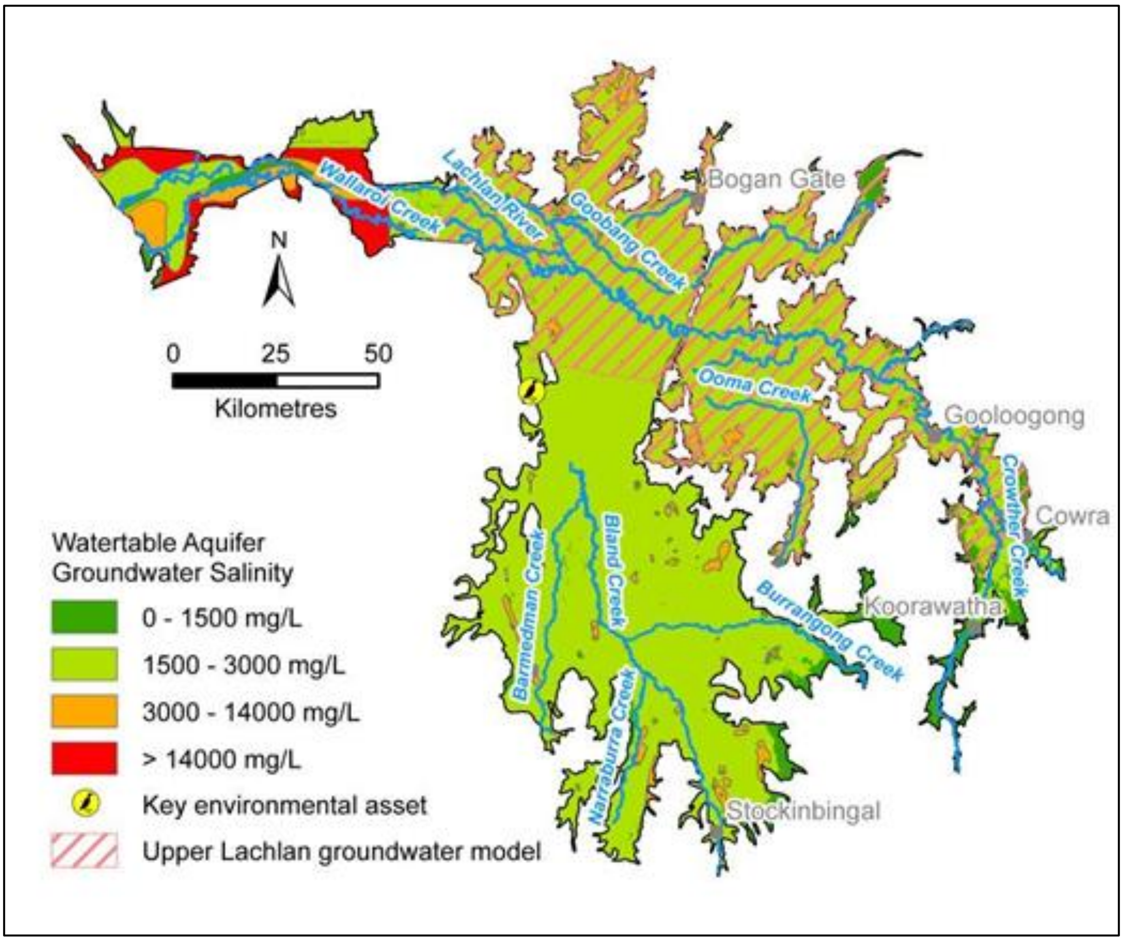


Figure 52: Upper Lachlan Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 139 and Table 140 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a low level of uncertainty.

Table 139: RRAM summary table for the Upper Lachlan Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	Risk (Y/N)	Yes	Yes	No	Risk to ESLT	High
				% Area	9%	82%	9%	Uncertainty Level	Low
SF	0.70	0.70	0.70	SF	0.80	0.90	N/A	SF	N/A

Table 140: PEL summary table for the Upper Lachlan Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	17.2	152.8	10.3	6.14	186.4
SF	0.56	0.63	0.70	0.70	N/A
PEL (GL/y)	9.65	96.3	7.23	4.30	117.5

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

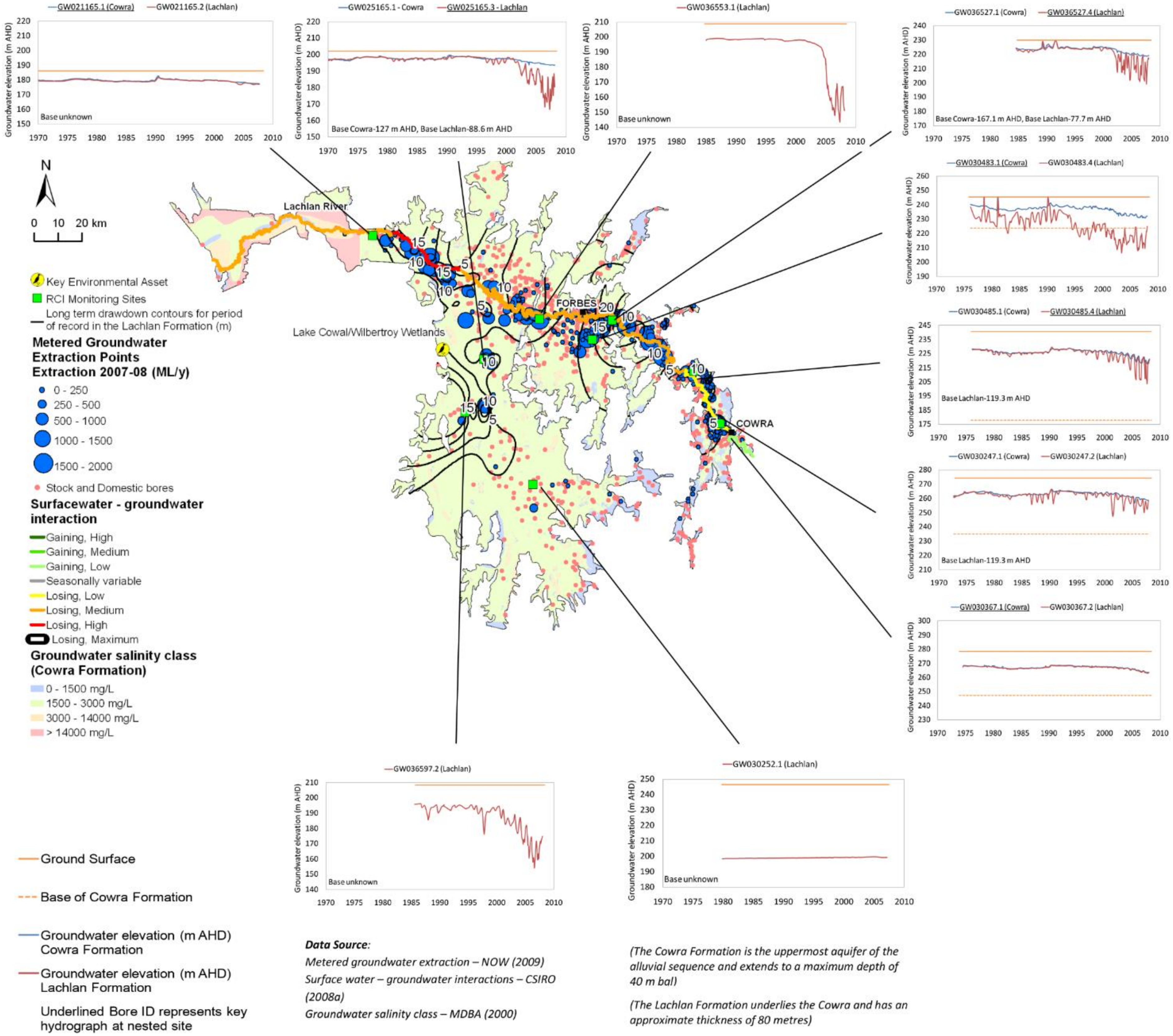


Figure 53: Detailed Upper Lachlan Alluvium SDL resource unit map

Hydrogeology

- There are two main aquifers within the Upper Lachlan Alluvium SDL resource unit.
- The Lachlan Formation consists of gravels and sands deposited in a palaeochannel that follows the present day Lachlan River. The Lachlan Formation underlies the lower permeability Cowra Formation that fills the rest of the valley.
- The majority of groundwater extraction occurs from the Lachlan Formation due to its higher permeability, and is located near the Lachlan River.
- The major creeks and rivers in the SDL resource unit are highly connected to the groundwater. A section of the Lachlan River above Cowra is gaining, below Cowra it is losing
- Recharge to the alluvial aquifer system occurs primarily from river leakage
- The Upper Lachlan alluvium is currently administered under the *Water Act 1912* and is proposed to be included as a water source of the inland alluvial Macro Water Sharing Plan, under the *Water Management Act 2000*, which is currently under development. RCLs have not previously been defined for the resource.

Resource condition analysis

- Selection of key monitoring sites:
  - should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should be able to monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
  - Features requiring priority in the Upper Lachlan include surface-groundwater interaction throughout the catchment, groundwater dependent environmental assets, the productive base of the resource in major zones of extraction, and water quality throughout.
- Analysis of historical data:
  - There is evidence of substantial drawdown in the Lachlan Formation since the start of groundwater level monitoring, at various locations along the Lachlan River (e.g. GW030483.4, GW25165.3) and at other localised points of extraction (GW036553.1 and GW036597.2).
  - The Lachlan formation appears to have become unconfined at some locations. For instance, at GW030483.4 the water level has fallen below the base of the Cowra formation
  - Water quality data is sparse.

Monitoring Points	Feature
GW025165.1	KEA
GW025165.3 GW036527.4 GW030483.4 GW030406.2 GW030485.4 GW030247.2 GW030252.1 GW036597.2	Productive base, Salinity
GW030367.1 GW030247.1 GW030483.1 GW025165.1 GW021165.1 GW036527.1 GW036553.1	Connectivity

Upper Macquarie Alluvium (GS45)

The Upper Macquarie Alluvium SDL resource unit is associated with the Macquarie River up and downstream of Dubbo (Figure 54). It transitions from a single shallow unconfined aquifer system in its upstream reaches to a deeper semi-confined aquifer at its downstream end. Ninety-six percent of the SDL resource unit is covered by a groundwater model, with a small region in the narrow valley immediately upstream of Wellington not covered. The alluvium represents sediments of Cainozoic age that have backfilled a riverine valley cut into the older landscape of the area. The area contains two main aquifers: the unconfined Cowra Formation and the semi-confined Lachlan Formation. The Cowra Formation aquifer consists of sands, silts and clays in a relatively heterogeneous distribution both in depth and area. It is generally considered to be of lower permeability than the deeper Lachlan Formation aquifer which is coarser and more uniform in its grain size distribution. The Cowra Formation represents a semi-confining layer for the underlying sediments of the Lachlan Formation.

The Upper Macquarie Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for Macquarie Bogan Unregulated and Alluvial Water Sources. The LTAAEL under this plan for the Upper Macquarie Alluvial Water Source was 17.9 GL/y, which was based on capping at the current level of development.

The Upper Macquarie Alluvium groundwater SDL resource unit sits within the Macquarie-Castlereagh Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 141: Summary table for the Upper Macquarie Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Upper Macquarie Alluvium (GS45)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Macquarie–Castlereagh Alluvium (GW12)
GMU(s) Covered	Upper Macquarie Alluvium (upstream of Narromine)
Recharge*	20.6 GL/y
Recharge Input	Numerical Model
PEL**	13.0 GL/y
BDL	17.9 GL/y
SDL***	17.9 GL/y
Licensed Entitlement****	32.7 GL/y
Measured Groundwater Use****	17.6 GL/y
Estimated S&D Use****	0.30 GL/y
Entitlement plus S&D	33.0 GL/y

*Groundwater recharge was derived from the calibration mass balance (1980 to 2008) for the groundwater model used during the development of the Basin Plan (CSIRO and SKM, 2010e).

**The PEL was determined by testing the current level of development in the groundwater model. The use figure that was used in the model has been superseded by more up to date figures provided by the NSW Government.

***SDL is set at current use (connected resources).

****All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources (2012).

Table 142: Summary of the groundwater and surface water fluxes derived from the numerical model and identified GDEs for the Upper Macquarie Alluvium

Summary characteristic	Volume / name
Groundwater Discharge to Streams*	7.51 GL/y
Stream Leakage to Groundwater*	8.35 GL/y
Impact of Groundwater Extraction on Streamflow**	6.89 GL/y
Groundwater Dependent KEA	None

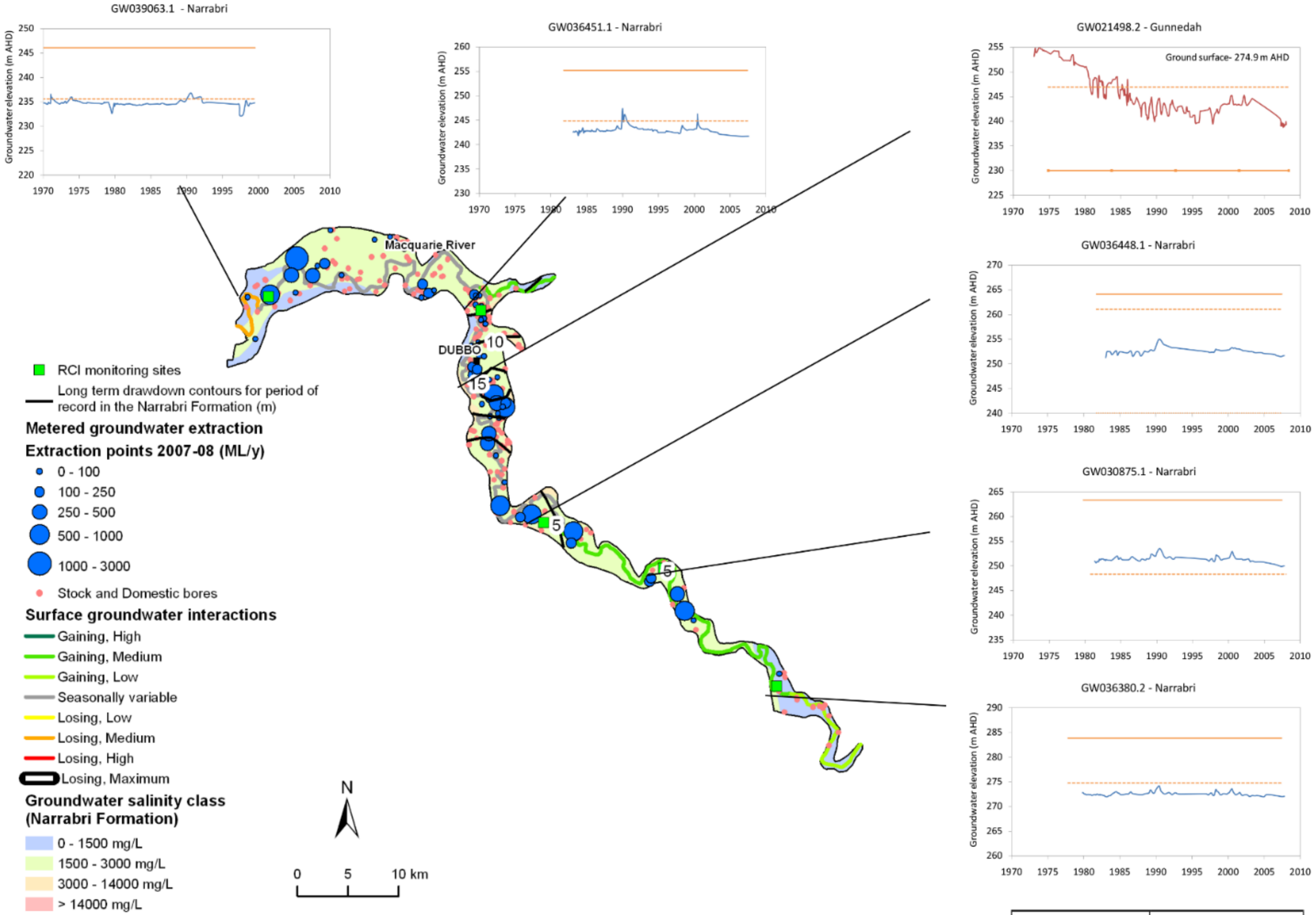
*Derived from the model results for Scenario 2 (i.e. groundwater take at the current level of entitlements).

**Derived by comparing river loss under the current levels of entitlement (Scenario 2) and the no groundwater extraction scenario (Scenario 1).

Recharge risk assessment method outcome

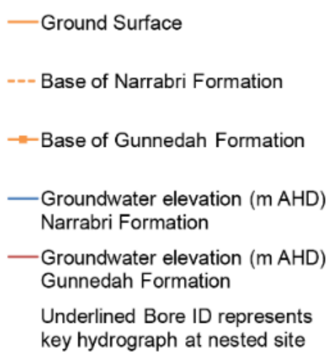
Although the RRAM was not applied in this SDL resource unit due to the availability of the groundwater model, the risk rankings were determined to be:

- low risk for KEAs
- medium risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a low level of uncertainty.



(The Narrabri Formation is the uppermost aquifer of the alluvial sequence and extends to an average depth of approximately 15 m bgl)

(The Gunnedah Formation underlies the Narrabri and has an average thickness of 40 metres)



Data Source:

Metered groundwater extraction – NOW (2009)

Surface water – groundwater interactions – CSIRO (2008a)

Groundwater salinity class – MDBA (2000)

Monitoring Points	Feature
GW039063.1 GW036451.1 GW036448.1 GW030875.1 GW036380.2 GW021498.1	Connectivity
GW021498.2	Productive base

Hydrogeology and water sharing arrangements

- The Upper Macquarie Alluvium SDL resource unit consists of a narrow alluvial aquifer system associated with the Macquarie River upstream of Narromine.
- The alluvium is comprised of two main systems. The Narrabri Formation overlies the Gunnedah Formation and is composed of shallow alluvial fan sediments deposited by creeks draining the adjacent highlands. Groundwater is contained in small discontinuous sand lenses and varies in quality and yield. The aquifers are essentially unconfined, while the deeper clean sands are partially confined by clay layers within the alluvium.
- Groundwater from these aquifers supplies irrigation, Stock, Domestic and town water supplies in the area. Thirty percent of Dubbo's water supply is sourced from groundwater.
- Recharge is predominantly via river leakage.
- The aquifer is in direct hydraulic connection with the river, which is gaining in the upstream reaches and seasonally varying in the downstream reaches of the SDL resource unit.
- The Upper Macquarie Alluvium is currently administered under the *Water Act 1912* and is proposed to be included as a water source of the inland alluvial Macro Water Sharing Plan, under the *Water Management Act 2000*, which is currently under development. RCLs have not previously been defined for the resource.

Resource condition analysis

- Selection of key monitoring sites:
  - should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should be able to monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
  - Features requiring priority in the Upper Macquarie Alluvium include surface-groundwater interaction where streams are in close connection with the aquifer, the productive base of the resource in zones of extraction (particularly near town water supply bore fields), and water quality throughout.
- Analysis of historical data:
  - Evidence of substantial drawdown from the start of monitoring in pockets of the region in the Gunnedah Formation (e.g. near Dubbo at GW021498.1). The available storage (shown by aquifer saturated thickness calculations) is generally satisfactory, but at risk within this zone of acute drawdown. The saturated thickness of the aquifer also appears to be reasonably thin at other locations (GW030875.1).
  - At other monitoring sites throughout this SDL, the water level has fallen below the base of the Narrabri Formation (GW039063.1, GW036451.1, GW036448.1, GW036380.2).
  - Although water quality data is sparse, there is a potential risk of groundwater extraction leading to water quality decline due to induced leakage.

Figure 54: Upper Macquarie Alluvium SDL resource unit

Upper Murray Alluvium (GS46)

The Upper Murray Alluvium SDL resource unit is associated with the NSW side of the River Murray between Hume and Corowa (Figure 55 and Figure 56). The area contains two main aquifers: the unconfined Shepparton Formation and the semi-confined Lachlan Formation, which is a palaeochannel facies with limited extent. The River Murray and rainfall have been identified as the major recharge sources for the aquifers while irrigation leakage was identified as a minor recharge source (Kulatunga, 2009).

The Lachlan Formation (equivalent to the Calivil Formation in the Murray Geological Basin to the west) is up to 80 m thick in the area (Kulatunga, 2009). The Shepparton Formation overlies the Lachlan Formation and is also up to about 80 m thick, varying between clay and gravel. The lower part of the Shepparton Formation has thick zones of sand and gravel.

The main aquifers are the quartz sand and gravel of the Lachlan Formation which have aquifer transmissivities up to 2,000 m^2/day (Williams, 1989). Some of the irrigation bores, which are tapping this aquifer, have the capacity to yield up to 10 ML/day.

The Shepparton Formation generally has much lower aquifer transmissivities (up to 250 m^2/day). Some irrigation bores which obtain groundwater from the gravel and coarse sand in this formation have the capacity to yield up to about 3 ML/day. Aquifers in this formation provide water to the majority of S&D bores in the area.

The Upper Murray Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for Murray Unregulated and Alluvial Water Sources. The LTAAEL under this plan for the Upper Murray Alluvial Water Source was 14.1 GL/y, which was based on capping at the current level of development.

The Upper Murray Alluvium groundwater SDL resource unit sits within the Murray Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 143: Summary table for the Upper Murray Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Upper Murray Alluvium (GS46)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Murray Alluvium (GW8)
GMU(s) Covered	Upper Murray Alluvium (upstream of Corowa)
Recharge (RRAM Step 1)*	19.7 GL/y
Recharge Input	WAVES recharge modelling
PEL	8.01 GL/y
BDL	14.1 GL/y
SDL**	14.1 GL/y
Licensed Entitlement***	41.3 GL/y
Measured Groundwater Use***	13.7 GL/y
Estimated S&D Use***	0.40 GL/y
Entitlement plus S&D	41.7 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via baseflow and/or evapotranspiration.

**SDL is set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Murray Unregulated and Alluvial Water Sources (2012).

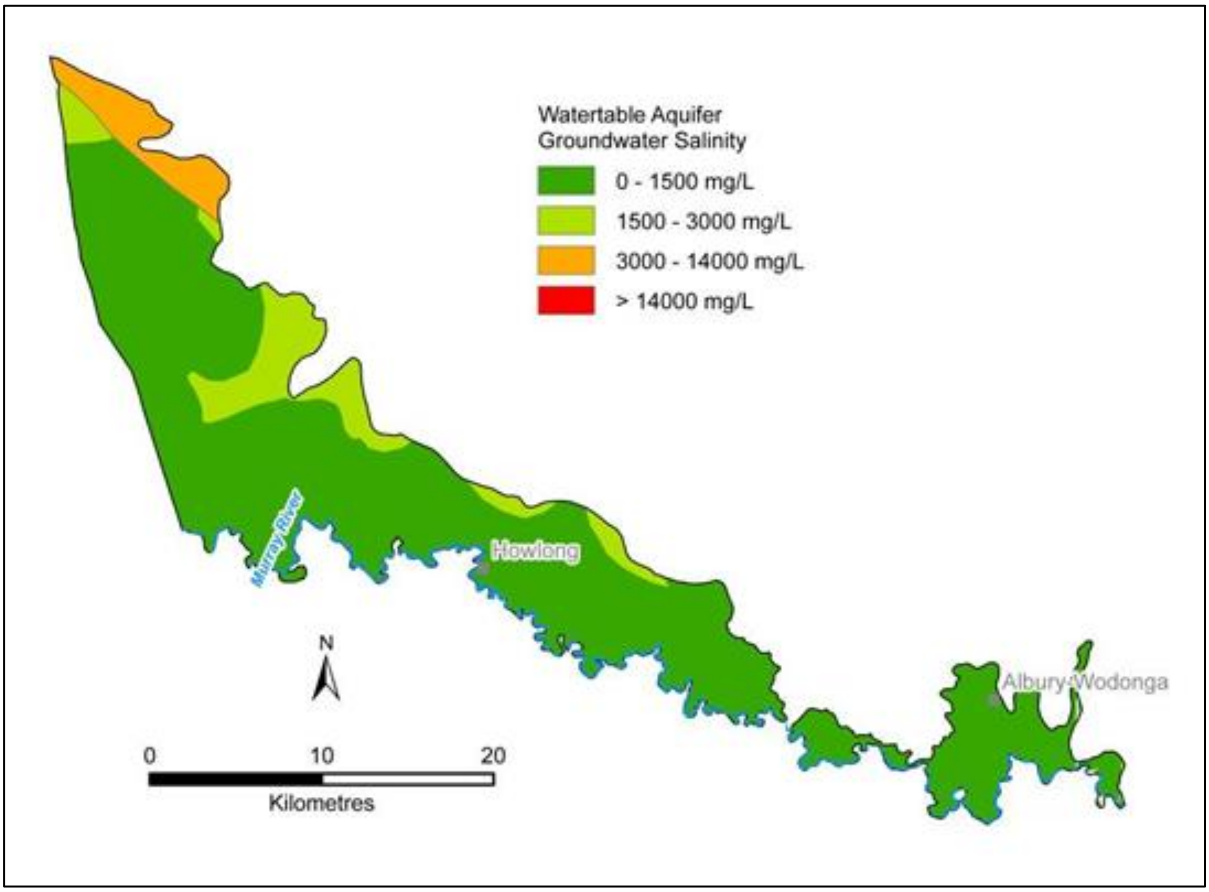


Figure 55: Upper Murray Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 144 and Table 145 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- medium risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a low level of uncertainty.

Table 144: RRAM summary table for the Upper Murray Alluvium

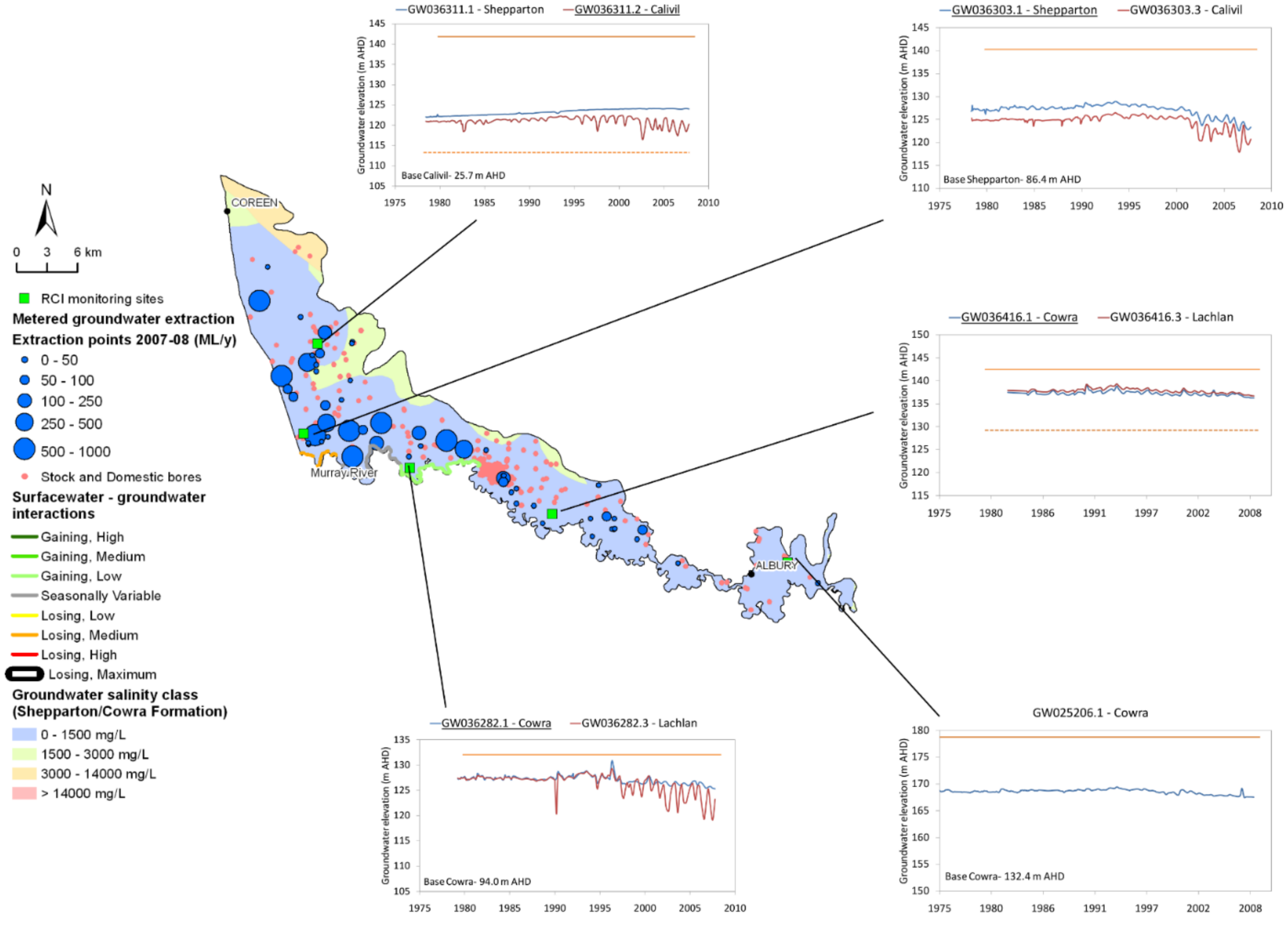
RRAM Step 2 Risks to KEA, KEF and PB	**KEA**	**KEF**	**PB**	**RRAM Step 3 Risks to fresh water**	**Salinity Class (KEO)**			**RRAM Step 4 Uncertainty**	
					Class 1	**Class 2**	**Class 3 & 4**		
Risk Ranking	Low	Med	Low	**Risk (Y/N)**	Yes	Yes	No	**Risk to ESLT**	Medium
				% Area	84%	11%	5%	**Uncertainty Level**	Low
SF	0.70	0.50	0.70	**SF**	0.80	0.90	N/A	**SF**	N/A

Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater.

Table 145: PEL summary table for the Upper Murray Alluvium

Salinity	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Total**
Recharge (GL/y)*	17.6	1.70	0.40	0.0	19.7
SF	0.40	0.45	0.50	N/A	N/A
PEL (GL/y)	7.04	0.77	0.20	0.0	8.01

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.



Ground Surface

Base of Shepparton/Cowra Formation

Groundwater elevation (m AHD) Shepparton/Cowra Formation

Groundwater elevation (m AHD) Calivil/Lachlan Formation

Underlined Bore ID represents key hydrograph at nested site

Data Source:

Metered groundwater extraction – NOW (2009)

Surface water – groundwater interactions – CSIRO (2008a)

Groundwater salinity class – MDBA (2000)

(The Shepparton/Cowra Formations are the uppermost aquifers of the alluvial sequence and extend to an average depth of approximately 35 m bgl)

(The Calivil/Lachlan Formations underlie the Shepparton/Cowra and have an average thickness of 65 metres)

Monitoring Points	Feature
GW036311.2	Productive base, Salinity
GW036282.1 GW036303.1 GW036416.1 GW025206.1	Connectivity

Hydrogeology and water sharing arrangements

- The Upper Murray Alluvium SDL resource unit is comprised of about 3-4 productive aquifers where groundwater occurs to a depth of 100 m mainly in the Lachlan and Shepparton formations. The majority of the irrigation bores tap the deeper Lachlan aquifers (correlated with the Calivil Formation) while most of the Stock and Domestic bores extract groundwater from shallow Shepparton aquifers (correlated with the Cowra formation).
- The Murray River and rainfall have been identified as the major recharge sources for the aquifers while irrigation leakage was identified as a minor recharge source as well.
- Groundwater levels in all aquifers were generally steady until the early 1990s. Thereafter, a rising trend was observed until the mid-1990s. Since then, a moderate decline of up to 25 cm/year has been observed in all aquifers.
- The groundwater salinity of both Shepparton and Lachlan aquifers are generally fresh with salinity levels less than 800 µS/cm but there are higher salinity levels recorded in some of the bores.
- The Murray River is in direct hydraulic connection with the groundwater. It is gaining for most of length through the SDL resource unit and becomes losing in its lower reaches near Corowa.
- No attempt has been made so far to identify groundwater dependent ecosystems. Eight wetlands have been identified which may have a connection to the groundwater system, but their dependency is unknown (Upper Murray Alluvium Groundwater Resources Status Report, 2008).
- The Upper Murray Alluvium is currently administered under the *Water Act 1912* and is proposed to be included as a water source of the inland alluvial Macro Water Sharing Plan, under the *Water Management Act 2000*, which is currently under development. RCLs have not previously been defined for the resource.

Resource condition analysis

- Selection of key monitoring sites:
  - should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should be able to monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
- Analysis of historical data:
  - Evidence of recent water level declines throughout the SDL resource unit, which is most acute in the western zone of extraction (e.g. GW036303.3).
  - The threat to remaining storage appears to be low, with current water levels above a 20 % decline in aquifer saturated thickness from pre-development levels
  - Water quality data is sparse.

Figure 56: Detailed Upper Murray Alluvium SDL resource unit map

Upper Namoi Alluvium (GS47)

The Upper Namoi Alluvium SDL resource unit is located upstream of Narrabri on the Namoi and Mooki Rivers (Figure 57). The geology of area is characterised by unconsolidated sediments overlying low permeability bedrock. The sediments are associated with the Namoi and Mooki Rivers and Coxs Creek and consist mainly of sands, gravels and clays. The alluvium is generally divided into two stratigraphic units, the basal Gunnedah Formation and the surficial Narrabri Formation. The Gunnedah Formation reaches a maximum thickness of 115 m and consists of sands and gravels with interbedded clays. It is conceptualised as a high yielding aquifer with good quality, low salinity water. The overlying Narrabri Formation reaches a maximum thickness of 70 m and is conceptualised as a lower yielding aquifer comprised generally of clays with some sand and gravel.

The Upper Namoi Alluvium SDL resource unit is subdivided into 12 zones (numbered 1 to 12). The Upper Namoi Alluvium numerical model represents zones 2, 3, 4, 5, 11 and 12. The non-modelled part of the unit includes the remaining zones; 1, 6, 7, 8, 9 and 10. The Upper Namoi numerical model covers 63 percent of the SDL resource unit, including the north and central zones.

The Upper Namoi Alluvium SDL resource unit was covered by the 2006 Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources. The LTAAEL under this plan for the Upper Namoi Alluvial Water Source was 122.1 GL/y (not including S&D). This limit was established through the Achieving Sustainable Groundwater Entitlements (ASGE) program, which had a staged reduction process and reduced groundwater use to the LTAAEL by 30 June 2016. Due to this process, the Upper Namoi Alluvium SDL resource unit was placed in the “existing reduction program” category of the Groundwater Assessment framework.

The groundwater annual average recharge is less than SDL for this groundwater resource unit (Table 146). The numerical groundwater modelling carried out for the Authority indicated that the PEL was less than the BDL for this SDL resource unit and recommended further reductions in diversion limits in these systems. However, the Authority considered the additional uncertainties associated with modelling groundwater systems that were undergoing a reduction program and the resultant change in groundwater extractions. Additionally, these resource units have large groundwater storages (a minimum of 200 years at current levels of use) and there is a low risk of depleting the volume of groundwater stored in these aquifers within the period of the Basin Plan. The large storages also suggest that the overall risk to the resource is relatively low for the period of the Basin Plan. Given these factors the Authority considered that an approach should be adopted that allowed the reduction program to be completed and the outcomes determined before further changes to the SDL were considered at a later stage. For this SDL resource unit where the ASGE program was in place, the SDL has been set at the final plan limit (i.e. ASGE completion) plus S&D rights. The Authority will continue to monitor and assess the impacts of groundwater take in these systems with the aim of reviewing the plan limits on an ongoing basis.

The Upper Namoi Alluvium SDL resource unit sits within the Namoi Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 146: Summary table for the Upper Namoi Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Upper Namoi (GS47)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Namoi Alluvium (GW14)
GMU(s) Covered	Upper Namoi Alluvium GMU
Recharge (RRAM Step 1)*	91.0 GL/y
Recharge Input:	Numerical Model
PEL**	96.7 GL/y
BDL	123.4 GL/y
SDL***	123.4 GL/y
Licensed Entitlement*****	122.1 GL/y
Measured Groundwater Use*****	96.3 GL/y
Estimated S&D Use*****	1.30 GL/y
Entitlement plus S&D	123.4 GL/y

*The results of the Upper Namoi Alluvium numerical modelling (2004-05 level of extraction) used for the Murray–Darling Basin Sustainable Yields Project have been used to estimate recharge (CSIRO, 2007b). The model includes recharge via dryland rainfall, flooding, irrigation, river leakage, hill slope runoff and lateral flow.

**The PEL was determined using the results from the groundwater model (71.4 GL/y) and the RRAM for the area outside the model domain (25.3 GL/y).

***SDL set at the ASGE reduction program limit plus S&D. The SDL recognised that the ASGE program was a ten-year reduction process that had not concluded at that time and the outcomes not yet realised. The Authority is committed to working with the NSW Government to review the SDL as the outcomes of the ASGE program are realised and new knowledge becomes available.

****All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources (2006), and from updated S&D data provided by the NSW Government on 10 February 2011.

Table 147: Summary of the groundwater and surface water fluxes derived from the numerical model and identified GDEs for the Upper Namoi Alluvium

Summary characteristic	Volume / name
Groundwater Discharge to Streams*	7.51 GL/y
Stream Leakage to Groundwater*	8.35 GL/y
Impact of Groundwater Extraction on Streamflow**	6.89 GL/y
Groundwater Dependent KEA	None

*Derived from the model results for Scenario 2 (i.e. groundwater take at the current level of entitlements).

**Derived by comparing river loss under the current levels of entitlement (Scenario 2) and the no groundwater extraction scenario (Scenario 1).

Recharge risk assessment method outcome

Table 148 and Table 149 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- medium risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a low level of uncertainty.

Table 148: RRAM summary table for the Upper Namoi Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Med	Low	Risk (Y/N)	Yes	Yes	No	Risk to ESLT	Medium
				% Area	94%	5%	1%	Uncertainty Level	Low
SF	0.70	0.50	0.70	SF	0.80	0.90	N/A	SF	N/A

Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater.

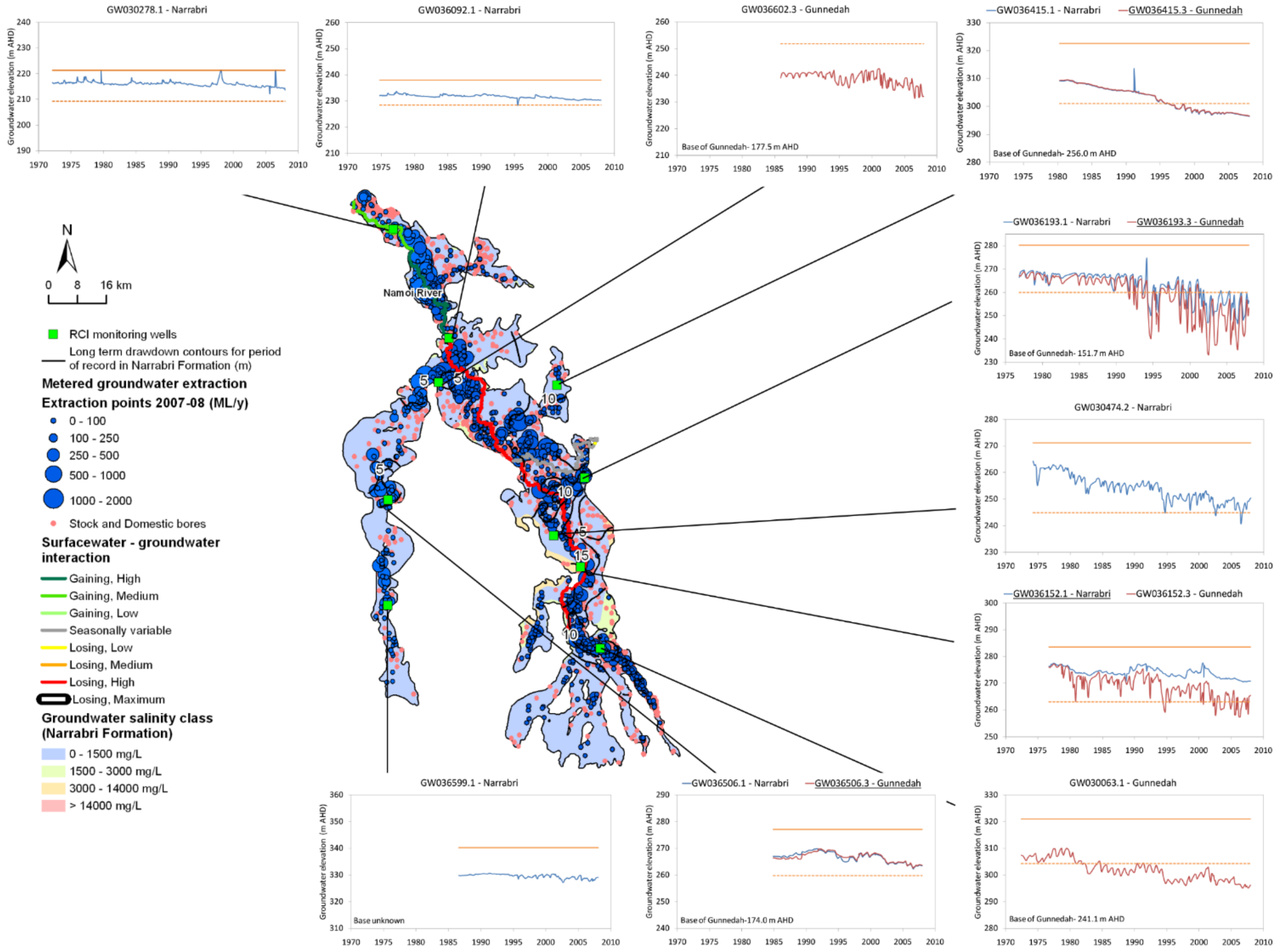
Table 149: PEL summary table for the Upper Namoi Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge to non-modelled zones 6, 7, 9, 10 (GL/y)*	18.0	0.0	0.0	0.0	18.0
SF	0.4	0.45	0.5	0.5	N/A
NSW plan limit for zones 1 and 8 (GL/y)	18.1	0.0	0.0	0.0	N/A
PEL (GL/y)**	25.3	0.0	0.0	0.0	25.3

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

**PEL is for the non-modelled portion of the SDL resource unit (37% – Zones 1, 6, 7, 8, 9, and 10).

The SDL resource unit contains 12 management zones used by the NSW Government. For the non-modelled part of the SDL resource unit, the hydrogeological understandings gained from the numerical modelling have been used to derive the PEL for groundwater management Zone 1 and Zone 8. The hydrogeological setting present in these zones is similar to that of the modelled management zones and hence the modelling outcome (namely that the current levels of extraction are sustainable due to the influence of groundwater surface water interaction) is assumed to hold for these management zones.



Hydrogeology and water sharing arrangements

- The aquifer system of the Upper Namoi comprises unconsolidated sediments of mainly sand and gravel associated with the Namoi River and its tributaries
- There are two alluvial aquifer systems identified: the shallow Narrabri Formation and the deeper Gunnedah Formation. Throughout most of the Upper Namoi, they act a single aquifer.
- A palaeochannel in the central valley area represents the deepest parts of the aquifer. This is the most productive aquifer of the GMU due to the coarseness of sediments.
- Recharge to the groundwater system on the alluvial plain is primarily via leakage from the stream channel under normal flows, leakage from overbank flooding and infiltration from rainfall.
- Rivers are in direct hydraulic contact with the water table for most of the GMU. The Upper reaches of the Namoi and Mooki Rivers are losing, and the Peel River is seasonally varying where it intersects the GMU. The lowermost reach of the Namoi River in the GMU is gaining
- Most groundwater extraction occurs from the Gunnedah Formation and where the palaeochannel is present in the central valley area.
- Existing water sharing arrangements are detailed in the Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources 2003. Arrangements include:
  - Water quality degradation is deemed unacceptable if groundwater salinity increases to beyond beneficial use class thresholds
  - Acceptable and unacceptable water level declines are not specified.

Resource condition analysis

- Selection of key monitoring sites:
  - should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should be able to monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
  - Features requiring priority in the Upper Namoi Alluvium include surface-groundwater interaction in the upper and lower reaches of the catchment where streams are highly connected, the productive base of the resource in major zones of extraction, and water quality throughout.
- Analysis of historical data:
  - Evidence of substantial drawdown in the Gunnedah Formation since start of monitoring (e.g. bores GW30063, GW30474, GW36506, GW36415, GW36152, GW36193)
  - The remaining storage within the Narrabri formation appears to be limited in places as shown by the aquifer saturated thickness (GW36506.1, GW30474.2) and in some cases has become unsaturated (GW36193.3, GW36415.1)
  - GW36415.1 has fallen below the base of the Narrabri Formation
  - Water quality data is sparse but previous investigations indicate some changes in water quality over time in response to extraction (Upper Namoi Status Report, 2004).

Ground Surface

Base of Narrabri Formation

Groundwater elevation (m AHD) Narrabri Formation

Groundwater elevation (m AHD) Gunnedah Formation

Underlined Bore ID represents key hydrograph at nested site

Data Source:

Metered groundwater extraction – NOW (2009)

Surface water – groundwater interactions – CSIRO (2008a)

Groundwater salinity class – MDBA (2000)

(The Narrabri formation is the uppermost aquifer of the alluvial sequence and extends to an average depth of approximately 30 m bgl)

(The Gunnedah formation underlies the Narrabri and has an average thickness of 50 metres)

Monitoring Points	Feature
GW036602.3 GW036415.3 GW036193.3 GW036506.3 GW030474.2 GW036152.3 GW030063.1	Productive base, Salinity
GW030278.1 GW036092.1 GW036193.1 GW036599.1	Connectivity

Figure 57: Upper Namoi Alluvium SDL resource unit map

Upper Namoi Tributary Alluvium (GS48)

The Upper Namoi Tributary Alluvium SDL resource unit is located in the Namoi River Catchment (Figure 58). The area is centred near the township of Werris Creek and the alluvial sediments are associated with the Currabubula, Werris, Quipolly and Quirindi Creeks. These alluvial aquifers are shallow, limited in their spatial extent and are not expected to be large groundwater resources. This is supported by the low volume of use in the area.

The Upper Namoi Tributary Alluvium SDL resource unit was covered by the 2012 Water Sharing Plan for Namoi Unregulated and Alluvial Water Sources. The LTAAEL under this plan for the Currabubula Alluvium, Quipolly Alluvium and Quirindi Alluvium Water Sources, which make up the Upper Namoi Tributary Alluvium SDL resource unit, was 1.77 GL/y, which was based on capping at the current level of development.

The Upper Namoi Alluvium Tributary groundwater SDL resource unit sits within the Namoi Alluvium WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 150: Summary table for the Upper Namoi Tributary Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Upper Namoi Tributary Alluvium (GS48)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Namoi Alluvium (GW14)
GMU(s) Covered	Miscellaneous Alluvium of the Barwon Region
Recharge (RRAM Step 1)*	2.36 GL/y
Recharge Input	WAVES recharge modelling
PEL	0.13 GL/y
BDL	1.77 GL/y
SDL**	1.77 GL/y
Licensed Entitlement:***	3.98 GL/y
Measured Groundwater Use***	1.73 GL/y
Estimated S&D Use***	0.04 GL/y
Entitlement plus S&D	4.02 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL is set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources (2012).

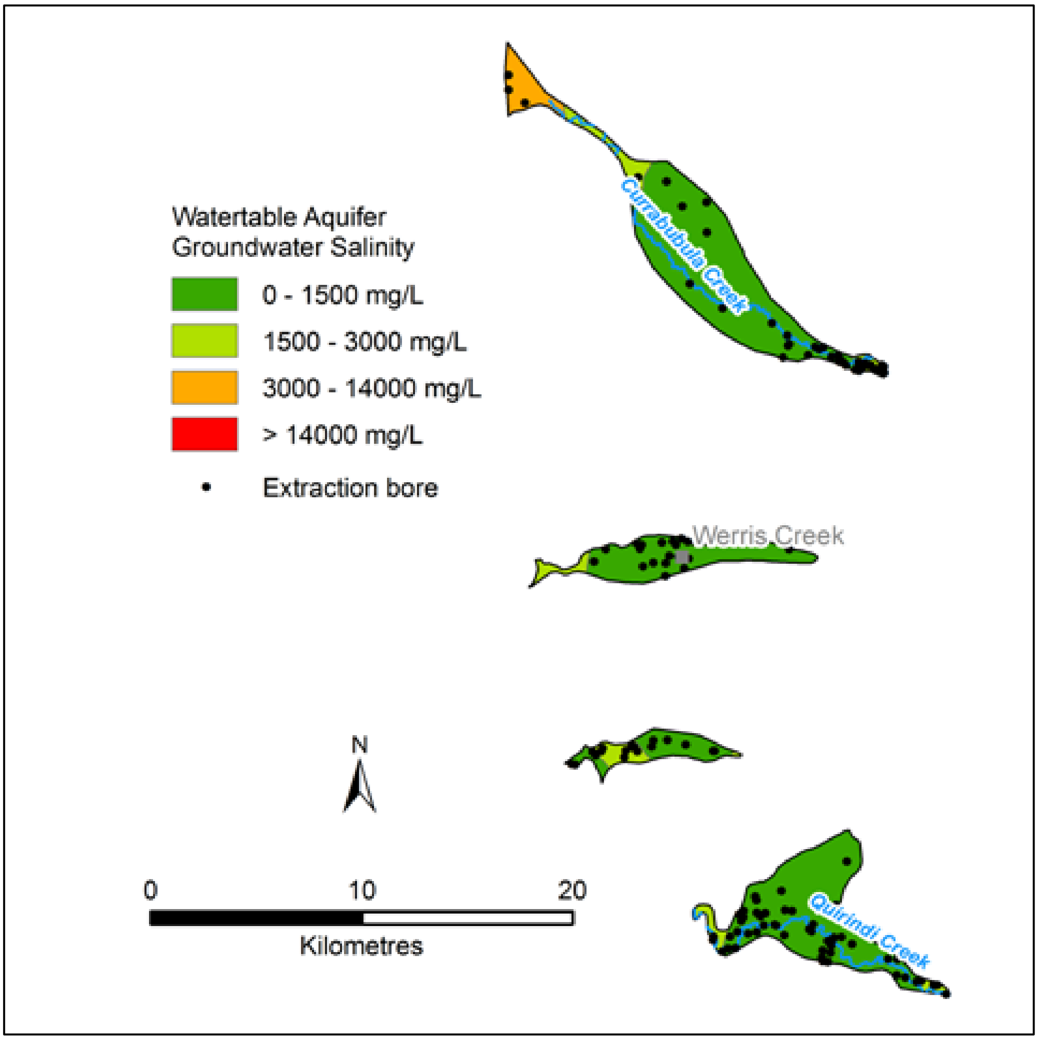


Figure 58: Upper Namoi Tributary Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 151 and Table 152 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- high risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 151: RRAM summary table for the Upper Namoi Tributary Alluvium

<table>
<tr><th rowspan="2">RRAM Step 2 Risks to KEA, KEF and PB</th><th rowspan="2">KEA</th><th rowspan="2">KEF</th><th rowspan="2">PB</th><th rowspan="2">RRAM Step 3 Risks to fresh water</th><th colspan="3">Salinity Class (KEO)</th><th rowspan="2" colspan="2">RRAM Step 4 Uncertainty</th></tr>
<tr><th>Class 1</th><th>Class 2</th><th>Class 3 & 4</th></tr>
<tr><td rowspan="2">Risk Ranking</td><td rowspan="2">Low</td><td rowspan="2">High</td><td rowspan="2">High</td><td>Risk (Y/N)</td><td>No</td><td>No</td><td>No</td><td>Risk to ESLT</td><td>High</td></tr>
<tr><td>% Area</td><td>86%</td><td>10%</td><td>4%</td><td>Uncertainty Level</td><td>High</td></tr>
<tr><td>SF</td><td>0.70</td><td>0.10</td><td>0.10</td><td>SF</td><td>N/A</td><td>N/A</td><td>N/A</td><td>SF</td><td>0.50</td></tr>
</table>

Table 152: PEL summary table for the Upper Namoi Tributary Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	1.91	0.36	0.09	0.0	2.36
SF	0.05	0.05	0.05	N/A	N/A
PEL (GL/y)	0.10	0.02	0.01	0.0	0.13

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Warrumbungle Basalt (GS49)

The Warrumbungle Basalt SDL resource unit is between Narrabri and Dubbo (Figure 59). Warrumbungle Basalt is defined as being comprised predominantly of basalt, dolerite and trachytes. The Basalt forms a fractured rock aquifer, with good groundwater quality and variable yields. Recharge to the basalt occurs mainly in the highlands on hilltops, whilst discharge is commonly at the break of slope and valley floors. A large portion of the area lies within a National Park and, as a result, the groundwater resources are relatively undeveloped and predominantly used for S&D purposes.

The Warrumbungle Basalt SDL resource unit was covered by the 2012 Water Sharing Plan for the NSW Murray–Darling Basin Porous Rock Groundwater Sources. The LTAAEL was 5.71 GL/y, which was based on the NSW risk assessment framework.

The Warrumbungle Basalt SDL resource unit sits within the NSW Murray–Darling Basin Fractured Rock WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 153: Summary table for the Warrumbungle Basalt

Summary characteristic	Name / description / volume
SDL resource unit	Warrumbungle Basalt (GS49)
Groundwater covered	All groundwater contained within all basalt of Cenozoic age and all unconsolidated alluvial sediments
WRP Area	NSW Murray–Darling Basin Fractured Rock (GW11)
GMU(s) Covered	Gulargambone Tertiary Basalt
Recharge (RRAM Step 1)*	31.3 GL/y
Recharge Input	WAVES recharge modelling
PEL	1.57 GL/y
BDL	0.55 GL/y
SDL**	0.55 GL/y
Licensed Entitlement***	0.01 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.54 GL/y
Entitlement plus S&D	0.55 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL is set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Murray–Darling Basin Porous Rock Groundwater Sources (2012).

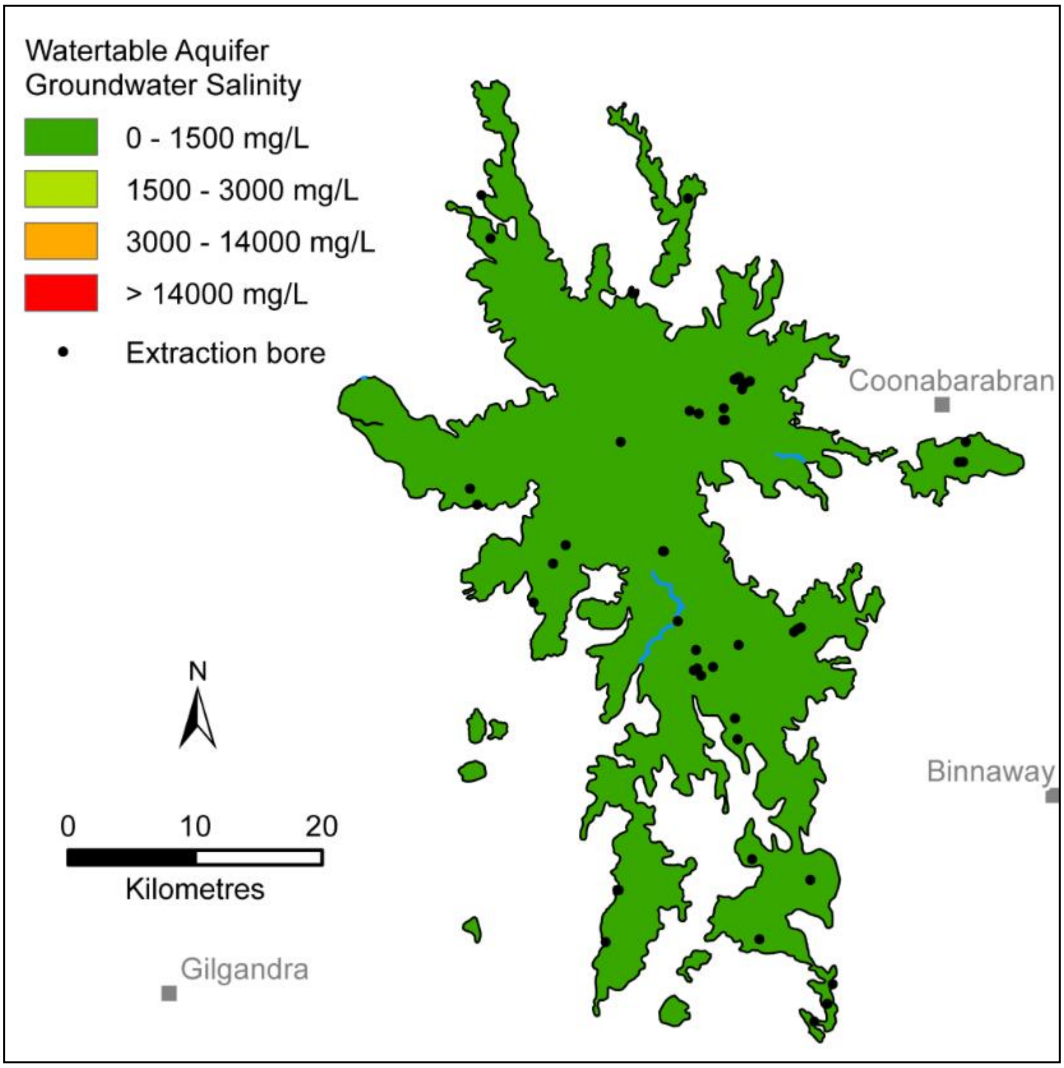


Figure 59: Warrumbungle Basalt SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 154 and Table 155 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- high risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 154: RRAM summary table for the Warrumbungle Basalt

RRAM Step 2 Risks to KEA, KEF and PB	**KEA**	**KEF**	**PB**	**RRAM Step 3 Risks to fresh water**	**Salinity Class (KEO)**			**RRAM Step 4 Uncertainty**	
					Class 1	**Class 2**	**Class 3 & 4**		
Risk Ranking	Low	High	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	100%	0%	0%	**Uncertainty Level**	High
SF	0.70	0.10	0.70	**SF**	N/A	N/A	N/A	**SF**	0.50

Table 155: PEL summary table for the Warrumbungle Basalt

Salinity	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Total**
Recharge (GL/y)*	31.3	0.0	0.0	0.0	31.3
SF	0.05	N/A	N/A	N/A	N/A
PEL (GL/y)	1.57	0.0	0.0	0.0	1.57

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Western Porous Rock (GS50)

The Western Porous Rock SDL resource unit is located in the Murray Basin in south-west NSW (Figure 60). The area incorporates all the major sedimentary aquifers in the region including the Renmark Group, the Murray Group Limestone and the Loxton–Parilla Sands. The Loxton–Parilla Sands grades to the Shepparton Formation to the east and north (Evans, 1988).

The Renmark Group contains the basal aquifer within the sedimentary basin and is composed of alluvial sands and gravels with inter-bedded carbonaceous clayey units. The Murray Group Limestone is a consolidated limestone limited to the southwestern parts, pinching out approximately beneath the Darling Anabranch. The Loxton–Parilla Sands overlie both the Murray Group and Renmark Group and consist of fine to coarse sands, whilst the Shepparton Formation is composed of fine-grained river- and lake-deposited sediments. The clay-rich nature of this latter formation means it is characterised by low transmissivities.

Groundwater quality in all aquifers is poor and consequently usage is limited, with S&D use from the Renmark Group the most predominant within the SDL resource unit. The groundwater is used for mining activities and there is potential for growth in groundwater use with prospective developments.

The Western Porous Rock SDL resource unit was covered by the 2012 Water Sharing Plan for the NSW Murray–Darling Basin Porous Rock Groundwater Sources. The LTAAEL was 530.5 GL/y, which was based on the NSW risk assessment framework. In determining the SDL for SDL resource units where the state plan limit is greater than the level of entitlement, the MDBA did not adopt the state extraction limits as the SDLs and carried out its own assessment. The SDL for this resource unit is 116.6 GL/y, which is based on the RRAM and the unassigned groundwater assessment.

When the Basin Plan was being finalised in 2012, concerns were raised by the NSW in relation to the groundwater SDLs in this SDL resource unit. In response, the Basin Plan included a requirement for a review of the SDL and BDL for the Western Porous Rock SDL resource unit to be conducted within two years after the commencement of the Basin Plan (by November 2014).

As per the provisions of the Basin Plan, a review panel was assembled to undertake the review. Also, to ensure the most up to date information was available to the review panels, MDBA in partnership with NSW appointed a consultant to bring together and synthesise the relevant information for the review. The review report and associated synthesis reports have been published on the MDBA website.

The review panel recommended that:

1. the SDL is varied to take account of the agreed area for the NSW Murray–Darling Basin Porous Rock WRP in line with the current MDBA calculation and applied sustainability factors;
2. the MDBA consider varying the Unassigned Water Factor for a SDL resource unit to a value to be determined once assurances have been made by the relevant jurisdiction that they can demonstrate that the resource will be managed via State policies and plans

in such a way that impacts are limited to acceptable levels. These assurances would need to be explicit and would include specification of the assets to be protected within Schedule 3 of the relevant NSW WSP, an agreement on the criteria that would be used to define acceptable impacts and monitoring, compliance and review processes.

The Authority accepted these recommendations and amended the SDL for the Western Porous Rock SDL resource unit to 226.0 GL/y in July 2018.

The Western Porous Rock SDL resource unit sits within the NSW Murray–Darling Basin Porous Rock WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 156: Summary table for the Western Porous Rock

Summary characteristic	Name / description / volume
SDL resource unit	Western Porous Rock (GS50)
Groundwater covered	All groundwater contained within all sediments of Cenozoic age, excluding groundwater contained in the following SDL resource units: Upper Darling Alluvium and Lower Darling Alluvium
WRP Area	NSW Murray–Darling Basin Porous Rock (GW6)
GMU(s) Covered	Western Murray Porous Rock
Recharge (RRAM Step 1)*	395.7 GL/y
Recharge Input	NSW Government
PEL	277.0 GL/y
BDL	63.1 GL/y
SDL**	226.0 GL/y
Licensed Entitlement***	36.4 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	26.8 GL/y
Entitlement plus S&D	63.2 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Murray–Darling Basin Porous Rock Groundwater Sources (2012).

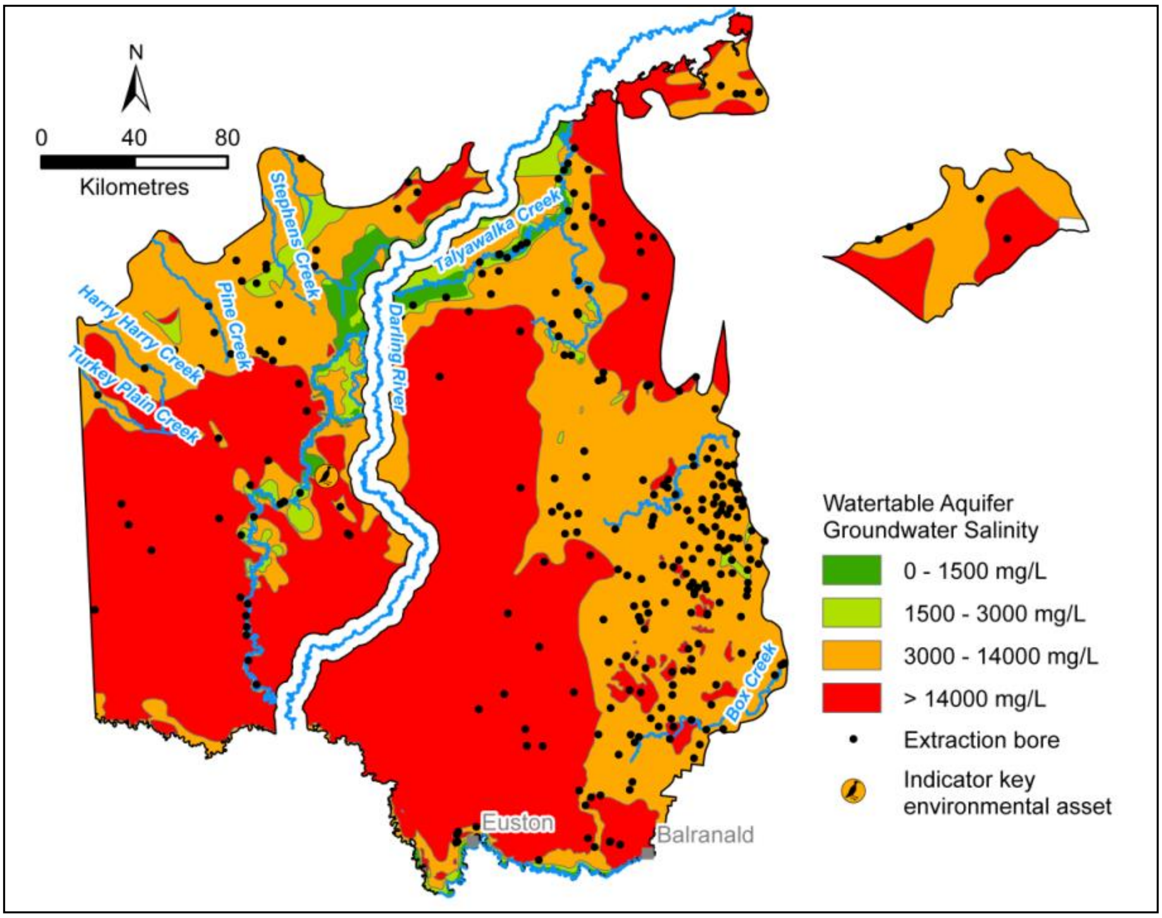


Figure 60: Western Porous Rock SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 157 and Table 158 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a low level of uncertainty.

Table 157: RRAM summary table for the Western Porous Rock

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	Low
				% Area	2%	20%	78%	**Uncertainty Level**	Low
SF	0.70	0.70	0.70	**SF**	N/A	N/A	N/A	**SF**	N/A

Table 158: PEL summary table for the Western Porous Rock

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	10.7	14.3	138.5	232.3	395.8
SF	0.70	0.70	0.70	0.70	N/A
PEL (GL/y)	7.48	9.98	97.0	162.6	277.0

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Young Granite (GS51)

The Young Granite SDL resource unit is centred on the town of Young in south eastern NSW and includes most of the outcropping Young Granite (Figure 61). Some of the Young Granite is overlain by thin alluvial sediments or weathered granite, and the aquifer has been developed for irrigation.

The Young Granite SDL resource unit was covered by the 2012 Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources. The LTAAEL was 9.53 GL/y, which was based on the NSW risk assessment framework.

The Young Granite SDL resource unit sits within the NSW Murray–Darling Basin Fractured Rock WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 159: Summary table for the Young Granite

Summary characteristic	Name / description / volume
SDL resource unit	Young Granite (GS51)
Groundwater covered	All groundwater
WRP Area	NSW Murray–Darling Basin Fractured Rock (GW11)
GMU(s) Covered	Young Granite
Recharge (RRAM Step 1)*	85.8 GL/y
Recharge Input	WAVES recharge modelling
PEL	4.29 GL/y
BDL	7.11 GL/y
SDL**	7.11 GL/y
Licensed Entitlement***	6.35 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.76 GL/y
Entitlement plus S&D	7.11 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL is set at current use (connected resources).

***All entitlement and use information provided by the NSW Government as reported in the Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources (2012).

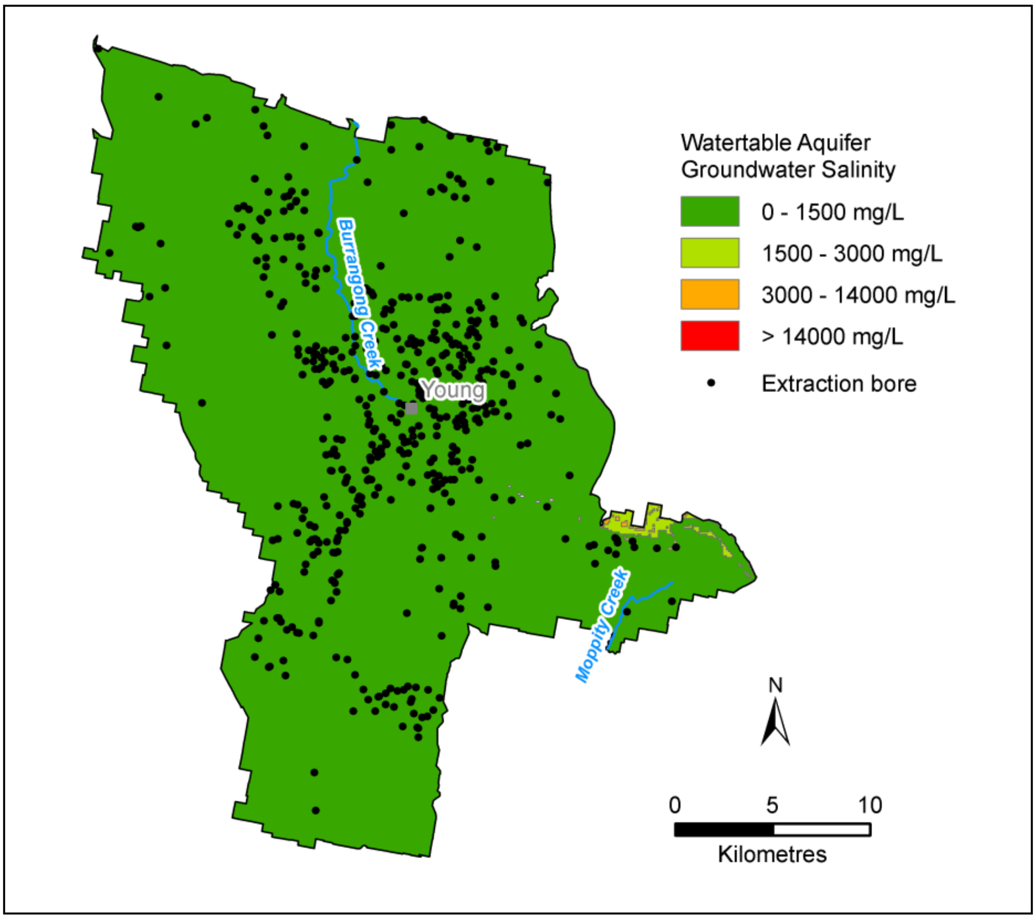


Figure 61: Young Granite SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 160 and Table 161 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- high risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 160: RRAM summary table for the Young Granite

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	High	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	99%	1%	0%	**Uncertainty Level**	High
SF	0.70	0.10	0.10	**SF**	N/A	N/A	N/A	**SF**	0.50

Table 161: PEL summary table for the Young Granite

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	85.6	0.23	0.05	0.0	85.9
SF	0.05	0.05	0.05	N/A	N/A
PEL (GL/y)	4.28	0.01	0.003	0.0	4.29

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Australian Capital Territory

Australian Capital Territory (Groundwater) (GS52)

The Australian Capital Territory (Groundwater) SDL resource unit includes the entire ACT and is completely encompassed by the Lachlan Fold Belt (Figure 62). The two main types of aquifers in the area are fractured rock and small alluvial valleys with low salinity groundwater in both. The groundwater is primarily drawn from the fractured rock aquifers.

The Australian Capital Territory (Groundwater) SDL resource unit sits within the Australian Capital Territory (groundwater) WRP area. The Water Resources (water available from areas) Determination 2007 provided for an extraction limit of 7.25 GL/y. Groundwater use, when compared to this limit, is significantly lower at approximately 0.50 GL/y. Groundwater is primarily taken from the fractured rock aquifer, for S&D purposes.

The BDL was updated in an amendment to the Basin Plan in July 2018 following a request from ACT based on new information, recent investigations and the subsequent issuing of entitlements, which indicated that the Commonwealth was using more water in the ACT in 2009 than was previously allowed for. No change was made to the SDL as there is still room for growth under the current SDL.

Table 162: Summary table for the ACT Groundwater

Summary characteristic	Name / description / volume
SDL resource unit	Australian Capital Territory (Groundwater) (GS52)
Groundwater covered	All groundwater
WRP Area	Australian Capital Territory (groundwater) (GW1)
GMU(s) Covered	ACT
Recharge (RRAM Step 1)*	150.4 GL/y
Recharge Input	WAVES recharge modelling
PEL	7.52 GL/y
BDL	2.27 GL/y
SDL**	3.16 GL/y
Licensed Entitlement***	1.70 GL/y
Metered Groundwater Use	0.50 GL/y
Estimated S&D use	0 GL/y
Entitlement plus S&D	1.70 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via base flow and/or evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the ACT Government as part of the RRAM process (CSIRO and SKM, 2010f).

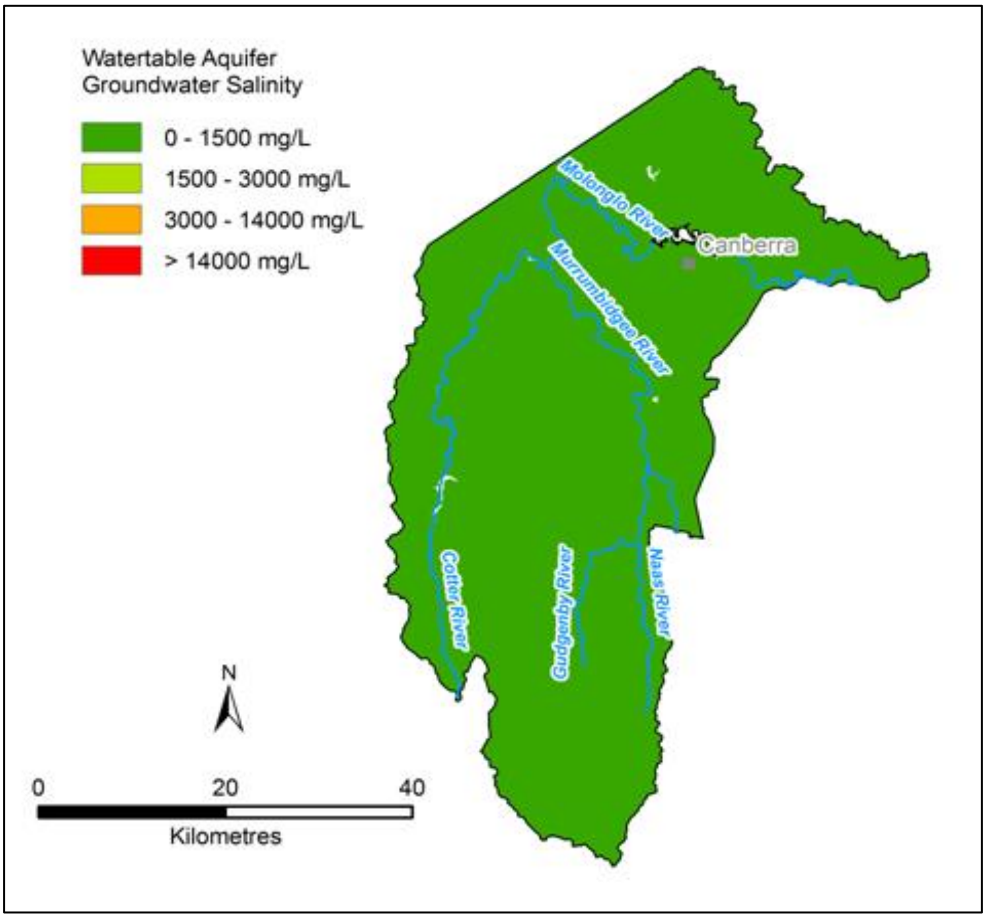


Figure 62: ACT Groundwater SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 163 and Table 164 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- high risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 163: RRAM summary table for the ACT Groundwater

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	High	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	100%	0%	0%	**Uncertainty Level**	High
SF	0.70	0.10	0.10	**SF**	N/A	N/A	N/A	**SF**	0.50

Table 164: PEL summary table for the ACT Groundwater

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	150.4	0.0	0.0	0.0	150.4
SF	0.05	N/A	N/A	N/A	N/A
PEL (GL/y)	7.52	0.0	0.0	0.0	7.52

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Queensland

Condamine Fractured Rock (GS53)

The Condamine Fractured Rock SDL resource unit is in south-east Queensland (Figure 63). The area is dominated by the sandstones and mudstones of the Upper Devonian Texas Beds and Lower Triassic granites of the Herries Range (Olgers et al., 1972). Groundwater use is limited, as the alluvial systems associated with the major rivers and creeks in the Upper Condamine Alluvium provide a more viable groundwater resource.

The Condamine Fractured Rock groundwater SDL resource unit sits within the Condamine-Balonne WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 165: Summary Table for the Condamine Fractured Rock

Summary characteristic	Name / description / volume
SDL resource unit	Condamine Fractured Rock (GS53)
Groundwater covered	All groundwater contained within all igneous and metamorphic rocks
WRP Area	Condamine–Balonne (GW21)
GMU(s) Covered	None
Recharge (RRAM Step 1)*	69.4 GL/y
Recharge Input	WAVES recharge modelling
PEL	3.47 GL/y
BDL	0.81 GL/y
SDL**	1.48 GL/y
Licensed Entitlement***	0.15 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.66 GL/y
Entitlement plus S&D	0.81 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via baseflow and/or evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the Queensland Government as reported in RRAM for entitlement (CSIRO and SKM, 2010g) and correspondence sent on 15 April 2011 for estimated S&D.

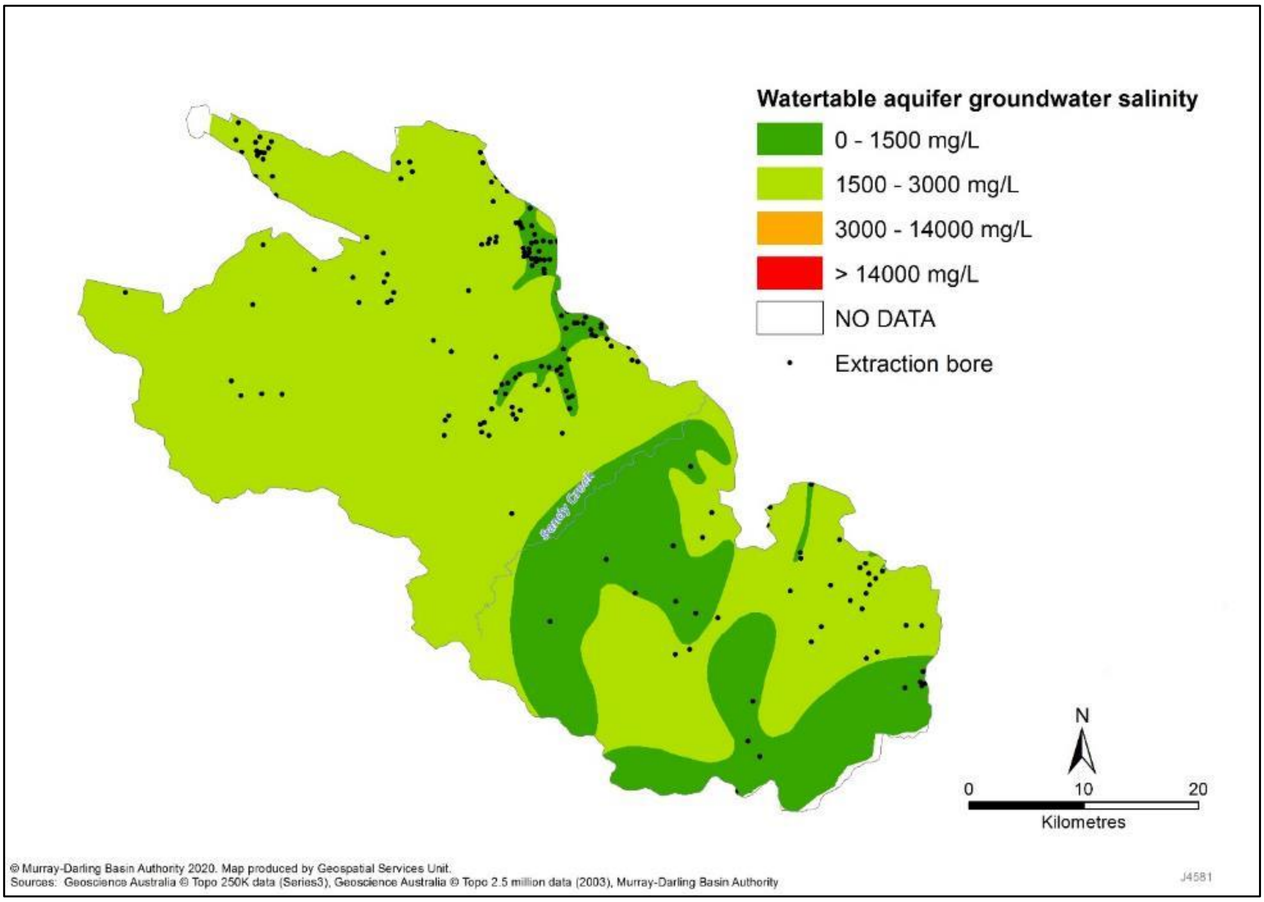


Figure 63: Condamine Fractured Rock SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 166 and Table 167 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- medium risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 166: RRAM summary table for the Condamine Fractured Rock

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	Med	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	High
				% Area	24%	76%	0%	**Uncertainty Level**	High
SF	0.70	0.10	0.50	**SF**	N/A	N/A	N/A	**SF**	0.50

Table 167: PEL summary table for the Condamine Fractured Rock

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	21.5	47.9	0.0	0.0	69.4
SF	0.05	0.05	N/A	N/A	N/A
PEL (GL/y)	1.08	2.39	0.0	0.0	3.47

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Queensland Border Rivers Alluvium (GS54)

The Queensland Border Rivers Alluvium SDL resource unit is associated with the Border Rivers valley, including the Macintyre River upstream of Goondiwindi (Figure 64). There are two aquifers that overlie the basement rock, separated by an aquitard. The water table aquifer consists of 10 to 30 m of unconsolidated clay, sand and gravel, is unconfined and responds hydraulically to flooding. The aquitard comprises semi-impervious clay layers. The deeper aquifer is semi-confined and comprises consolidated clay, sandstone and gravel up to about 50 m thick and extends to about 50 to 100 m below the ground surface (Welsh, 2007). Groundwater resources are relatively undeveloped. The Border Rivers Agreement between Queensland and NSW includes groundwater and a portion of the area is included in the area covered by the agreement.

The Queensland Border Rivers Alluvium groundwater SDL resource unit sits within the Queensland Border Rivers-Moonie WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 168: Summary table for the Queensland Border Rivers Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Queensland Border Rivers Alluvium (GS54)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Queensland Border Rivers–Moonie (GW19)
GMU(s) Covered	Border River
Recharge (RRAM Step 1)*	68.5 GL/y
Recharge Input	WAVES recharge modelling
PEL	16.9 GL/y
BDL	14.0 GL/y
SDL**	14.0 GL/y
Licensed Entitlement***	22.0 GL/y
Measured Groundwater Use	6.57 GL/y (within the Border Rivers agreement area)
Estimated S&D Use***	1.45 GL/y
Entitlement plus S&D	23.4 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via baseflow and/or evapotranspiration.

**SDL set at current use for Border Rivers Agreement Area and entitlement plus S&D for outside the Agreement Area (5.43 GL/y) as there is no metering (connected resources). The current use figure is from the NSW section of the Border Rivers Agreement Area (8.39 GL/y), as the states wanted equity in the SDL for this area and current use in both states is within the PEL.

***All entitlement and use information provided by the Queensland Government as reported in RRAM for entitlement (CSIRO and SKM, 2010g) and correspondence sent on 27 May 2012 for estimated S&D.

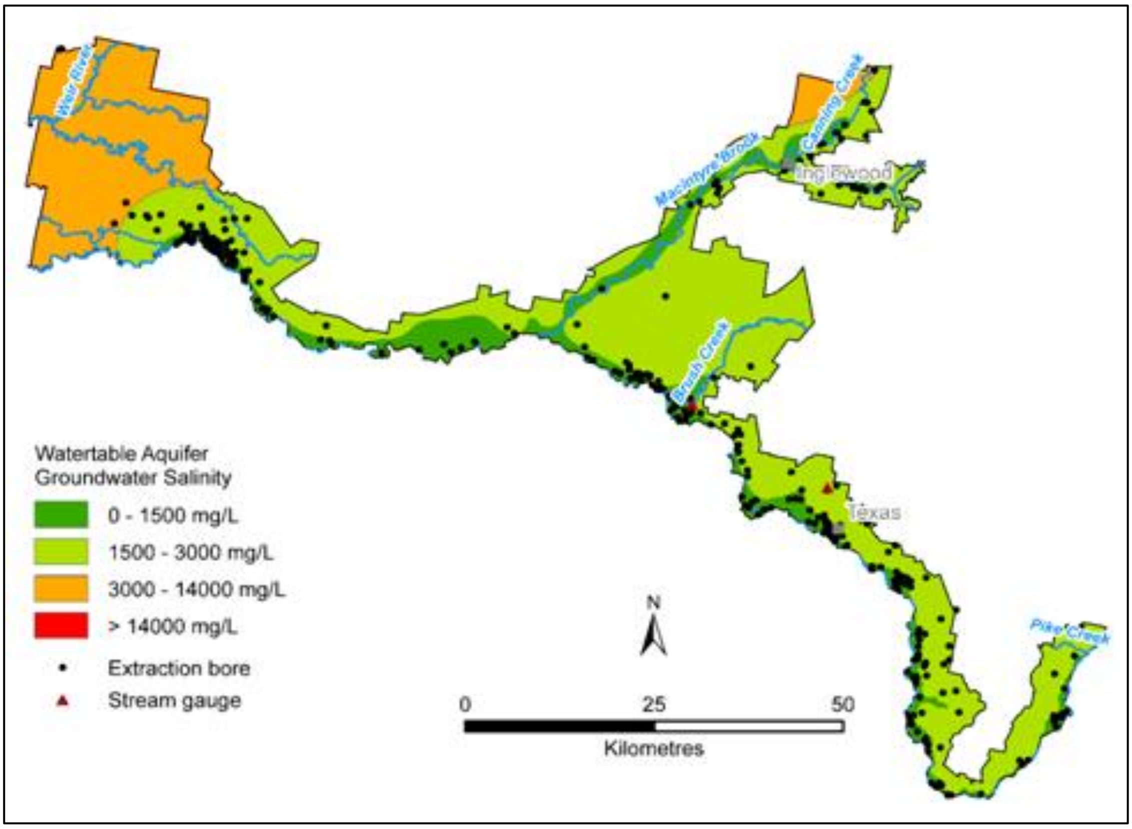


Figure 64: Queensland Border Rivers Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 169 and Table 170 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- medium risk for KEFs
- medium risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 169: RRAM summary table for the Queensland Border Rivers Alluvium

<table>
<tr><th rowspan="2">RRAM Step 2 Risks to KEA, KEF and PB</th><th rowspan="2">KEA</th><th rowspan="2">KEF</th><th rowspan="2">PB</th><th rowspan="2">RRAM Step 3 Risks to fresh water</th><th colspan="3">Salinity Class (KEO)</th><th colspan="2" rowspan="2">RRAM Step 4 Uncertainty</th></tr>
<tr><th>Class 1</th><th>Class 2</th><th>Class 3 & 4</th></tr>
<tr><td rowspan="2">Risk Ranking</td><td rowspan="2">Low</td><td rowspan="2">Med</td><td rowspan="2">Med</td><td>Risk (Y/N)</td><td>No</td><td>No</td><td>No</td><td>Risk to ESLT</td><td>Medium</td></tr>
<tr><td>% Area</td><td>16%</td><td>59%</td><td>25%</td><td>Uncertainty Level</td><td>High</td></tr>
<tr><td>SF</td><td>0.70</td><td>0.50</td><td>0.50</td><td>SF</td><td>N/A</td><td>N/A</td><td>N/A</td><td>SF</td><td>0.50</td></tr>
</table>

Note: Although there is fresh and saline groundwater within this resource unit, the nature of the groundwater flow paths means that there is a low risk of salinisation of the fresh groundwater.

Table 170: PEL summary table for the Queensland Border Rivers Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	23.8	39.3	4.37	0.0	67.5
SF	0.25	0.25	0.25	N/A	N/A
PEL (GL/y)	5.95	9.82	1.09	0.0	16.9

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Queensland Border Rivers Fractured Rock (GS55)

The Queensland Border Rivers Fractured Rock SDL resource unit is located in the south-east corner of the Queensland part of the MDB (Figure 65). The area is dominated by the sandstones and mudstones of the Upper Devonian Texas Beds. Thin Quaternary alluvium associated with streams also occurs in the area (Mond et al., 1968). Groundwater resources in this area are relatively undeveloped.

The Queensland Border Rivers Fractured Rock groundwater SDL resource unit sits within the Queensland Border Rivers-Moonie WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 171: Summary table for the Queensland Border Rivers Fractured Rock

Summary characteristic	Name / description / volume
SDL resource unit	Queensland Border Rivers Fractured Rock (GS55)
Groundwater covered	All groundwater contained within all igneous and metamorphic rocks, excluding groundwater in the Queensland Border Rivers Alluvium SDL resource unit
WRP Area	Queensland Border Rivers–Moonie (GW19)
GMU(s) covered	None
Recharge (RRAM Step 1)*	236.6 GL/y
Recharge Input	WAVES recharge modelling
PEL	11.8 GL/y
BDL	10.1 GL/y
SDL**	10.5 GL/y
Licensed Entitlement***	0.56 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	9.53 GL/y
Entitlement plus S&D	10.1 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers), and does not account for water that is discharged from the system via baseflow and/or evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the Queensland Government as reported in RRAM for entitlement (CSIRO and SKM, 2010g) and correspondence sent on 15 April 2011 for estimated S&D.

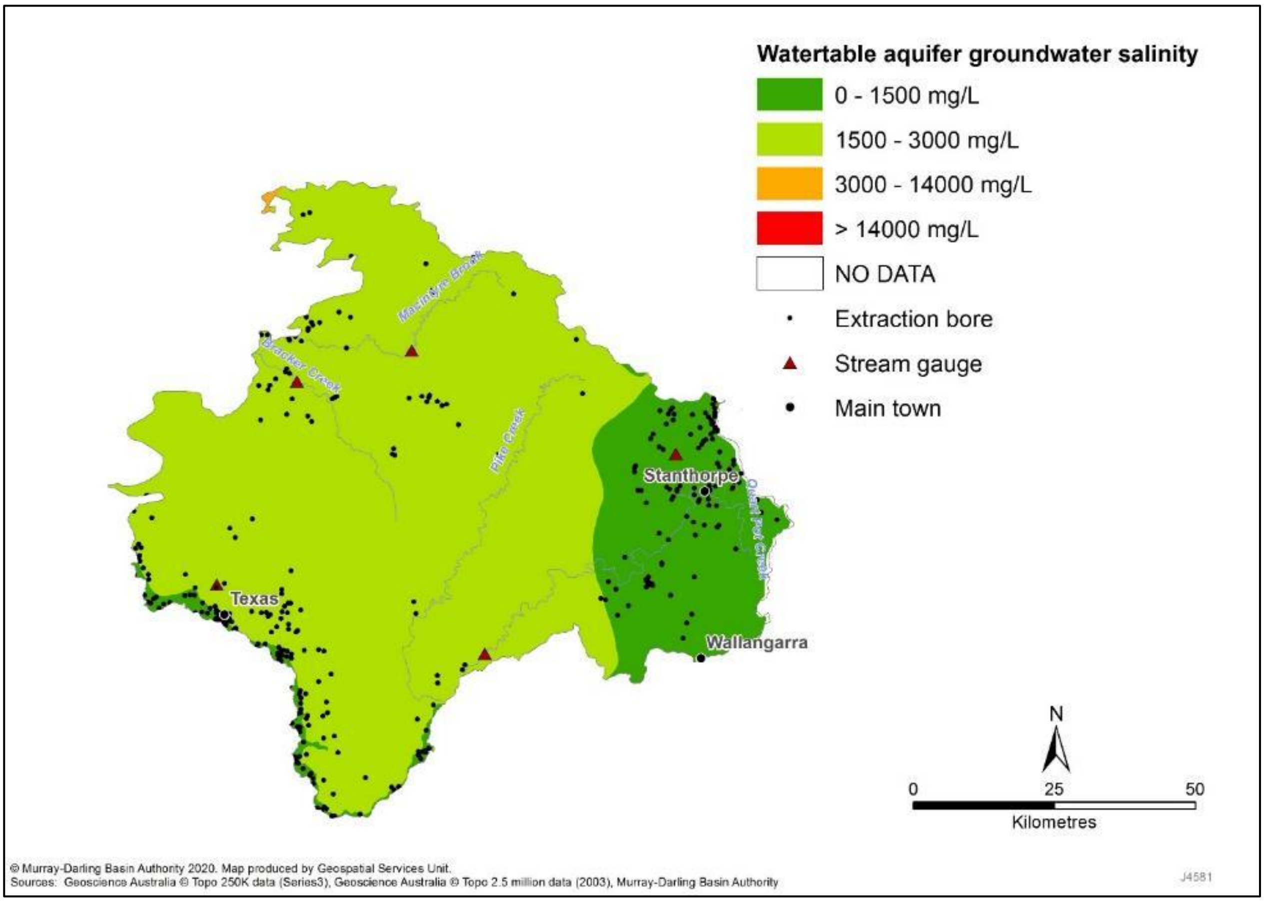


Figure 65: Queensland Border Rivers Fractured Rock SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 172 and Table 173 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- high risk for KEFs
- high risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 172: RRAM summary table for the Queensland Border Rivers Fractured Rock

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	High	High	Risk (Y/N)	No	No	No	Risk to ESLT	High
				% Area	20%	80%	0%	Uncertainty Level	High
SF	0.70	0.10	0.10	SF	N/A	N/A	N/A	SF	0.50

Table 173: PEL summary table for the Queensland Border Rivers Fractured Rock

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	87.2	149.2	0.14	0.0	236.5
SF	0.05	0.05	0.05	N/A	N/A
PEL (GL/y)	4.36	7.46	0.007	0.0	11.8

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Queensland MDB: deep (GS56)

The Queensland MDB: deep SDL resource unit covers groundwater below the GAB in the Queensland MDB (Figure 66). There is no development and the Queensland Government does not have a groundwater management plan for this groundwater resource. An SDL was set as a part of the drafting of the Basin Plan (May 2012), to ensure all Basin water resources are covered in the Basin Plan.

Due to limited information, the SDL was set at a volume considered appropriate for the size of the resource; considering the level of risk to the ESLT; and based on technical advice provided by a group of groundwater experts engaged by the MDBA to provide advice on technical elements of the Basin Plan.

The Bowen Basin is the deepest and oldest of the geological formations and aquifer resources within the SDL resource unit and the entire MDB. It stretches from north to south through the centre of the SDL resource unit, extending from central Queensland, south beneath the Surat Basin, into NSW, where it eventually connects with the Gunnedah–Oxley Basin. The connection is considered significant (DNRME, 2018).

Recharge to the Bowen Basin occurs by infiltration of rainfall into the outcropping sandstone aquifers and leakage through unconsolidated sediments overlying the aquifers from the north in Roma in a south west direction towards St George and the Queensland/NSW border. Discharge from the Queensland part of the Bowen Basin has not been estimated but is expected to be small and generally restricted to connected Bowen sub-basins, with discharge toward the southern Bowen Basin, including the Gunnedah–Oxley Basin in NSW (DNRME, 2018).

To date, groundwater in the Queensland MDB: deep SDL resource unit has only been accessed within the Bowen Basin and little is known about the extent of some of the other water resources. This is because the groundwater resources within the associated basins are very deep (up to 9,000 m) and because there are more easily accessible and readily available water resources above these basins. Extraction of groundwater in the Bowen Basin is low and mostly associated with coal seam gas extraction (from Bandanna Formation) in the area between Injune and Roma, where it underlays the Condamine and Balonne catchment. Water quality is poor (salinity up to 9,000 mg/L (DNRME, 2018)).

The Queensland MDB: deep SDL resource unit sits within the Condamine-Balonne WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

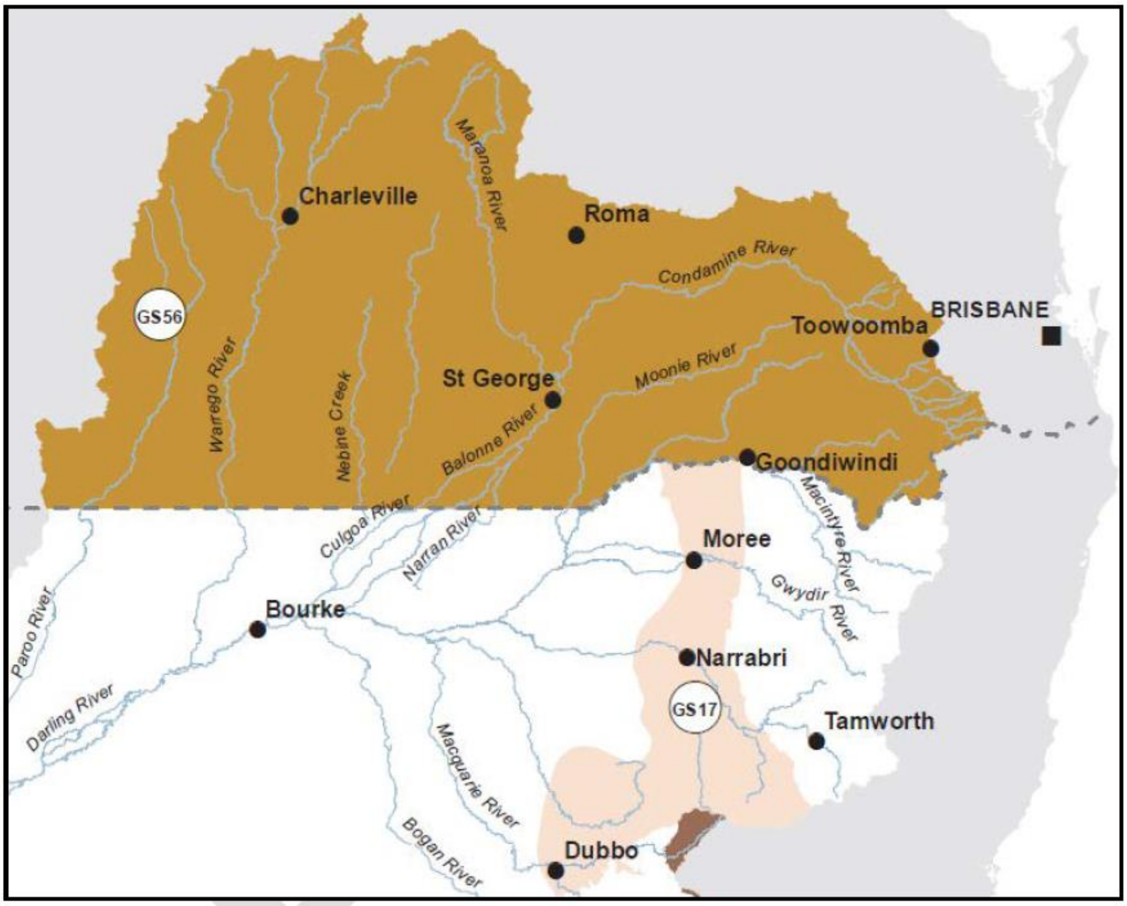


Figure 66: Queensland MDB: Deep SDL resource unit map (DNRME, 2018)

Table 174: Summary table for the Queensland MDB: Deep

Summary characteristic	Name / description / volume
SDL resource unit*	Queensland MDB: deep (GS56)
Groundwater covered	All groundwater in aquifers below the GAB
WRP Area	Condamine–Balonne (GW21)
GMU(s) covered	None
Recharge (RRAM Step 1)	N/A
Recharge Input	N/A
PEL	N/A
BDL	0 GL/y
SDL	100.0 GL/y
Licensed Entitlement	0 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use	0 GL/y
Entitlement plus S&D	0 GL/y

*The SDL resource unit covers all groundwater below the GAB and has been attributed to the Condamine–Balonne WRP area for reporting purposes.

Sediments above the Great Artesian Basin: Border Rivers–Moonie (GS57)

The Sediments above the Great Artesian Basin: Border Rivers–Moonie SDL resource unit incorporates the shallow Quaternary alluvium and undifferentiated Tertiary and Quaternary clastics that overlie the GAB, within the Border Rivers and Moonie catchments (Figure 67 and Figure 68). The dominant source of groundwater in this area is the underlying GAB Jurassic and Cretaceous confined sandstone aquifers which are separated from this SDL resource unit by thick confining beds. Groundwater resources in this area are relatively undeveloped.

This SDL resource unit is a part of the 'Sediments above the GAB' groundwater system that was split into four SDL resource units (Border Rivers, Condamine–Balonne, Moonie and Warrego–Paroo–Nebine) for the Basin Plan to align with the Queensland planning arrangements. The two SDL resource units 'Sediments above the GAB: Border Rivers' and 'Sediments above the GAB: Moonie' were merged into one SDL unit (Sediments above the Great Artesian Basin: Border Rivers-Moonie) in an amendment to the Basin Plan in July 2018. The RRAM assessment is described separately for these two areas in this report card, as the volumes of the SDLs were combined during this process and not amended.

The Sediments above the Great Artesian Basin: Border Rivers–Moonie SDL resource unit sits within the Queensland Border Rivers-Moonie WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 175: Summary table for the Sediments above the GAB: Border Rivers

Summary characteristic	Name / description / volume
SDL resource unit	Sediments above the Great Artesian Basin: Border Rivers (former name)
Groundwater covered	All groundwater contained within all consolidated sediments above the GAB, excluding groundwater in the Queensland Border Rivers Alluvium SDL resource unit
WRP Area	Queensland Border Rivers–Moonie (GW19)
GMU(s) Covered	None
Recharge (RRAM Step 1)*	109.4 GL/y
Recharge Input	WAVES recharge modelling
PEL	57.4 GL/y
BDL	0.14 GL/y
SDL**	46.9 GL/y
Licensed Entitlement***	0 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.04 GL/y
Entitlement plus S&D	0.04 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the Queensland Government as reported in RRAM for entitlement (CSIRO and SKM, 2010g) and correspondence sent on 15 April 2011 for estimated S&D.

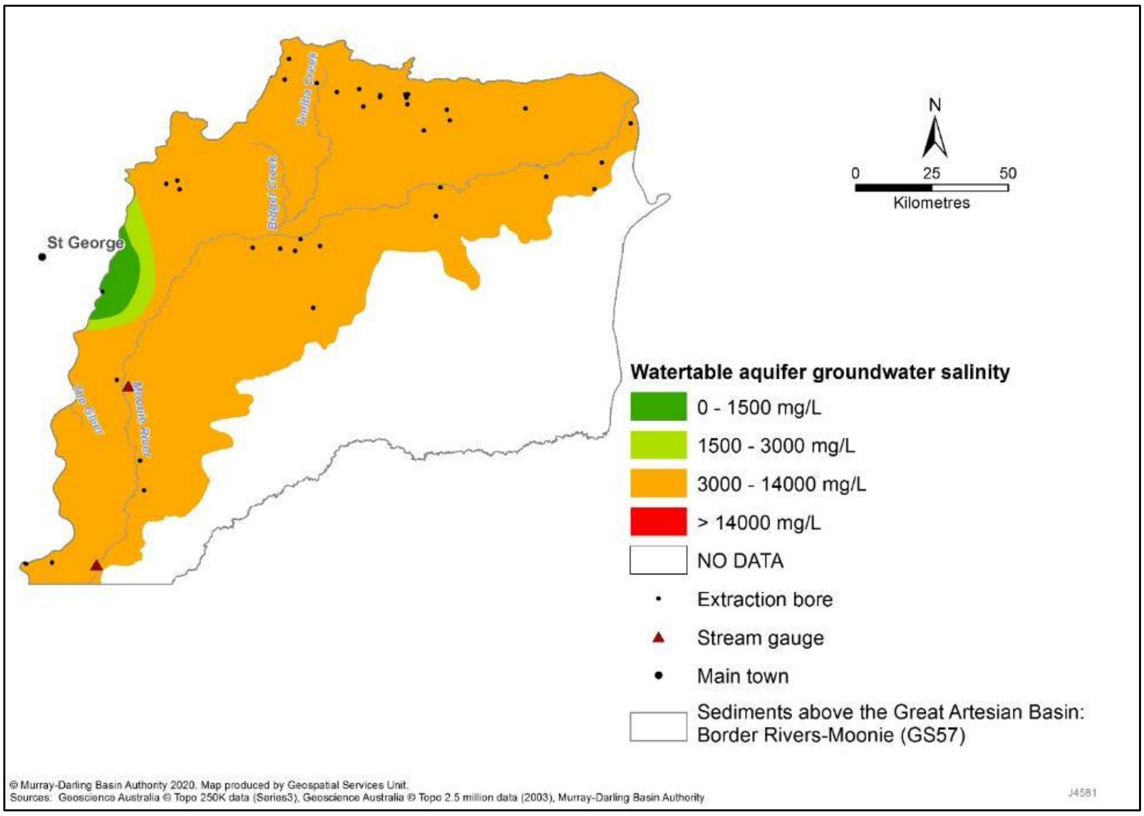


Figure 67: Sediments above the GAB (Border Rivers) SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome – Border Rivers

Table 176 and Table 177 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 176: RRAM summary table for the Sediments above the GAB: Border Rivers

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	Risk (Y/N)	No	No	No	Risk to ESLT	Low
				% Area	0%	0%	100%	Uncertainty Level	High
SF	0.70	0.70	0.70	SF	N/A	N/A	N/A	SF	0.75

Table 177: PEL summary table for the Sediments above the GAB: Border Rivers

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	0.0	0.0	109.4	0.04	109.4
SF	N/A	N/A	0.53	0.53	N/A
PEL (GL/y)	0.0	0.0	57.4	0.02	57.4

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Table 178: Summary table for the Sediments above the GAB: Moonie

Summary characteristic	Name / description / volume
SDL resource unit	Sediments above the Great Artesian Basin: Moonie (former name)
Groundwater covered	All groundwater contained within all consolidated sediments above the GAB, excluding groundwater in the Queensland Border Rivers Alluvium SDL resource unit
WRP Area	Queensland Border Rivers–Moonie (GW19)
GMU(s) Covered	None
Recharge (RRAM Step 1)*	247.2 GL/y
Recharge Input	WAVES recharge modelling
PEL	129.8 GL/y
BDL	0.10 GL/y
SDL**	32.5 GL/y
Licensed Entitlement***	0.02 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.08 GL/y
Entitlement plus S&D	0.10 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the Queensland Government as reported in RRAM for entitlement (CSIRO and SKM, 2010g) and correspondence sent on 15 April 2011 for estimated S&D.

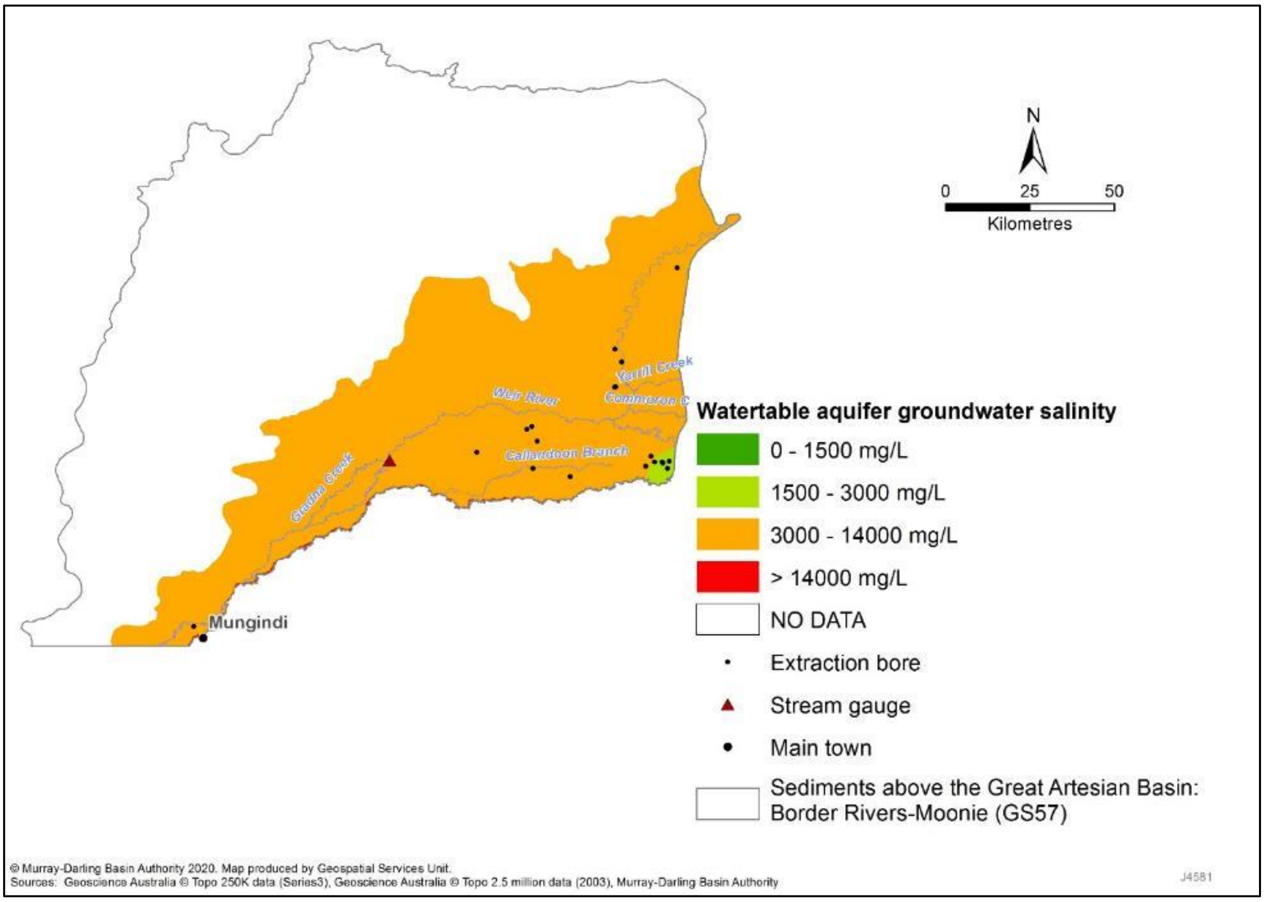


Figure 68: Sediments above the GAB (Moonie) SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome – Moonie

Table 179 and Table 180 provides a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 179: RRAM summary table for the Sediments above the GAB: Moonie

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	Low
				% Area	0.5%	1.5%	98%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	N/A	N/A	N/A	**SF**	0.75

Table 180: PEL summary table for the Sediments above the GAB: Moonie

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	1.73	3.49	242.0	0.0	247.2
SF	0.53	0.53	0.53	N/A	N/A
PEL (GL/y)	0.91	1.83	127.0	0.0	129.7

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Sediments above the Great Artesian Basin: Condamine–Balonne (GS58)

The Sediments above the Great Artesian Basin: Condamine–Balonne SDL resource unit is located east of St George, with the Balonne River draining through the SDL resource unit (Figure 69). The area incorporates the Cretaceous sandstone, siltstone and mudstone of the Griman Creek Formation. The dominant source of groundwater in this area is the underlying GAB Jurassic and Cretaceous confined sandstone aquifers which are separated from this SDL resource unit by thick confining beds. Groundwater resources in this area are relatively undeveloped.

This SDL resource unit is a part of the 'Sediments above the GAB' groundwater system that was split into four SDL resource units (Border Rivers, Condamine–Balonne, Moonie and Warrego–Paroo–Nebine) for the Basin Plan, to align with the Queensland planning arrangements.

The Sediments above the Great Artesian Basin: Condamine–Balonne SDL resource unit sits within the Condamine-Balonne WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 181: Summary table for the Sediments above the GAB: Condamine–Balonne

Summary characteristic	Name / description / volume
SDL resource unit	Sediments above the GAB: Condamine-Balonne (GS58)
Groundwater covered	All groundwater contained within all consolidated sediments above the GAB
WRP Area	Condamine–Balonne (GW21)
GMU(s) Covered	None
Recharge (RRAM Step 1)*	134.4 GL/y
Recharge Input	WAVES recharge modelling
PEL	70.6 GL/y
BDL	0.66 GL/y
SDL**	18.1 GL/y
Licensed Entitlement***	0.07 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.59 GL/y
Entitlement plus S&D	0.66 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the Queensland Government as reported in RRAM for entitlement (CSIRO and SKM, 2010g) and correspondence sent on 15 April 2011 for estimated S&D.

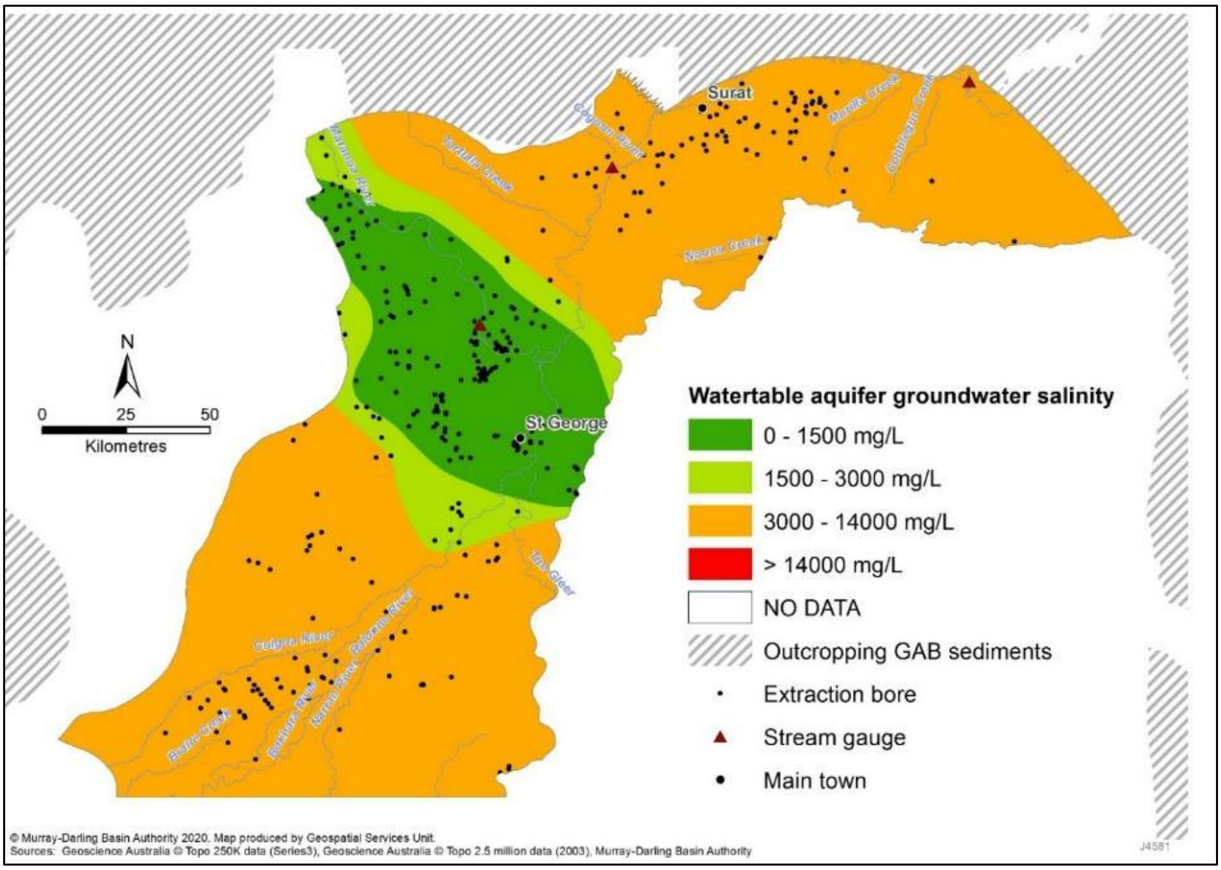


Figure 69: Sediments above the GAB (Condamine–Balonne) SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 182 and Table 183 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 182: RRAM summary table for the Sediments above the GAB: Condamine–Balonne

RRAM Step 2 Risks to KEA, KEF and PB	**KEA**	**KEF**	**PB**	**RRAM Step 3 Risks to fresh water**	**Salinity Class (KEO)**			**RRAM Step 4 Uncertainty**	
					Class 1	**Class 2**	**Class 3 & 4**		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	Low
				% Area	5%	3%	92%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	N/A	N/A	N/A	**SF**	0.75

Table 183: PEL summary table for the Sediments above the GAB: Condamine–Balonne

Salinity	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Total**
Recharge (GL/y)*	10.0	7.10	117.3	0.0	134.4
SF	0.53	0.53	0.53	N/A	N/A
PEL (GL/y)	5.25	3.73	61.6	0.0	70.6

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Sediments above the Great Artesian Basin: Warrego–Paroo–Nebine (GS60)

The Sediments above the Great Artesian Basin: Warrego–Paroo–Nebine SDL resource unit is located on the north-west boundary of the MDB (Figure 70). The area incorporates the shallow Quaternary and Tertiary sediments that overlie the GAB. Recent Quaternary alluvium of fluviatile origin occurs along the Paroo River and extends up to 100 m depth. Older Quaternary deposits, of undifferentiated alluvium deposited under fluviatile, sheetwash and aeolian environments, extend over the flatter areas and are up to 20 m thick (CSIRO, 2007c). The Tertiary Glendower Formation comprises silicified quartzose sandstone (Senior and Thomas, 1968). Outcrops of the Glendower Formation are generally less than
15 m thick but may be as thick as 70 m (CSIRO, 2007c). The dominant source of groundwater in this area is the underlying GAB Jurassic and Cretaceous confined sandstone aquifers which are separated from this SDL resource unit by thick confining beds.

This SDL resource unit is a part of the Sediments above the GAB groundwater system that was split into four SDL resource units (Border Rivers, Condamine–Balonne, Moonie and Warrego–Paroo–Nebine) for the Basin Plan, to align with the Queensland planning arrangements.

The Sediments above the Great Artesian Basin: Warrego–Paroo–Nebine SDL resource unit sits within the Warrego–Paroo–Nebine WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 184: Summary table for the Sediments above the GAB: Warrego–Paroo–Nebine

Summary characteristic	Name / description / volume
SDL resource unit	Sediments above the GAB: Warrego–Paroo–Nebine (GS60)
Groundwater covered	All groundwater contained within all consolidated sediments above the GAB
WRP Area	Warrego–Paroo–Nebine (GW22)
GMU(s) Covered	None
Recharge (RRAM Step 1)*	819.1 GL/y
Recharge Input	WAVES recharge modelling
PEL	392.2 GL/y
BDL	1.21 GL/y
SDL**	99.2 GL/y
Licensed Entitlement***	0.10 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	1.11 GL/y
Entitlement plus S&D	1.21 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the Queensland Government as reported in RRAM for entitlement (CSIRO and SKM, 2010g) and correspondence sent on 15 April 2011 for estimated S&D.

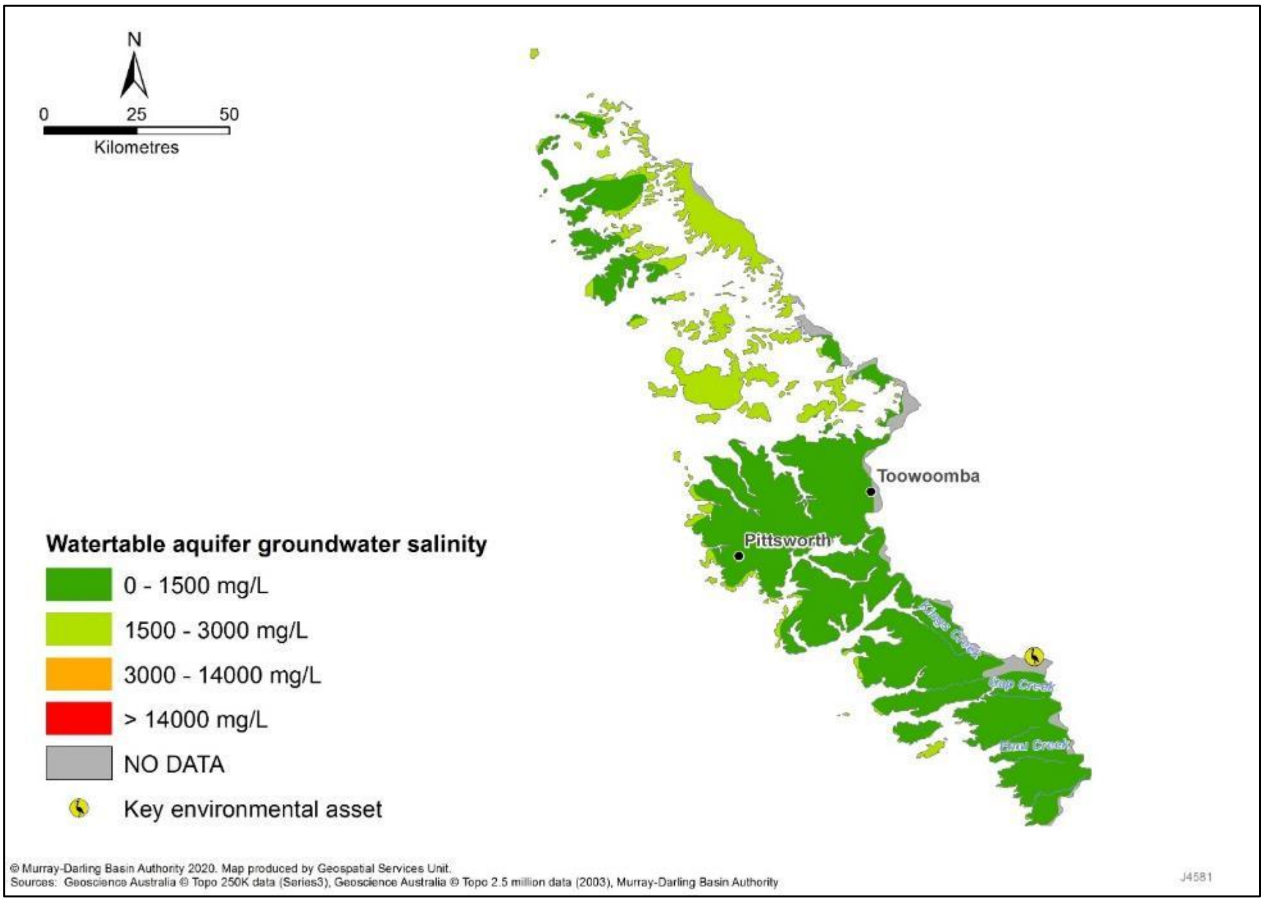


Figure 70: Sediments above the Great Artesian Basin (Warrego–Paroo–Nebine) SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 185 and Table 186 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a high level of uncertainty.

Table 185: RRAM summary table for the Sediments above the GAB: Warrego–Paroo–Nebine

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	Risk (Y/N)	Yes	Yes	No	Risk to ESLT	Low
				% Area	25%	42%	31%	Uncertainty Level	High
SF	0.70	0.70	0.70	SF	0.80	0.90	N/A	SF	0.75

Table 186: PEL summary table for the Sediments above the GAB: Warrego–Paroo–Nebine

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	181.3	341.6	296.2	0.0	819.1
SF	0.42	0.47	0.53	N/A	N/A
PEL (GL/y)	76.1	160.6	155.5	0.0	392.2

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

St George Alluvium: Condamine–Balonne (GS61)

The St George Alluvium: Condamine–Balonne SDL resource unit is located in Queensland with the Condamine and Culgoa Rivers draining through the SDL resource unit (Figure 71). The regional centre of St George is located in the SDL resource unit.

The St George Alluvium is a formation of alluvial deposits associated with the Lower Balonne and the Moonie rivers and their tributaries. Its development over two time periods has resulted in a lower (deep) aquifer set down in an incised paleo-channel and a broad upper (shallow) aquifer deposited more recently. The shallow aquifer covers a much larger footprint (DNRME, 2018b).

The SDL resource unit is split into shallow and deep aquifers. The shallow Quaternary aquifer consists of multiple unconsolidated fine to very coarse sand beds up to 4 m thick that are present to 30 m depth. Water from the shallow aquifer is generally only suitable for S&D purposes with low yields and variable, but generally poor, water quality (Free, 2004). A leaky aquitard separates the Quaternary aquifer from the deeper unconsolidated coarse Tertiary sand beds and gravel layers that occur at irregular intervals form a trough aligned in a north-east to south-west direction. The aquifer occurs between 60 and 220 m below surface and can be up to 30 m thick. The Tertiary sediments provide a greater potential as a source of water supply with yields of up to 120 L/s achievable from production bores (Free, 2004). Groundwater resources in this area are relatively undeveloped.

This SDL resource unit is a part of the St George Alluvium groundwater system that was split into three SDL resource units (Condamine–Balonne, Moonie and Warrego–Paroo–Nebine) for the Basin Plan, to align with the Queensland planning arrangements.

The St George Alluvium: Condamine–Balonne SDL resource unit sits within the Condamine-Balonne WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 187: Summary table for the St George Alluvium: Condamine–Balonne

Summary characteristic	Name / description / volume
SDL resource unit	a) St George Alluvium: Condamine–Balonne (shallow) (GS61a) b) St George Alluvium: Condamine–Balonne (deep) (GS61b)
Groundwater covered	a) All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground excluding groundwater in the St George Alluvium: Condamine–Balonne (deep) SDL resource unit b) All groundwater contained within the lower part of all unconsolidated alluvial sediments occupying the Dirranbandi Trough that lies below the middle leaky confined bed
WRP Area	Condamine–Balonne (GW21)
GMU(s) Covered	St George Alluvium
Recharge (RRAM Step 1)*	226.5 GL/y
Recharge Input	WAVES recharge modelling
PEL**	108.4 GL/y
BDL	a) 0.77 GL/y b) 12.6 GL/y
SDL***	a) 27.7 GL/y b) 12.6 GL/y
Licensed Entitlement****	a) 0 GL/y b) 12.6 GL/y
Measured Groundwater Use	No metered use

Summary characteristic	Name / description / volume
Estimated S&D Use**	a) 0.77 GL/y b) 0 GL/y
Entitlement plus S&D	a) 0.77 GL/y b) 12.6 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**PEL is for the shallow sub-unit as the deep does not receive rainfall recharge.

***SDL for the shallow is calculated using the unassigned groundwater assessment (25% factor); and for the deep based on discussion between MDBA and the Queensland Government (existing planning arrangements).

****All entitlement and use information provided by the Queensland Government as reported in RRAM for entitlement (CSIRO and SKM, 2010g) and correspondence sent on 15 April 2011 for estimated S&D.

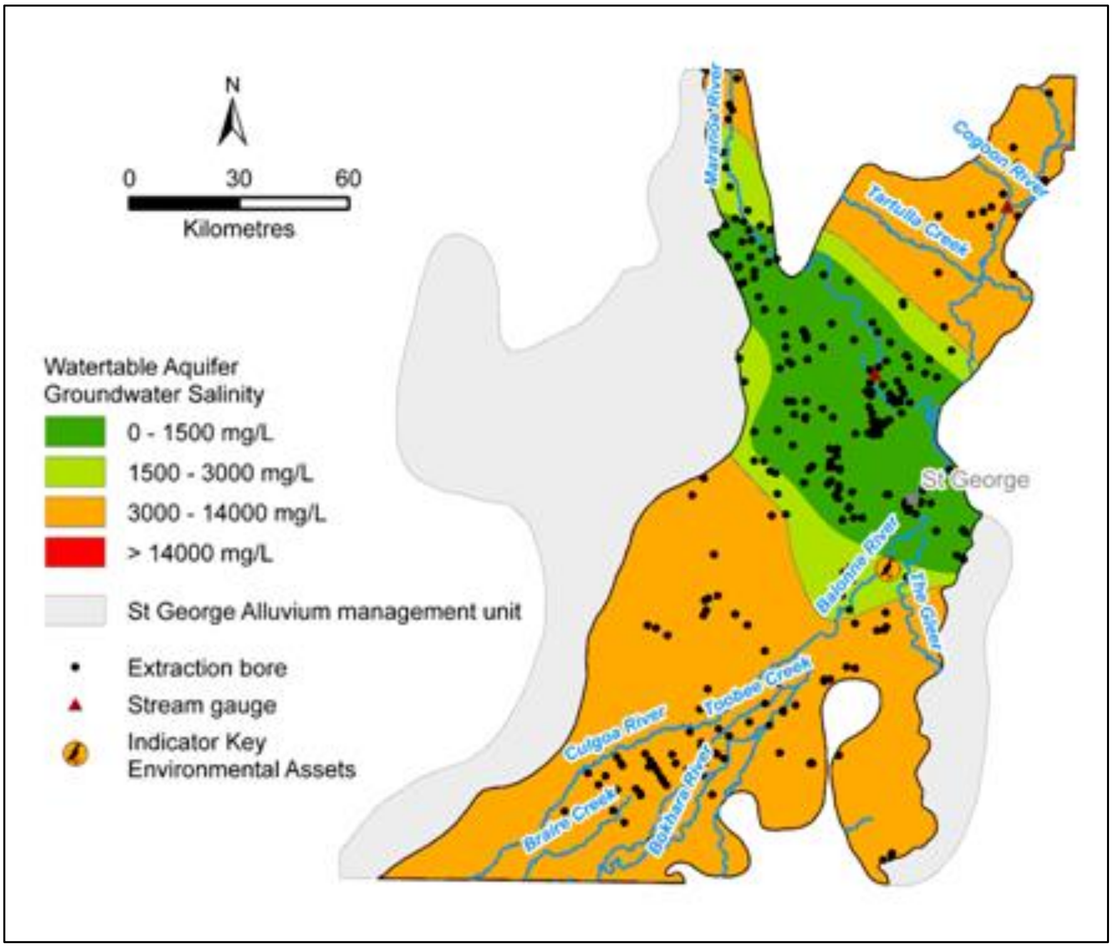


Figure 71: St George Alluvium (Condamine–Balonne) SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 188 and Table 189 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a high level of uncertainty.

Table 188: RRAM summary table for the St George Alluvium: Condamine–Balonne

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	Yes	Yes	No	**Risk to ESLT**	Low
				% Area	22%	10%	68%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	0.80	0.90	N/A	**SF**	0.75

Table 189: PEL summary table for the St George Alluvium: Condamine–Balonne

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	83.1	32.3	111.1	0.0	226.5
SF	0.42	0.47	0.53	N/A	N/A
PEL (GL/y)**	34.9	15.2	58.3	0.0	108.4

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

**PEL is for the shallow sub-unit as the deep does not receive rainfall recharge.

St George Alluvium: Moonie (GS62)

The St George Alluvium: Moonie SDL resource unit is located south-east of St George (Figure 72). The St George Alluvium comprises two aquifer systems. The shallow Quaternary aquifer consists of multiple unconsolidated fine to very coarse sand beds up to 4 m thick that are present to 30 m depth (Free, 2004). A leaky aquitard separates the Quaternary aquifer from the deeper unconsolidated coarse Tertiary sand beds and gravel layers that occur at irregular intervals forming a trough aligned in a north-east to south-west direction. The aquifer occurs between 60 and 220 m below surface and can be up to 30 m thick. The Tertiary sediments provide a greater potential as a source of water supply with yields of up to 120 L/s achievable from production bores (Free, 2004). Groundwater resources in this area are relatively undeveloped.

This SDL resource unit is a part of the St George Alluvium groundwater system that was split into three SDL resource units (Condamine–Balonne, Moonie and Warrego–Paroo–Nebine) for the Basin Plan, to align with the Queensland planning arrangements.

The St George Alluvium: Moonie SDL resource unit sits within the Queensland Border Rivers-Moonie WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 190: Summary table for the St George Alluvium: Moonie

Summary characteristic	Name / description / volume
SDL resource unit	St George Alluvium: Moonie (GS62)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Queensland Border Rivers–Moonie (GW19)
GMU(s) Covered	St George Alluvium
Recharge (RRAM Step 1)*	5.20 GL/y
Recharge Input	WAVES recharge modelling
PEL	2.74 GL/y
BDL	0.01 GL/y
SDL**	0.69 GL/y
Licensed Entitlement	0 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.01 GL/y
Entitlement plus S&D	0.01 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the Queensland Government as reported in RRAM for entitlement (CSIRO and SKM, 2010g) and correspondence sent on 15 April 2011 for estimated S&D.

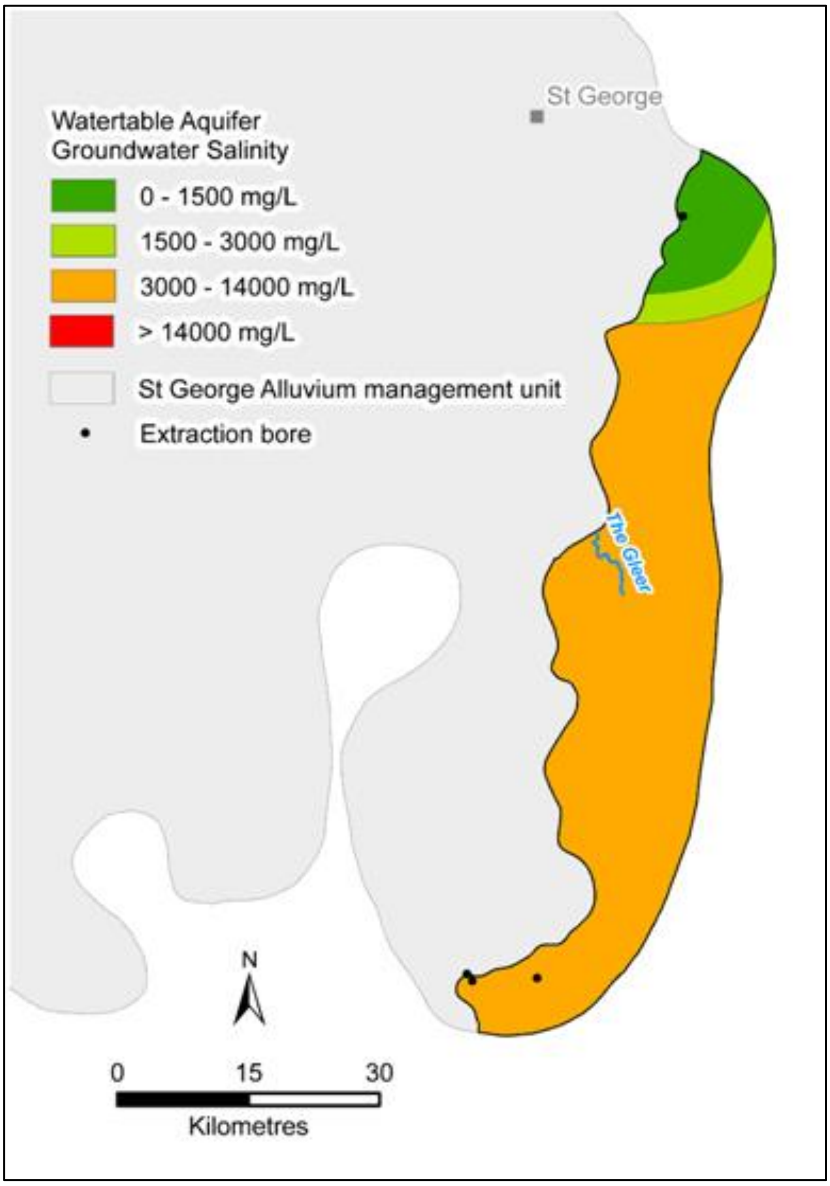


Figure 72: St George Alluvium (Moonie) SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 191 and Table 192 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having no risk to the key environmental outcome
- as having a high level of uncertainty.

Table 191: RRAM summary table for the St George Alluvium: Moonie

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	No	No	No	**Risk to ESLT**	Low
				% Area	5%	17%	78%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	N/A	N/A	N/A	**SF**	0.75

Table 192: PEL summary table for the St George Alluvium: Moonie

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	0.47	0.51	4.22	0.0	5.20
SF	0.53	0.53	0.53	0.53	N/A
PEL (GL/y)	0.25	0.27	2.22	0.0	2.74

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

St George Alluvium: Warrego–Paroo–Nebine (GS63)

The St George Alluvium: Warrego–Paroo–Nebine SDL resource unit is located west of St George (Figure 73). The St George Alluvium comprises two aquifer systems. The shallow Quaternary aquifer consists of multiple unconsolidated fine to very coarse sand beds up to 4 m thick that are present to 30 m depth (Free, 2004). A leaky aquitard separates the Quaternary aquifer from the deeper unconsolidated coarse Tertiary sand beds and gravel layers that occur at irregular intervals forming a trough aligned in a north-east to south-west direction. The aquifer occurs between 60 and 220 m below surface and can be up to 30 m thick. The Tertiary sediments provide a greater potential as a source of water supply with yields of up to 120 L/s achievable from production bores (Free, 2004). Groundwater resources in this area are relatively undeveloped.

This SDL resource unit is a part of the St George Alluvium groundwater system that was split into three SDL resource units (Condamine–Balonne, Moonie and Warrego–Paroo–Nebine) for the Basin Plan, to align with the Queensland planning arrangements.

The St George Alluvium: Warrego–Paroo–Nebine SDL resource unit sits within the Warrego-Paroo-Nebine WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 193: Summary table for the St George Alluvium: Warrego–Paroo–Nebine

Summary characteristic	Name / description / volume
SDL resource unit	St George Alluvium: Warrego–Paroo–Nebine (GS63)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Warrego–Paroo–Nebine (GW22)
GMU(s) Covered	St George Alluvium
Recharge (RRAM Step 1)*	193.0 GL/y
Recharge Input	WAVES recharge modelling
PEL	98.0 GL/y
BDL	0.12 GL/y
SDL**	24.6 GL/y
Licensed Entitlement	0 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.12 GL/y
Entitlement plus S&D	0.12 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the Queensland Government as reported in RRAM for entitlement (CSIRO and SKM, 2010g) and correspondence sent on 15 April 2011 for estimated S&D.

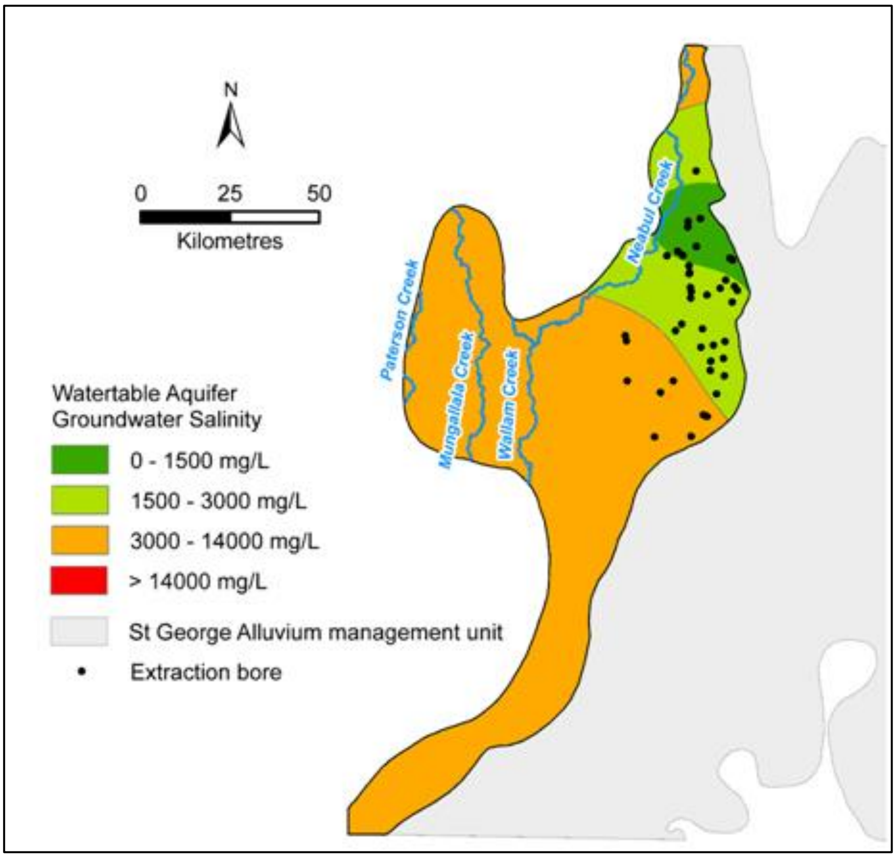


Figure 73: St George Alluvium (Warrego–Paroo–Nebine) SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 194 and Table 195 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a high level of uncertainty.

Table 194: RRAM summary table for the St George Alluvium: Warrego–Paroo–Nebine

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	Yes	Yes	No	**Risk to ESLT**	Low
				% Area	5%	17%	78%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	0.80	0.90	N/A	**SF**	0.75

Table 195: PEL summary table for the St George Alluvium: Warrego–Paroo–Nebine

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	11.6	40.1	141.3	0.0	193.0
SF	0.42	0.47	0.53	N/A	N/A
PEL (GL/y)	4.87	18.9	74.2	0.0	98.0

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

Upper Condamine Alluvium (GS64)

The Upper Condamine Alluvium SDL resource unit is located in the headwaters of the Condamine River, and extends from Killarney to downstream of Chinchilla (Figure 74). The Upper Condamine Alluvium represents the sequence of alluvial sediments deposited by the Condamine River. The alluvial sediments are up to about 140 m thick in valleys formed from weathered Palaeozoic, Mesozoic and Tertiary bedrock. Huxley (1982) described the alluvial sediments of the Condamine as heterogeneous floodplain and sheetwash deposits. The Upper Condamine Alluvium SDL resource unit is partially represented by a numerical groundwater flow model that makes up approximately 30% of the total SDL resource unit.

In draft versions of the Basin Plan, the BDL and SDL were reported for the entire SDL resource unit. For the Basin Plan, the SDL resource unit has been separated into two zones: the Upper Condamine Alluvium (Central Condamine Alluvium) (GS64a) and the Upper Condamine Alluvium (Tributaries) (GS64b). The split was made to assist in determining the BDL and SDL and proportioning overall reductions in groundwater take.

The Basin Plan identified the Upper Condamine Alluvium as the only groundwater system in the Basin where the BDL is greater than SDL. The SDLs in the Basin Plan for the Upper Condamine Alluvium have been set at 46.0 GL/y for the Upper Condamine Alluvium (Central Condamine Alluvium) and at 40.4 GL/y for the Upper Condamine Alluvium (Tributaries). As the SDLs are lower than the baseline diversion limits (BDLs) of 81.4 GL/y for the Upper Condamine Alluvium (Central Condamine Alluvium) and 45.5 GL/y for the Upper Condamine Alluvium (Tributaries), a reduction in groundwater use or potential use (also known as ‘bridging the gap’) was required to ensure the SDLs are not exceeded.

The 2012 Water Management Plan for the Upper Condamine Alluvium Sustainable Diversion Limit Area (the interim WRP) limited the total diversion of water from the Upper Condamine Alluvium SDL resource unit so that it cannot exceed the BDL specified in the Basin Plan. This has been implemented by the water sharing rules of this plan which limits announced entitlements to 87% of the total volume of entitlements in the CCA.

Reductions in groundwater use to meet the SDLs have been facilitated by the Australian Government’s Queensland Upper Condamine Alluvium Groundwater Purchase Tenders. Tranche 3 was finalised on 31 August 2018. These tenders seek to reach a target of 35.4 GL/y (long-term diversion limit equivalent)[1] for the Upper Condamine Alluvium (Central Condamine Alluvium) and a target of 3.05 GL/y for the Upper Condamine Alluvium (Tributaries).

The Upper Condamine Alluvium SDL resource unit sits within the Condamine-Balonne WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

[1] For more information of recovery targets and long-term diversion limit equivalent (LTDLE) factors please see the Transitional Water Take Report 2018-19 found at https://www.mdba.gov.au/publications/mdba-reports/transitional-sdl-water-take-reports

Table 196: Summary table for the Upper Condamine Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	a) Upper Condamine Alluvium (Central Condamine Alluvium) (GS64a) b) Upper Condamine Alluvium (Tributaries) (GS64b)
Groundwater covered	a) All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground b) All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Condamine–Balonne (GW21)
GMU(s) Covered	All Condamine Alluvium GMUs
Recharge (RRAM Step 1)*	a) 128.0 GL/y b) 84.0 GL/y
Recharge Input	Numerical model
PEL**	a) 46.0 GL/y b) 40.4 GL/y
BDL	a) 81.4 GL/y b) 45.5 GL/y
SDL***	a) 46.0 GL/y b) 40.5 GL/y
Licensed Entitlement****	a) 86.2 GL/y b) 42.0 GL/y
Measured Groundwater Use****	a) 52.6 GL/y b) No metered use
Estimated S&D****	a) 6.00 GL/y b) 3.50 GL/y

*The recharge figure is the average recharge for the last 10 years of the calibration model (1990 to 2009). The recharge rate was extrapolated to the area outside the model.

**PEL based on groundwater model results for (a) and the RRAM assessment for (b).

***SDL based on the PEL (proposed reduction).

****All entitlement and use information provided by the Queensland Government. Measured use is for 2002-03 to 2007-08 and is for the five sub areas of the Central Condamine Alluvium that had metering at that point in time.

Table 197: Summary of the groundwater and surface water fluxes derived from the numerical model and identified GDEs for the Upper Condamine Alluvium

Summary characteristic	Volume / name
Groundwater discharge to streams (GL/y)*	0.10
Stream leakage to groundwater (GL/y)*	19.0
Impact of groundwater extraction on streamflow (GL/y)**	12.5
Groundwater Dependent KEA	None

*Derived from the model results for Scenario 2 (i.e. groundwater take at the current level of entitlements and under an historical climate).

**Derived by comparing river loss under the current levels of entitlement (Scenario 2) and the no groundwater extraction scenario (Scenario 1).

Recharge risk assessment method outcome

Table 198 and Table 199 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a high level of uncertainty.

Table 198: RRAM summary table for the Upper Condamine Alluvium: Tributaries

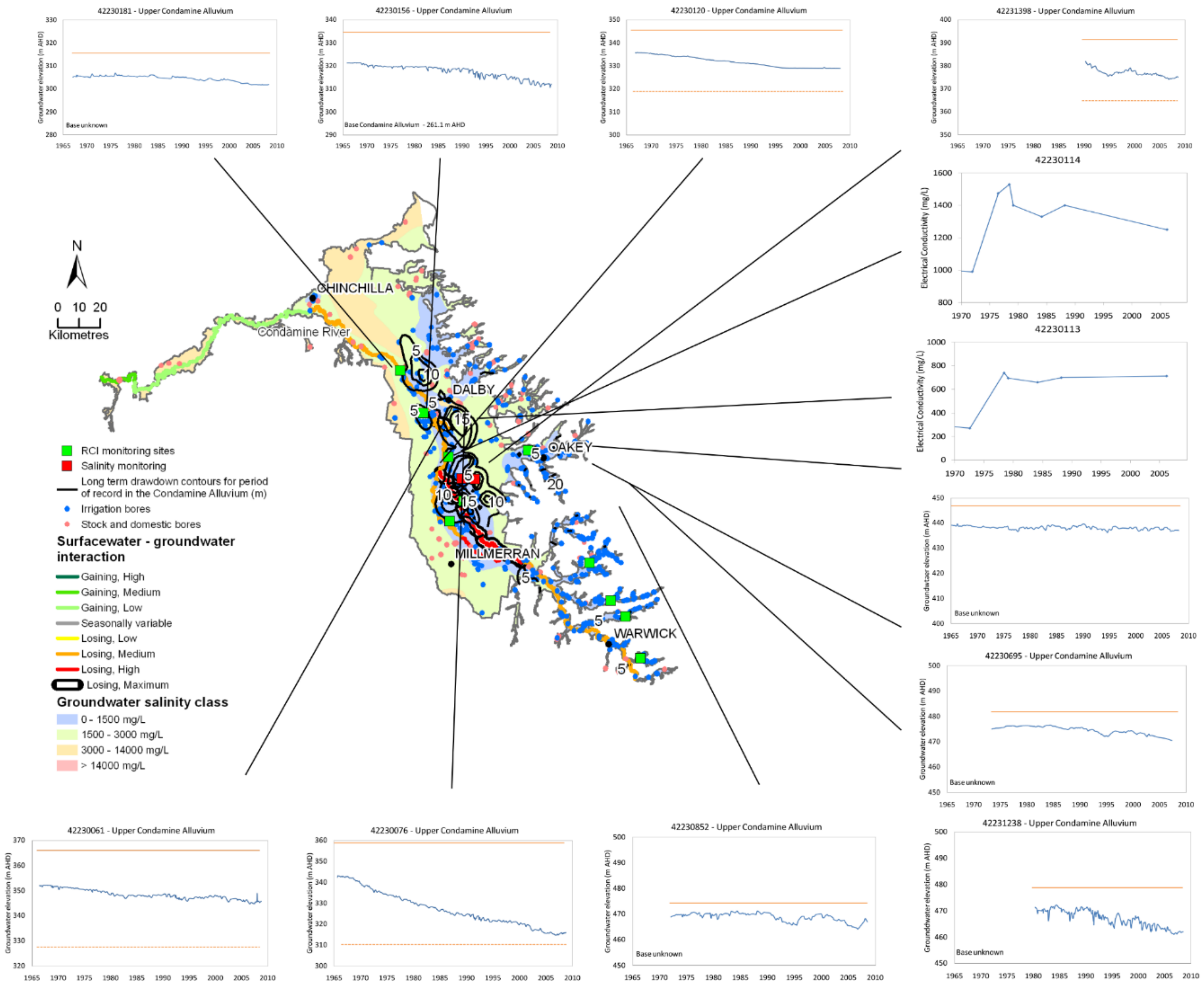
RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	Yes	Yes	No	**Risk to ESLT**	Low
				% Area	31%	50%	19%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	0.80	0.90	N/A	**SF**	0.75

Table 199: PEL summary table for the Upper Condamine Alluvium: Tributaries

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	19.6	44.0	21.9	0.0	85.5
SF	0.42	0.47	0.53	N/A	N/A
PEL (GL/y)**	8.23	20.7	11.5	0.0	40.4

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

**The PEL is for the Tributaries (70% of the area) and excludes the Central Condamine Alluvium, where the groundwater model was available to determine the PEL.



Ground surface

Base of Condamine Alluvium

Groundwater elevation (m AHD) Condamine Alluvium

Salinity (mg/L) Condamine Alluvium

***Data Source**:*

Metered groundwater extraction & salinity data – DERM (2009b)

Surface water – groundwater interactions – CSIRO (2008a)

Groundwater salinity class – MDBA (2000)

(The Condamine Alluvium ranges in thickness from less than 10 metres in headwater areas and along the floodplain margins to more than 120 metres in the central part of the area. Depending on the thickness, depth, particle size and sorting of aquifer material, water users experience bore yields of between 2 and 60 (L/s) (DERM, 2009a))

Monitoring Points	Feature
42230061, 42230076, 42230114, 42230113, 42230156	Productive base, Salinity
42230695, 42230852, 42231238, 42230792, 42231398, 42230181, 42230120, 42230695	Connectivity

Hydrogeology and water sharing arrangements

- The most significant aquifers in the Upper Condamine Alluvium SDL resource unit are the alluvial systems associated with major rivers and creeks in the area.
- The dominant forms of recharge to the system is via rainfall infiltration, flood recharge and river leakage.
- The alluvium is hydraulically connected to the Toowoomba basalts of the adjacent Condamine Basalts SDL resource unit in the east of this sub-catchment, although the extent of the connection is unknown.
- Most groundwater extraction occurs within zones of good quality water (< 1500 mg/L) that occur through the central valley area and in the narrow alluvial systems of the upper catchment.
- There are some areas of significant drawdown in the central valley area.
- Current groundwater management arrangements in the Condamine Catchment are most comprehensive in the existing Central Condamine Alluvium—and in the Oakey Creek and Upper Hodgson Creek groundwater management areas.
- Metering became a requirement throughout the Condamine GMA in 1979 and the announced entitlement system came into effect in 1994. Announced entitlement over the following years has been as low as 60% of nominal entitlement in some areas. Where metering is not required, annual volumetric limits (also expressed as a percentage of nominal entitlement) are still applied and pumping hours are restricted (DERM, 2009a).
- An *information report* was prepared by DERM (2009a) outlining the requirements of an amendment to the Condamine and Balonne WRP, to include groundwater of the Central Condamine Alluvium area. This report indicates that 'over the past four decades, increased groundwater development and use have had adverse impacts on the resource, including declining system performance and water levels over extensive areas.

Resource condition analysis

- Selection of key monitoring sites:
  - Should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should be able to monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
- Analysis of historical data:
  - Evidence of significant drawdown from pre-development in the central valley area, which does not appear to be have been significantly replenished by rainfall (e.g. sites 42230061, 42230076, 42230120, 42230181 and 42230156).
  - The remaining storage appears to be limited in places as shown by the aquifer saturated thickness. For instance, at site 42230076, there appears to be only 6 m of aquifer saturated thickness, compared to 30 m at pre-development.
  - Water quality data is sparse. Monitoring bores 42230113 and 42230114 both show a peak in salinity in 1977 and have remained significantly higher than pre-development levels.

Figure 74: Upper Condamine Alluvium SDL resource unit map

Upper Condamine Basalts (GS65)

The Upper Condamine Basalts SDL resource unit is made up of Tertiary basalts that form the headwaters of the Upper Condamine catchment (Figure 75 and Figure 76). The groundwater is an important source of good quality water for the district and is used extensively for Stock, Domestic, irrigation, commercial and industrial purposes (Free, 2004).

The Upper Condamine Basalts SDL resource unit sits within the Condamine-Balonne WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 200: Summary table for the Upper Condamine Basalts

Summary characteristic	Name / description / volume
SDL resource unit	Upper Condamine Basalts (GS65)
Groundwater covered	All groundwater contained within all volcanic (basalt) rocks
WRP Area	Condamine–Balonne (GW21)
GMU(s) Covered	Toowoomba City and Upper Hodgson Creek Basalts
Recharge (RRAM Step 1)*	115.0 GL/y
Recharge input	WAVES recharge modelling and advice from the Queensland Government regarding irrigation recharge
PEL	80.5 GL/y
BDL	79.0 GL/y
SDL**	79.0 GL/y
Licensed Entitlement***	61.1 GL/y
Measured Groundwater Use:	78.9 GL/y
Estimated S&D***	17.9 GL/y
Entitlement plus S&D	79.0 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge does not account for water that is discharged from the system via baseflow and/or evapotranspiration.

**SDL set at entitlement plus S&D as this is supported by the PEL (existing planning arrangements).

***All entitlement and use information provided by the Queensland Government as reported in RRAM for entitlement (CSIRO and SKM, 2010g) and correspondence sent on 15 April 2011 for estimated S&D.

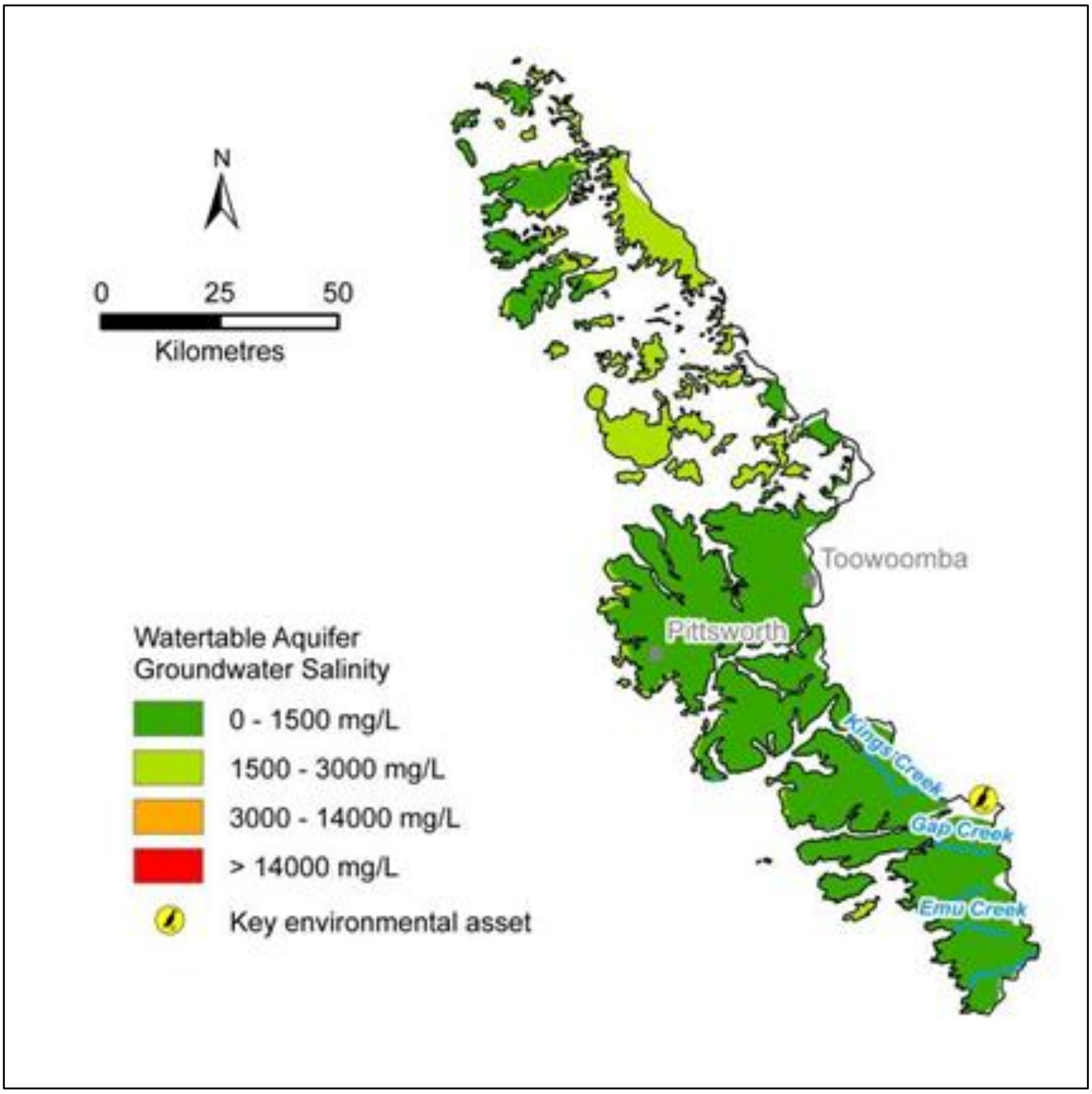


Figure 75: Upper Condamine SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 201 and Table 202 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- low risk to the key environmental outcome
- high level of uncertainty.

Table 201: RRAM summary table for the Upper Condamine Basalts

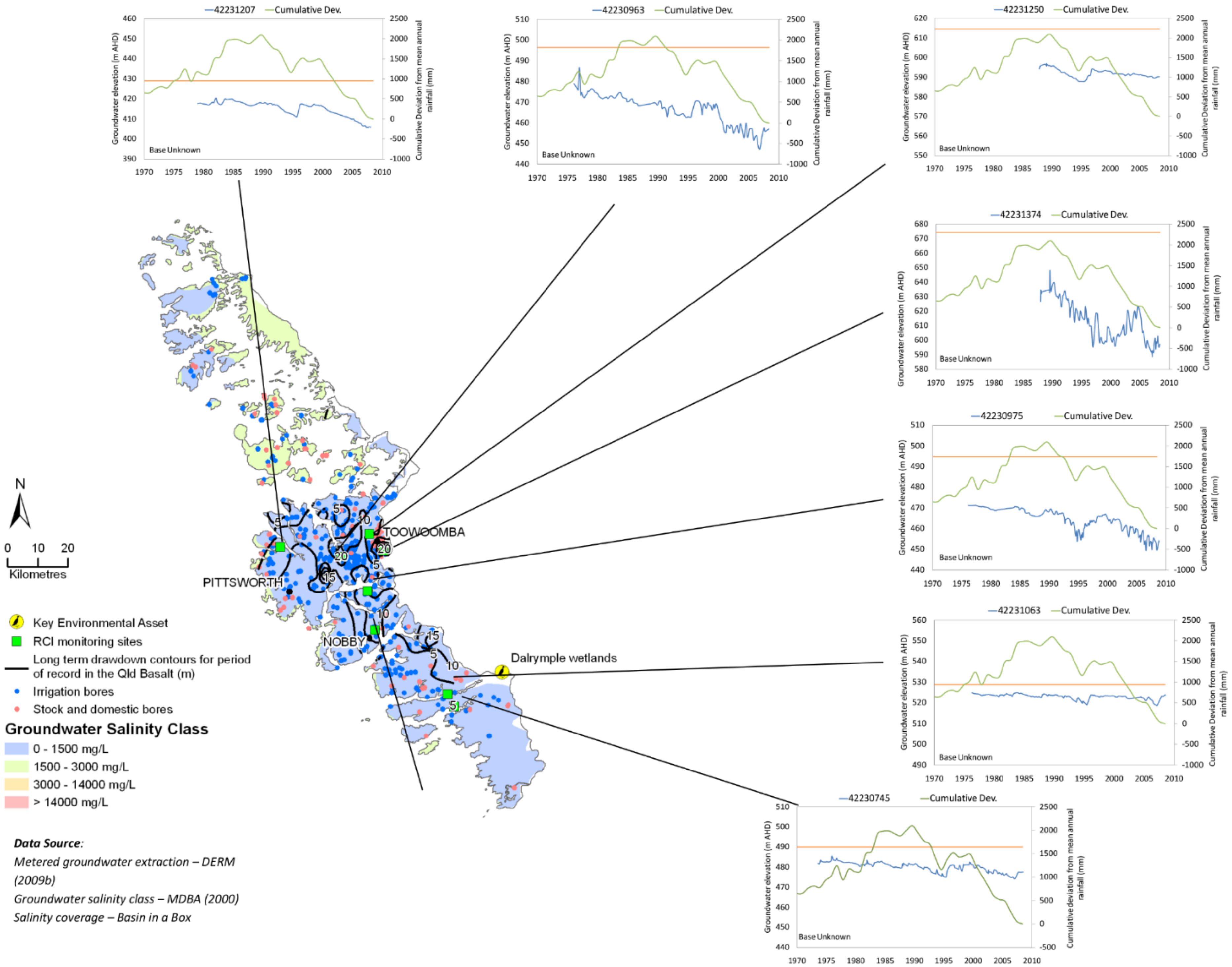
RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	Risk (Y/N)	No	No	No	Risk to ESLT	Low
				% Area	78%	22%	0%	Uncertainty Level	Low
SF	0.70	0.70	0.70	SF	N/A	N/A	N/A	SF	N/A

Note: The Dalrymple wetlands are maintained via stormwater and groundwater discharge (DEWHA 2009). Most of the wetlands is within a national park and are remote from significant groundwater take. Furthermore, the wetlands are on a catchment divide that naturally drains towards the eastern catchment of the Lockyer Valley (DERM 2009, pers. comm.). Based on this assessment, the Upper Condamine Basalt SDL resource unit is considered low risk with respect to environmental assets.

Table 202: PEL summary table for the Upper Condamine Basalts

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	86.0	29.0	0.0	0.0	115.0
SF	0.70	0.70	N/A	N/A	N/A
PEL (GL/y)	60.2	20.3	0.0	0.0	80.5

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.



Hydrogeology and water sharing arrangements

- The basalts form the highlands in the eastern headwaters of the catchment.
- The surficial basalts are recharged from rainfall through well-drained porous soils in the headwaters and catchment divides.
- The basalts are hydraulically connected and discharge to the Condamine Alluvium along the eastern SDL resource unit boundary (to the adjacent SDL resource unit).
- DERM started a major program to meter all significant rural water users in Queensland following Cabinet approval of the Metering Water Extractions Policy and amendments to the *Water Regulation 2002* in 2005. This program deals with water taken from declared groundwater sources and focuses on currently unmetered extractions. The metering program was completed for the Toowoomba City Basalts GMA in 2006–07 (DERM, 2008).
- In 2007 a moratorium was announced for groundwater extraction from the basalt aquifers in the Toowoomba City Local Government Area.

Resource condition analysis

- Selection of key monitoring sites:
  - Should be based on the environmentally sustainable level of take (ESLT) characteristics, i.e. the network should monitor the resource condition in terms of its capacity to support key environmental assets, surface-groundwater interactions, the productive base of the resource and water quality.
  - A challenge for the Upper Condamine Basalts will be to select sites representative of a broader area, given that the fractured rock hydrogeological setting can lead to variable and localised impacts from extraction.
- Analysis of historical data:
  - Some evidence of significant drawdown in the Upper Condamine Basalt since monitoring commenced (e.g. sites 42230975, 42230963, 42231374).
  - There is generally a close relationship between groundwater level and rainfall, which is somewhat less clear at a few sites – suggesting that extraction is a major factor in places (e.g. 42231374).
  - 42231250 and 42231219 show stable water tables even though there is a declining rainfall pattern.
  - Water quality data is sparse.
  - Aquifer thickness data was not available at the time of reporting, however new observation bores were drilled in 2009 in this area and the lithological sequence intercepted during drilling, could provide information to minimise this data gap.

—Ground surface

—Groundwater elevation (m AHD) Qld Basalts

—Cumulative Deviation from mean annual rainfall

(Basalt aquifers are never homogeneous and the lateral extent of highly permeable fracture and vesicular zones is extremely variable (Free, 2003). For this reason, these aquifers are characterised by variable yields.)

Monitoring points	Feature
42231063	Key environmental asset
42231250, 42231374, 42230963	Productive base, Salinity
42231207, 42230963, 42230975, 42231219, 42230745	Connectivity

Figure 76: Detailed Upper Condamine SDL resource unit map

Warrego Alluvium (GS66)

The Warrego Alluvium SDL resource unit is located in the north-west portion of the Basin and is associated with the Warrego River in Queensland (Figure 77). The dominant source of groundwater in this area is from the underlying GAB Jurassic and Cretaceous confined sandstone aquifers. The groundwater in these aquifers is separated from the Warrego Alluvium aquifer by thick confining beds resulting in little interaction between the deeper GAB and the overlying Warrego Alluvium.

The Warrego Alluvium SDL resource unit sits within the Warrego–Paroo–Nebine WRP area. The WRP sets out the rules for how water is used at a local or catchment level, including new limits on how much water can be taken from the system, how much water will be made available to the environment, and how water quality standards can be met. Basin state governments are responsible for complying with WRPs and accounting for water taken from the river system.

Table 203: Summary table for the Warrego Alluvium

Summary characteristic	Name / description / volume
SDL resource unit	Warrego Alluvium (GS66)
Groundwater covered	All groundwater contained within all unconsolidated alluvial sediments below the surface of the ground
WRP Area	Warrego–Paroo–Nebine (GW22)
GMU(s) Covered	Warrego
Recharge (RRAM Step 1)*	79.2 GL/y
Recharge Input	WAVES recharge modelling
PEL	38.9 GL/y
BDL	0.70 GL/y
SDL**	10.2 GL/y
Licensed Entitlement***	0.30 GL/y
Measured Groundwater Use	No metered use
Estimated S&D Use***	0.40 GL/y
Entitlement plus S&D	0.70 GL/y

*Groundwater recharge only includes rainfall recharge (i.e. does not include river and flood recharge or inflows from other aquifers). The recharge figure also does not account for water that is discharged from the system via base flow and evapotranspiration.

**SDL calculated using the unassigned groundwater assessment (25% factor).

***All entitlement and use information provided by the Queensland Government as reported in RRAM for entitlement (CSIRO and SKM, 2010g) and correspondence sent on 15 April 2011 for estimated S&D.

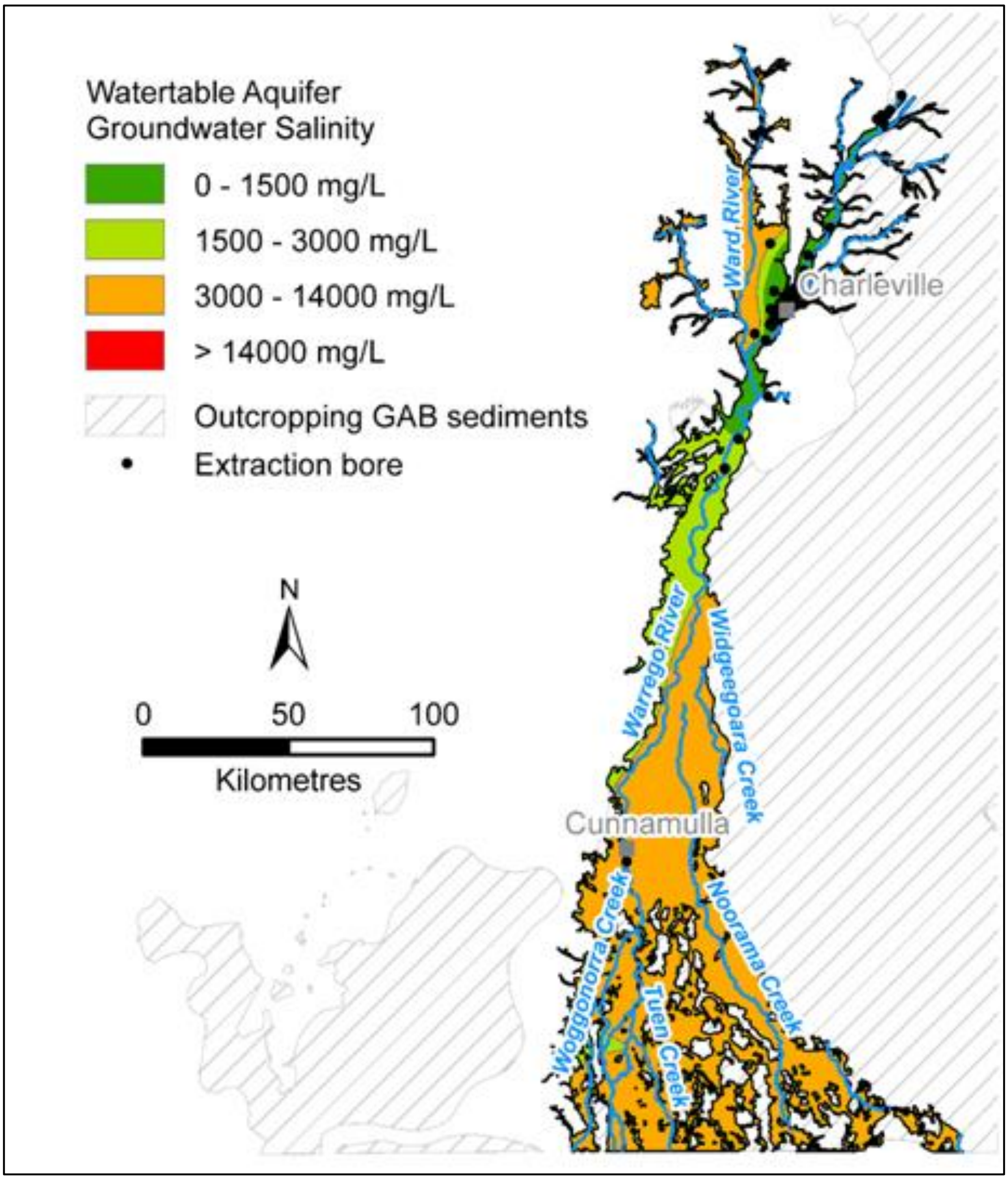


Figure 77: Warrego Alluvium SDL resource unit map

Note: The groundwater salinity distribution was derived from the Basin in a Box dataset (MDBC, 2000).

Recharge risk assessment method outcome

Table 204 and Table 205 provide a summary of the RRAM risk ranking and the PEL calculated from the RRAM risk ranking and recharge estimate. In summary, the SDL resource unit is ranked:

- low risk for KEAs
- low risk for KEFs
- low risk for the productive base
- as having a risk to the key environmental outcome
- as having a high level of uncertainty.

Table 204: RRAM summary table for the Warrego Alluvium

RRAM Step 2 Risks to KEA, KEF and PB	KEA	KEF	PB	RRAM Step 3 Risks to fresh water	Salinity Class (KEO)			RRAM Step 4 Uncertainty	
					Class 1	Class 2	Class 3 & 4		
Risk Ranking	Low	Low	Low	**Risk (Y/N)**	Yes	Yes	No	**Risk to ESLT**	Low
				% Area	8%	15%	76%	**Uncertainty Level**	High
SF	0.70	0.70	0.70	**SF**	0.80	0.90	N/A	**SF**	0.75

Table 205: PEL summary table for the Warrego Alluvium

Salinity	Class 1	Class 2	Class 3	Class 4	Total
Recharge (GL/y)*	16.2	19.0	44.0	0.0	79.2
SF	0.42	0.47	0.53	N/A	N/A
PEL (GL/y)	6.79	8.92	23.1	0.0	38.8

*Recharge per Salinity Class was derived using salinity datasets of high uncertainty and should be used as a guide only.

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