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NSW BSM2030 Comprehensive Report 2021/2022 – 2022/2023

December 2023

Acknowledgement of Country

The Department of Planning and Environment acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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Murray-Darling Basin Authority and partner states, for funding contribution and collaboration in the Joint Venture Program.

Front image: Before and after photographs of ‘Gunyah’ salt site, Upper Lachlan NSW.

Photo: 1. NSW Salt Action Team (2004)

2. Andrew Wooldridge (2023)

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Glossary of terms

Acronym	Description
BSM	Basin Salinity Management
BSMAP	Basin Salinity Management Advisory Panel
BSMS	Basin Salinity Management Strategy
BSM2030	Basin Salinity Management 2030 Strategy
DPE	Department of Planning and Environment, or the department
EC	a unit of measurement for electrical conductivity, commonly used as an indicator of water salinity (salt concentration).
EHG	Environmental and Heritage Group
EOVT	End-of-Valley Target
HGL	Hydrogeological Landscapes
IQQM	Integrated Quality Quantity Model
KGI	Knowledge Gap Initiatives
KPI	Key Performance Indicator
LLS	Local Land Services
LoH	Legacy of History
LWMP	Land and Water Management Plan
MDBA	Murray-Darling Basin Authority
NSW	New South Wales
RISI	Reduced Irrigation Salinity Impact
SDLAM	Sustainable Diversion Limit Adjustment Mechanism
SIS	Salt Interception Schemes
The Agreement	Murray-Darling Basin Agreement
TLM	The Living Murray

Executive summary

Salinity remains an issue in New South Wales and requires ongoing management. The NSW Government continued to address the ongoing challenge of salinity through a variety of measures in 2021/22 and 2022/23. Outcomes and achievements for this period are listed in line with the eight key elements of the Basin Salinity Management 2030 (BSM2030) Strategy.

Securing additional resources, coupled with a new endorsed program of works, has led to significant progress in conducting register reviews and the evaluation of new accountable actions and processes to embody salinity assessment in the NSW water management framework.

Salinity Accountability Framework

NSW maintained a net credit balance on the Salinity Register in 2021/22 and 2022/23, in a continued commitment to Schedule B of the Murray-Darling Basin Agreement.

Five register reviews were completed as part of the upgrade of the Sunraysia model (EM2) upgrade including the benefit from the Lower Murray salt interception schemes (SIS) and the Reduced Irrigation Salinity Impact (RISI) actions. NSW also finalised the review for the Upper Darling SIS. Assessment for the combined Sunraysia Irrigation Development 1997-2006 and (provisional) 2007-2018 commenced, with significant progress made to deliver on phase 1 (investment case) and phase 2 (data inputs). Phase 3 (modelling) will be initiated during the next reporting period.

NSW also progressed preliminary investigations into several Basin Plan projects to determine whether they should be notified as accountable actions under the Schedule B, including the Yanco Creek Offtake Modernisation; Reconnecting River Country Program – Murrumbidgee River; Murray and Murrumbidgee National Parks and Lock 8 and 9 weir pool supply measure projects.

Management of salt interception schemes (SIS)

The Joint Venture Salt Interception Schemes operational statistics declined during this reporting period with large-scale flooding impacting all sites and resulting in the cessation of operations for a large portion of the 2022/23 financial year. In total, 83,747 tonnes of salt was diverted from the Murray and Darling River systems in 2021/22 and 56,131 tonnes of salt in 2022/23.

In addition, the Department of Planning and Environment's Water Division (DPE Water) progressed two key initiatives during this reporting period including:

- the completion of an Asset register and Asset Management Plan (2023) to assist with understanding future budget requirements and service delivery of the program
- a groundwater monitoring review completed by department hydrogeologists (2021) to ensure the SIS monitoring network remains fit-for-purpose. Several recommendations were made specific to each scheme.

Salinity management in catchments

DPE Water continued working with other government agencies on initiatives to support the delivery of BSM2030 tasks and objectives. The development of information and products for catchment management is also supporting the delivery of NSW policy and Basin responsibilities.

NSW maintains a high profile of work within catchments along with conducting programs of community engagement and communication with a wide variety of stakeholders across NSW. Activity has focussed on the Lachlan and Murrumbidgee catchments this reporting period in response to emerging dryland/catchment salinity.

Efficient governance

There has been continued progress during the reporting period to ensure NSW's obligations as set out in BSM2030 are met, with a particular focus on reviewing the NSW BSM Program Plan, refocusing priorities and resourcing needs up until 2026. The BSM Steering Committee has provided valuable input and program oversight. NSW has continued to be an active member of the Basin Salinity Management Advisory Panel and has aided the delivery of multiple interjurisdictional BSM2030 tasks.

Strategic knowledge improvement

NSW has pursued knowledge improvements during this reporting period, with respect to landscape management, salinity dynamics and processes. Key projects and innovations included the continuation of hydrogeological mapping of very high and high salinity hazard landscapes, successful testing of modelled results with known mapped sites, trialling trend analysis of electrical conductivity (EC) to detect change in catchments and applying new data to improve management in both the urban and regional context.

Community engagement and communication

Community engagement and communication activities continued during this reporting period, with a wide range of stakeholders participating in events. Salinity-related activities such as training, project support and field days were delivered across the state, supporting the knowledge and implementation of salinity management across NSW.

Future priorities

NSW future priorities will build on the achievements in this period and continue to increase capacity to successfully implement and contribute to BSM2030 key tasks and objectives. Sourcing and securing appropriate skills and funding will continue to be a key priority.

Other key priorities include:

- the completion of high priority register reviews
- developing strategies and tools to manage the impact of irrigation development in Sunraysia area
- implementing and refining the preliminary salinity assessment procedure

- progressing the review of end of valley targets and catchment monitoring needs
- evaluating catchment salinity risk and needs analysis for catchment modelling
- continued investment in salinity information to inform land and water management decisions.

NSW will continue working with other Basin states and the Murray-Darling Basin Authority on key priorities and to prepare for the BSM2030 mid-term review.

Purpose of report

Implementation reporting has been rationalised under the BSM2030 Strategy. Commencing in 2016, State Contracting Governments and the MDBA are required to prepare alternating BSM2030 status updates and comprehensive biennial reports for the Basin Officials Committee and Ministerial Council. The NSW BSM2030 Comprehensive Report for 2021/22 and 2022/23 has been prepared consistent with the Basin Salinity Management (BSM) Procedures.

This report includes information contained in the 2021/22 Annual Status Report, resulting in a consolidated two-year report for 2021/22 and 2022/23 with information compiled against BSM2030 key elements, as required by MDBA.

1. Salinity accountability framework

Under Schedule B of the Murray-Darling Basin Agreement, the NSW Government is accountable for all actions assessed to have a significant effect on River Murray salinity. Actions such as new irrigation development, salt interception schemes, improved irrigation efficiency and changed river operations can all impact on NSW's salinity credit balance.

a. NSW Salinity Register position

NSW maintained a net credit balance on the Salinity Register in 2021/22 and 2022/23 (Table 1), in a continued commitment to Schedule B of the Murray-Darling Basin Agreement .

Based on the MDBA 2023 Salinity Registers, NSW has a salinity effect of **-26.7 electrical conductivity (EC).** This equates to a salinity cost effect of **$5.309 million/year**.

A decrease in NSW credits can be attributed to the outcomes from several register reviews completed during the reporting period. In 2022, there was a reduction benefit for the Mallee Cliffs salt interception scheme (SIS) and Reduced Irrigation Salinity Impact (RISI) Stage 1 and 2 register entries. In 2023, the completion of the review for the Upper Darling SIS also resulted in a reduction in benefit, as did the joint benefit from the review of the Murtho SIS. The positive effect of increased credits from the review of shared benefits of the Mildura Merbein SIS refurbishment and improved Buronga and Mildura/Merbein SIS offset the reduction somewhat, resulting in net reduction in NSW balance of 6.5 EC compared to 2021. The NSW register entries of RISI Stage 1 and RISI Stage 2 and their salinity credit were combined to the one register entry following the review in 2022.

Table 1: NSW Salinity Register balance sheet summary.

Register Description	2021	2022	2023
Register A	**EC ($million/yr)[2]**	**EC ($million/yr)[1]**	**EC ($million/yr)[2]**
Salinity & Drainage Strategy	-15.7	-14.8	-14.8
Basin Salinity Management Strategy (BSMS)	-5.7	-5.8	-4.9
Shared (NSW and Victorian) Measures	-1.1	-1.1	-1.3
NSW Works and Measures	-8.6	-4.6	-4.7
Balance - Register A	**31.03 (6.35)**	**-26.3 (5.34)**	**-25.5 (5.08)**
Register B			
Transfers from Register A (BSMS)	-3.0	-3.1	-2.57
NSW Delayed Salinity Impacts	1.1	1.1	1.3
Balance - Register B	**-1.89(0.552)**	**-1.9 (0.396)**	**-1.27 (0.225)**
Net Balance - Register A and B	**-32.9 (6.901)**	**-28.2 (5.736)**	**-26.7 (5.309)**

Table 2 and Table 3 outlines NSW salinity credits and debits as per the 2023 Salinity Registers.

[1] Where EC refers to the salinity impact i.e. average electrical conductivity (µS/cm) in the Murray River at Morgan, South Australia; and $/year refers to the salinity cost effect.

Table 2: NSW 2023 Salinity Register A credit and debit summary.

Register Entry - Credit	EC[2]	Register Entry - Debit	EC[2]
Salinity & Drainage Strategy		**Salinity & Drainage Strategy**	
Woolpunda Salt Interception Scheme (SIS)	8.5	Changed operation of Menindee and Lower Darling	-0.2
Improved Buronga & Mildura/Merbein SIS	0.8		
New Operating Rules for Barr Creek Pumps	0.9		
Waikerie SIS	2.6		
Changed MDBC River Operations 1988 to 2000	0.3		
Mallee Cliffs SIS	0.9		
Waikerie SIS Phase 2A	0.6		
Changed MDBC River Operations 2000 to 2002	0.3		
Basin Salinity Management Strategy		**Basin Salinity Management Strategy**	
Changed MDBC River Operations post 2002	0.0	*None*	
Pyramid Creek SIS	0.6		
Bookpurnong Joint SIS	0.8		
Improved Buronga SIS	0.1		
Loxton SIS	1.1		
Waikerie Lock 2 SIS	1.0		
Upper Darling SIS	0.6		
Murtho SIS	0.6		
Shared Measures		**Shared Measures**	
Permanent Trade Accounting Adjustment - NSW to Victoria	0.1	*None*	
Barmah-Millewa Forest Operating Rules	1.0		
NSW Works and Measures		**NSW Works and Measures**	
Boggabilla Weir	0.1	Pindari Dam Enlargement	-0.7
Tandou Pumps from Lower Darling	0.1	Sunraysia Irrigation Development 1997-2006	-1.7
Murray Land and Water Management Plan (LWMP)	4.0	Sunraysia Irrigation Development 2006-2018 (provisional)	-3.7
NSW Changes to Edward-Wakool and Escapes	2.0		
Permanent Trade Accounting Adjustment - NSW to SA	0.4		
NSW RISI	4.0		
Salinity & Drainage Strategy Commitment Adjustment	0.0		
Total Credits	**31.6**	**Total Debits**	**-6.2**

[2] Where EC refers to the salinity impact [i.e., average electrical conductivity (µS/cm)] in the Murray River at Morgan, South Australia.

Table 3: NSW 2023 Salinity Register B credit and debit summary.

Register Entry - Credit	EC[3]	Register Entry – Debit	EC[3]
Transfers from Register A		**Transfers from Register A**	
BSMS	2.6	*None*	
NSW (Delayed Salinity Impacts)		**NSW (Delayed Salinity Impacts)**	
None		Darling Catchment Legacy of History (LoH) - Macquarie, Macintyre, Gil Gil Ck, Gwydir, Namoi, Castlereagh, Bogan	-0.5
		Lachlan LoH	0
		Murrumbidgee Catchment LoH	-0.1
		Mallee LoH - Dryland	-0.4
		Mallee LoH - Irrigation	-0.3
Total Credits	**2.6**	**Total Debits**	**-1.3**

b. New accountable actions

NSW is required to report all actions with a significant effect on River Murray salinity for inclusion on the Salinity Registers. An action is significant if it is assessed as causing a change in average daily salinity of Morgan of 0.1 EC or more by 2100.

In the reporting period, DPE Water progressed investigation into several actions to determine whether they should be notified as accountable actions under Schedule B of the Agreement including:

- Sunraysia irrigation development 2006-2018 (provisional)
- Billabong Creek Salt Interception Scheme
- Yanco Creek Offtake Modernisation project (SDLAM)
- Reconnecting River Country Program – Murrumbidgee River (SDLAM)
- Murray and Murrumbidgee National Parks (Yanga / Millewa SDLAM projects)
- Lock 8 and 9 weir pool supply measure project (SDLAM).

Sunraysia Irrigation Development 2006-2018 (provisional)

At BSMAP meeting 46 (August 2020), a new NSW Sunraysia irrigation development 2006 to 2018 register entry of 3.7 EC at 2020 (debit) was endorsed as provisional.

The assessment and re-estimation of the provisional register entry is being completed with the review of Register action for the Sunraysia irrigation development (1997-2006).

See Section 4b for further detail on progress made in the current period.

Billabong Creek Salt Interception Scheme

The Billabong Creek catchment was identified as having a high salt load in the upper catchment (Williamson et al, 1997). The Murray-Darling Basin Salinity Audit (1999) also defined it as likely to have a large salt load increase over the next 50 years. The salt loads were estimated to increase the salinity at Morgan by around 3.9 EC by 2020.

The Billabong Creek SIS was established in 2001 and was designed to manage the discharge of shallow saline groundwater into Billabong Creek by reducing the upward hydraulic gradient in the deep alluvium via abstraction from a production bore. The bore is constructed in the deep alluvial aquifer and is only operated when the flow at Walbundrie is below 320 ML/day (Figure 1).

In 2007, an assessment of potential impact on Billabong Creek salinity levels and salinity levels in the Murray River at Morgan using the Murrumbidgee Salinity Integrated Quality Quantity Model (IQQM) was undertaken to determine salinity impacts and recommend operational parameters. Results from the modelling suggested that the operation of the SIS at Billabong Creek would reduce EC levels at the End of Valley site at Wakool Junction by approximately 0.1 to 0.2EC and at Morgan by approximately 0.1EC.

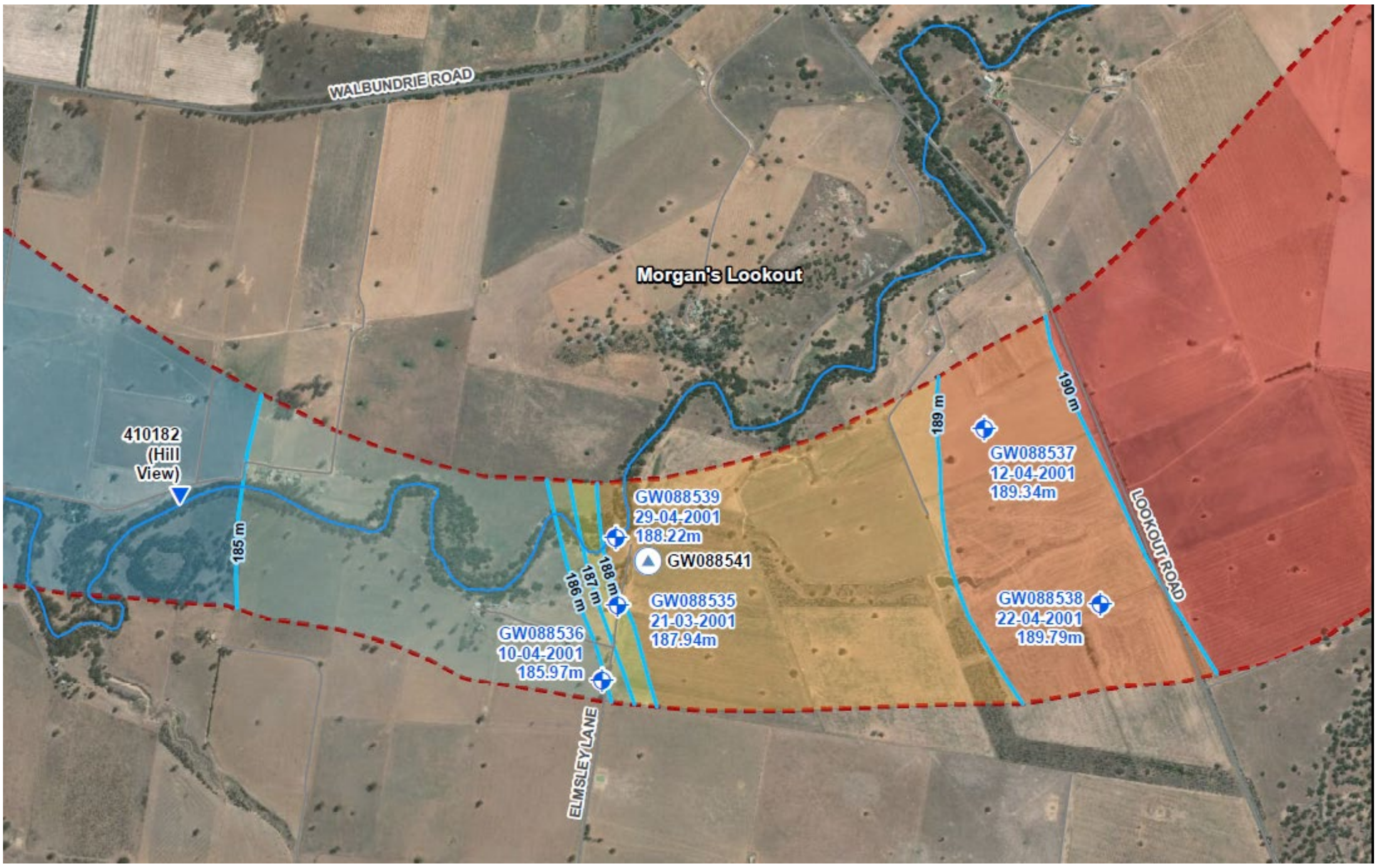

Figure 1: Billabong Creek SIS production bore in deep aquifer (Lachlan formation) (Golder, 2023).

In 2023, DPE Water completed a groundwater flow model of the SIS to:

- improve the understanding of surface and groundwater interactions including the effects of prolonged period of low river flows
- assess the effectiveness of deep pumping to reduce discharge of shallow saline groundwater into the Billabong Creek
- inform future monitoring requirements
- provide a decision support tool to resource managers to manage salinity in the Billabong Creek.

Simulated results confirm the effectiveness of the SIS bores to change groundwater-creek behaviours from gaining to losing (i.e., baseflows change from negative to positive) which supports the concept that pumping from the deep aquifer reduces discharge of saline groundwater into the Billabong Creek.

A cost/benefit analysis will be undertaken to inform the operation of the scheme. A preliminary salinity impact assessment will also be completed to determine the significance of effect on the River Murray salinity.

Murray and Murrumbidgee National Parks (Yanga/Millewa SDLAM projects)

The Murrumbidgee and Murray National Park Projects are situated in the Yanga and Murray Valley (Millewa) National Parks and are part of the SDLAM Acceleration Program. Works are proposed at multiple sites for the Yanga and Millewa projects, with the aim of improving wetland connectivity, providing fish passage, simplifying operation and enabling more effective delivery of water to ecological assets. Generally, the works consist of the replacement or upgrade of existing regulators and more operational flexibility, resulting in relatively small changes to hydrology.

Most project sites in the Yanga and Millewa National Parks were assessed as having no, or a low risk of salinity impacts. Douglas Swamp was further investigated as inundation of the swamp may dissolve salt accumulated in the dry lakebed and wash the salt into waterways that eventually connect with the River Murray. The additional inundation was estimated to add 0.005 T/day of salt downstream in the Edward River, which converts to a salinity impact of 0.00084 EC at Morgan. The assessment was based on information in the concept design and recommended the assessment be reviewed once specific details of changes in operation are confirmed, however these are unlikely to result in a significant effect as defined by Schedule B of the Agreement.

Yanco Creek Offtake Modernisation (SDLAM project)

The Yanco Creek system flows off the Murrumbidgee, near Narrandera, and joins the Edward River approximately 250 km downstream at Moulamein. Yanco, Colombo and the western part of Billabong Creeks are regulated, while Forest Creek and the upstream section of Billabong Creek are unregulated (Figure 2).

The Yanco Creek Modernisation Project incorporates all works downstream of Morundah. It has recently been reduced from its original scope and now consists of six structures requiring a preliminary salinity assessment - Hartwood Regulator, Wanganella Regulator, Wanganella Swamp inundation, Wilson Anabranch Offtake and Forest Creek return flows.

All work locations fall into areas of moderate salinity hazard apart from Wanganella Swamp, which is rated as a moderate to high salinity hazard. The risks of increased salinity in the River Murray for each site was assessed and also whether an impact pathway existed based on conceptual modelling. Only the operation of Wanganella regulator at full supply levels was rated moderate risk, the remaining risks were rated low. The total estimated salinity impact on creeks in the Yanco system was estimated to be approximately 0.054 T/day, which converted to an EC impact of 0.067 EC at Morgan. The assessment recommended the salinity impact estimate be reviewed should details of the project be changed, however is unlikely to result in a significant effect as defined by Schedule B of the Agreement.

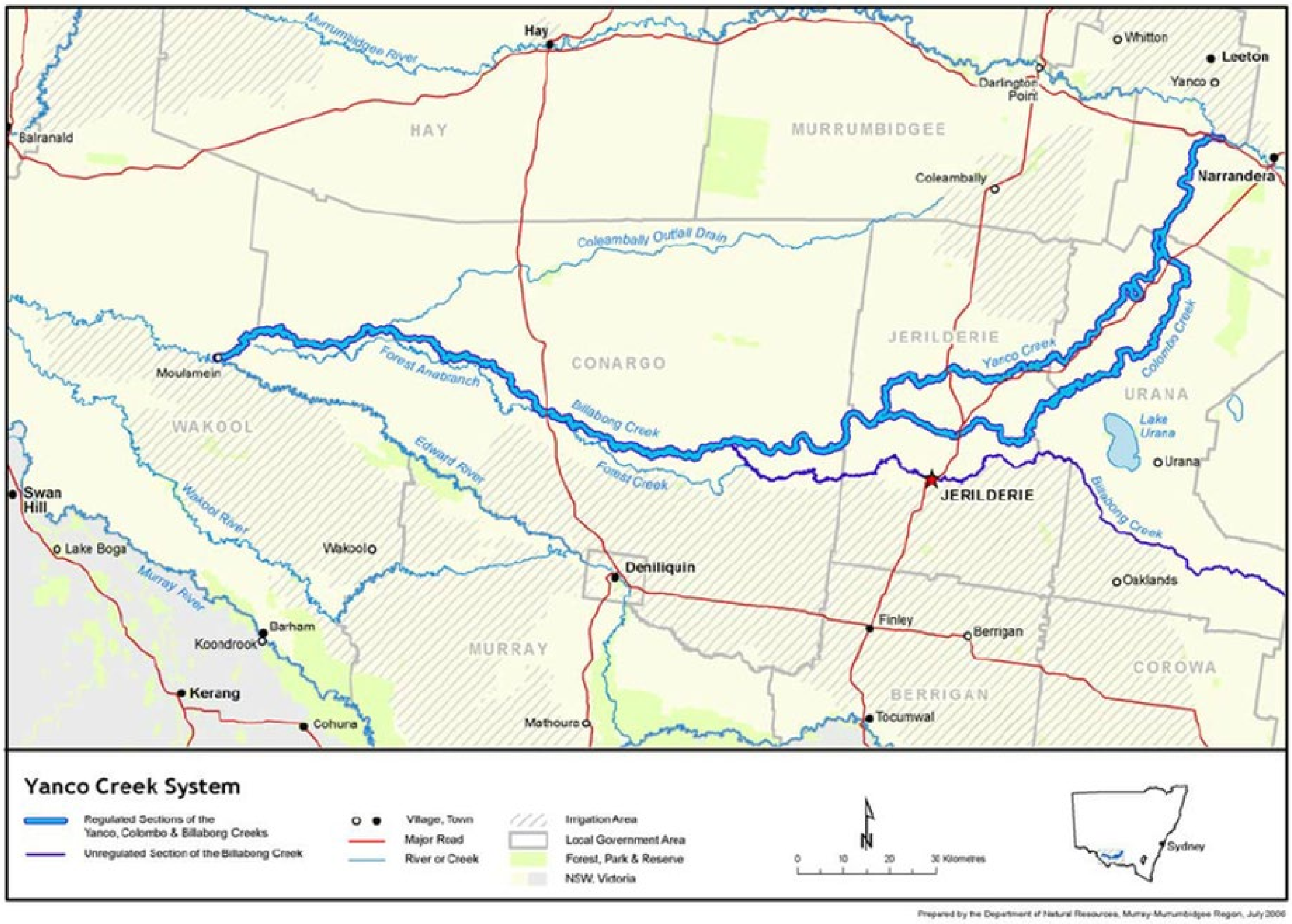

Figure 2: Yanco Creek location map (Doody et al, 2006)

Reconnecting River Country Program - Murrumbidgee

Currently in development, the Murrumbidgee Reconnecting River Country project aims to enable the flexible use of water for the environment to increase the frequency and extent rivers connect to their wetlands and floodplains .for environmental benefit over the length of the Murrumbidgee River (Figure 3). If the program proceeds to delivery, it would increase the frequency of wetland-connecting flows, with more frequent low-level inundation of lower-lying parts of the floodplain. There would be an increase in low to moderate flows, offset by a decrease in higher flows greater than 40 GL/day. The additional inundation caused by these events has the potential to mobilise salt from the floodplain into the Murrumbidgee River.

An initial preliminary assessment uncovered difficulties in estimating the salinity effect and resulted in an overestimation due to:

- a lack of data on hydraulic impacts (i.e., the method has not been able to consider the benefits of a reduction in higher flows)
- the ready reckoner overestimation of impact at Morgan (due to inability to capture the additional dilution flows from the Murrumbidgee).

Further investigation will be undertaken given the high uncertainty associated with the initial assessment.

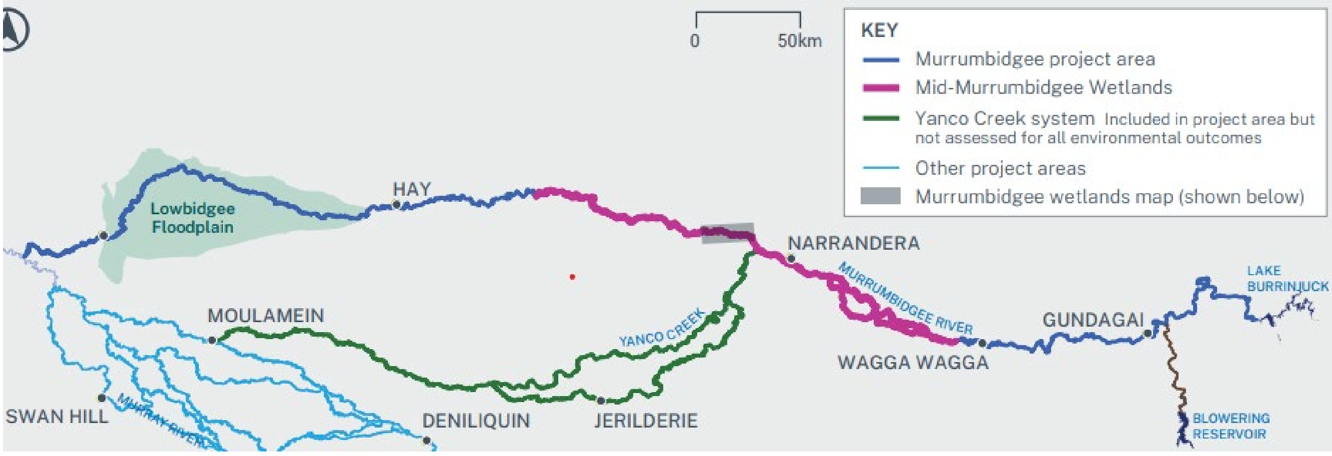

Figure 3: Reconnecting River Country Program - Murrumbidgee project area

Lock 8 and 9 weir pool supply measure project (SDLAM)

The Locks 8 and 9 supply-measure project aims to enhance environmental outcomes in and around the Lock 8 and 9 area. The project has proposed operating rule changes to increase the variability of the weir pool height at both Locks 8 and 9 within and between seasons.

In 2021, CDM Smith completed a preliminary analysis suggesting an accountable action is probable if the Lock 9 weir pool is to operate at a lower level (on average), but the lowering of the Lock 8 weir pool would not lead to a significant increase in salt load to the river. It was recommended these results all required further analysis.

In 2023, the Locks 8 and 9 project was used as a case study to test the effectiveness of a proposed preliminary salinity assessment procedure against CDM Smith's (2021) original findings. Jacobs (2023) identified and documented more risks than were analysed in the CDM Smith approach, with the overall risk rated as moderate for Lock 8 and high for Lock 9. The results identified Lock 9 as having a significant impact and Lock 8 as having a negligible impact. Lock 9 could be an accountable action and a detailed salinity impact assessment is required.

c. Salinity accountability for environmental water management

The Department of Planning and Environment's Environment and Heritage Group manage the delivery of water for the environment on behalf of the NSW Government, the Commonwealth Environmental Water Office and The Living Murray (TLM) program. Delivery of water for the environment considers and manages salinity impacts of environmental watering events, with a particular emphasis on impacts of site watering and receiving streams and waterways.

Long Term Water Plans guide the management of water for the environment over the longer term (see Section 3a) and identify any areas of known salinity or acid sulphate soil risk with specific strategies for management. These plans are supported by annual watering plans outlining the priorities for the coming year, depending on climate factors and water availability. Advisory groups have input to watering priorities and have a role in raising issues or concerns. Water quality is monitored in river via an established monitoring network. Additional site-specific and event monitoring also occurs.

Prior to any environmental watering event, the department uses a Salinity Calculator (Baldwin, 2015) to determine the volume of salt being exported from the system. This then informs what flow rates are required to provide sufficient dilution to negate salinity impacts in-situ or to receiving streams.

Current or potential environmental watering accountable actions are summarised below. Further detail on how environmental water is managed is provided in Section 3a.

The Living Murray

Salinity impacts of a The Living Murray (TLM) icon site located in NSW, the Koondrook-Perricoota Forest, is included in the collective TLM Works and Measures provisional accountable action. The forest is considered to be primarily a groundwater recharge area, with little risk of seepage of saline groundwater entering the River Murray or other streams in the area. The assessment of salinity impacts of enhanced flooding within the Koondrook-Perricoota Forest (Salient Solutions, 2007) found the salinity effect at Morgan was 0 EC and therefore not significant.

Sustainable Diversion Limit Works and Measures

NSW are the lead proponent for 11 sustainable diversion limit works and measures projects including:

- Koondrook-Perricoota flood enhancement proposal
- Gayini Nimmie-Caira project
- 2011 Snowy Water Licence Schedule 4 Amendments to River Murray Increased Flows Call Out Provisions
- Computer aided river management (CARM) Murrumbidgee
- Yanco Creek Modernisation project
- Murray (Millewa Forest) and Murrumbidgee (Yanga National Park) Valley National Parks
- Locks 8 and 9 Weir Pool Manipulation
- Improved Flow Management Works at the Murrumbidgee River-Yanco Creek Offtake project
- Yarrawonga to Wakool Junction key focus area – Reconnecting River Country Program
- Murrumbidgee program area – Reconnecting River Country Program
- Menindee Lakes Water Savings Project (including consideration of Lower Darling constraints).

Both the Koondrook-Perricoota and Nimmie-Caira projects had assessments completed previously as part of the broader TLM assessment process and during the initial phases of the Nimmie-Caira proposal. Both projects were deemed not to be accountable actions (i.e., the salinity impacts were not significant). The Locks 8 and 9 Weir Pool Manipulation project has had a preliminary assessment completed indicating potential accountable action and further detailed assessment is required once the project is finalised (see Section 1 b).

Salinity impacts were considered in initial risk assessments supporting the business cases for the remaining SDLAM projects, wherein salinity risk mitigation was not considered necessary as the impacts were <0.1EC. More detailed evaluation salinity impacts will be undertaken where projects proceed to the pre-construction phase. In the last year, several accelerated SDLAM projects have trialled a preliminary salinity assessment procedure. Results are detailed in Section 1b.

Consistent with the approach for determining the salinity benefits of salt interception schemes, an operational plan will be the basis for estimation of salinity impacts of works or measures that are identified in the preliminary assessment as requiring further investigation. Prior to construction, the proposed operational plan will inform the estimate of salinity impact and will be entered as a provisional entry on the registers. Once the works or measures are constructed, a post construction review will be undertaken, and the preliminary estimate of salinity impact updated according to the endorsed operating plan and formally entered on the Salinity Registers using approved fit-for-purpose models or methods in accordance with Schedule B[3].

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[3] As per BSM Procedure - Environmental Water Accountability.

2. Management of salt interception schemes

Salt interception schemes were established to reduce in-river salinity and provide Basin States with salinity credits to offset salinity-generating activities. Salt interception schemes are large-scale pumping schemes that prevent saline groundwater and drainage water from entering rivers. A bore and pump system extracts the groundwater and, in most schemes, the groundwater extracted is pumped to salt disposal basins, where a significant portion of the water is evaporated, leaving a concentrated brine to strategically seep back into the groundwater system at very low rates.

The NSW Government's Salt Interception Scheme (SIS) program currently consists of four salt interception schemes (Figure 4) including the:

- Mallee Cliffs SIS - located on the River Murray, in the south-west corner of NSW
- Buronga SIS - located on the River Murray, in the south-west corner of NSW and downstream of Mallee Cliffs
- Upper Darling SIS – located on the Darling River in the town of Bourke, in north-west NSW
- Billabong Creek SIS – located on the Billabong Creek in southern NSW, north of Albury.

Figure 4: Location of NSW Salt Interception Schemes.

The first three schemes are included in the MDBA Joint Venture Program and are jointly owned, with costs and benefits shared between Basin States. The Billabong Creek scheme is solely owned by NSW, as are the benefits to the community it generates. The Billabong Creek scheme is not included as an accountable action on the BSM2030 salinity registers, so the benefits are not included in this report.

a. Salt intercepted

The Joint Venture operational scheme statistics for 2021/22 and 2022/23 are shown in Table 4 and Table 5 below. Operating Protocols are in place for each SIS, relating to in-stream flows. Flows above a threshold generally dictate the cessation of a scheme's operation for the period flows exceed the threshold, due to the hydraulic pressure preventing groundwater flow into the river.

In total, 83,747 tonnes of salt was diverted from the Murray and Darling river systems in 2021/22 and 56,131 tonnes of salt in 2022/23. The decrease in 2022/23 was attributed to large scale flooding impacting all sites resulting in cessation of operations for a large part of the 2022/23 financial year.

Table 4: 2021/2022 Joint Venture Salt Interception Scheme statistics.

Scheme	Volume pumped (ML)	Salt load diverted (t)	Average salinity (EC)	Target achievement (%)[4]	Power consumption (kWh)
Mallee Cliffs	890	30,949	53,926	97%	223,308
Buronga	1,870	50,858	42,802	86%	356,660
Upper Darling	62	1,910	47,520	68%	55,933

Table 5: 2022/23 Joint Venture Salt Interception Scheme statistics.

Scheme	Volume pumped (ML)	Salt load diverted (t)	Average salinity (EC)	Target achievement (%)[11]	Power consumption (kWh)
Mallee Cliffs	264	8,895	51,750	25%	47,445
Buronga	1,603	43,117	39,285	68%	309,982
Upper Darling	145	4,119	43,051	17%	20,695

Until the Responsive Management Trial is completed (scheduled 2025), the Mallee Cliffs SIS site will continue to operate full time as per operating protocols.

Asset Register and Asset Management Plan

The development and endorsement of an asset register and Asset Management Plan (AMP) for NSW managed Joint Venture was completed in 2023. The Asset Register includes all production bores, collector and disposal main pipelines, disposal basins and monitoring pontoons. At this point in time, monitoring bore (and associated instrumentation) are yet to be included pending the endorsement of stakeholders of the revised monitoring network. Plant, property and equipment will also be included in the next iteration of the asset register. Key findings related to each scheme are detailed below.

[4,11] Refers to run-time.

SIS Groundwater Monitoring Review

The groundwater monitoring network for Joint Venture SIS was reviewed by department hydrogeologists in June 2021 to ensure that each monitoring bore was fit-for-purpose, efficient and remained suitable to achieve the goal of monitoring the impact of the scheme now and into the future. This review recommended changes to the monitoring program, demonstrating efficiency and providing confidence to SIS partners in the management of shared assets.

Each monitoring bore was ranked and reviewed to determine its value based on its contribution to monitoring of the impact of the Scheme and to inform more efficient operations. Higher weightings were attributed to bores providing data informing annual scheme performance reporting and scheme Key Performance Indicators (KPIs). The value of each bore was further considered by assessing proximity to scheme infrastructure and the variability and trends of water levels observed in each bore. A new monitoring plan has been proposed from this ranking system and the review.

The following broad recommendations resulted from the review:

- Implement described changes to monitoring network in practicable manner
- Communicate deviations from the recommended monitoring plan within the department
- Discuss with WaterNSW[5] and MDBA and agree on proposed new monitoring plan
- Consider construction of proposed new groundwater monitoring sites to fill identified data gaps

Proposed changes to the monitoring network for each scheme are detailed in Section 2b.

b. Joint Works and Measures operations

Upper Darling SIS

Operating protocols are triggered when flows in the Darling River at Weir 19A are greater than 4,500Ml/Day. High river flows for almost all of 2021-22 have resulted in Upper Darling SIS operations being shut down for 348 days, with actual run time of only 417 hours. As a result, the Upper Darling SIS only achieved a pumping rate of 68 per cent. This does not include Pump 1 (which has been decommissioned), and Pump 4 not operational due to a variable speed device fault.

Prolonged high flows and floods continued to affect the schemes performance in 2022/23, with the Upper Darling SIS shut down for most of the year due to instream flows exceeding the 4,500 ML/day (downstream of Weir 19A) threshold. Access to the disposal basin was only achieved mid-May 2023. As a result, the scheme's pumping rate was 17 per cent, with significant damage from the floods resulting in some pumps requiring further rehabilitation.

Numerous monitoring bores were also inundated due to the flooding event. An external contractor was engaged to complete minor repair works on flood affected bores.

Asset Register and condition assessments

Key insights from this piece of work for the Upper Darling SIS include:

- 31 per cent of assets are due to reach end of useful life over the next 15 years
- 60 per cent of assets are in either good or very good condition, with 81per cent of asset condition ratings rated as 3 (fair) or higher
- an annual operations and maintenance budget of $0.34M is required to maintain the asset base
- an additional $1.95M is required over the next 10 years in order to meet condition and renewal backlogs

[5] WaterNSW undertakes monitoring of some bores on behalf of DPE.

- additional funding related to renewals (based on asset lifecycle) is expected to peak in 2024/25 (~$2.29M).

These outcomes will be used to inform future budget requirements and service delivery.

Groundwater Monitoring Review

The groundwater review proposed five new monitoring bores across three sites be constructed within the Upper Darling SIS. The locations and justification for this proposal can be found in the review.

Table 6 Summary of proposed changes to the Upper Darling Salt Interception Scheme Monitoring Plan

Monitoring Aspects	Current monitoring plan	Proposed monitoring plan	Difference between monitoring plans
Number of monitored bores	50	45	-5
Number of loggers	20	13	-7
Number of manually monitored sites	30	32	+2
Number of JV bores swapped to IPART	-	5	
Number of IPART bores to be swapped to JV	-	0	
Number of bores to be decommissioned	-	0	
Proposed new bores	-	5 bores at 3 sites	+5

Disposal basin condition assessment

Inspection in late 2021 noted that heavy rainfall events have accelerated the erosion of evaporation pond embankments. Remediation options are being considered to repair damage, preserve access and address any changes to pond operation while repairs are in progress. While a business case was progressed in 2022/23 to further ascertain viable remediation options, limited progress was made due to inability to access the site. Site inspections undertaken in May 2023 showed that the existing erosion had been exacerbated by the recent floods. Repair work will commence in 2024 once the business case is finalised.

Upper Darling SIS Performance Review

In 2019, DPE Water commissioned a *Post Construction and Performance Review* of the Upper Darling SIS under the responsibilities of the Murray Darling Basin Agreement – Schedule 1 of the Water Act 2007. During this reporting period, 10 of the 15 recommendations have been completed or are in progress.

Buronga SIS

Consistent with historic pumping, the Buronga SIS was generally operated on a 24-hour basis, (notwithstanding maintenance periods) during 2021/22. High river flows dominated the 2022/23 financial year, with the Buronga SIS shut down from October 2022 to March 2023 resulting in the system running at 69 per cent of its target.

Bore yield is significantly compromised in some production bores within the Buronga SIS. The pump at Production Bore 1 was removed in 2020/21 after the bore was unable to sustain more than 25 per cent of its expected yield. Bores 2, 3 and 4 are also impacted by reduced flow which have been exacerbated since the flood. Similarly, to the production bores, a large portion of the monitoring bores were unable to be accessed due to inundation of the floodplain.

Asset Register and condition assessments

Key insights from this piece of work for the Buronga SIS include:

- 26 per cent of assets are due to reach end of useful life over the next 15 years
- 84 per cent of assets are in either good or very good condition, with 92 per cent of asset condition ratings rated as 3 (fair) or higher
- an annual operations and maintenance budget of $0.29M is required to maintain the asset base
- an additional $0.8M is required over the next 10 years in order to meet condition and renewal backlogs
- additional funding related to renewals (based on asset lifecycle) is expected to peak in 2026/27 (~$0.31M) and again in 2028/29 (~$0.27M) over the next 10 years.

These outcomes will be used to inform future budget requirements and service delivery.

Groundwater Monitoring Review

The groundwater review proposed four new monitoring bore sites be constructed, two existing sites be rehabilitated, and 10 decommissioned within the Buronga SIS. The locations and justification for these proposals can be found in the review.

Table 7 Summary of proposed changes to the Buronga Salt Interception Scheme Monitoring Plan

Monitoring Aspects	Current monitoring plan	Proposed monitoring plan	Difference between monitoring plans
Number of monitored bores	107	90	-17
Number of loggers	23	29	+6
Number of manually monitored sites	84	61	-23
Number of JV bores swapped to IPART		7	
Number of IPART bores to be swapped to JV		2	
Number of bores to be decommissioned		10	-10
Proposed new bores		4	+4

Buronga SIS Performance Review

In 2021, DPE Water commissioned a *Five-year Performance Review* of the Buronga SIS under the responsibilities of the Murray Darling Basin Agreement – Schedule 1 of the Water Act 2007. During this reporting period, 17 of the 40 recommendations have been completed or are in progress.

Mallee Cliffs SIS

The Mallee Cliffs SIS was turned off for five months in 2021-2022 in accordance with the operating rules. Down-time was utilised for planned maintenance where possible. Mallee Cliffs Bore sites 2 and 3 were being upgraded and have not run for the 2021-22 period. For the remaining seven months, the Mallee Cliffs SIS ran satisfactorily.

The 2022/23 was again dominated by high river flows, in accordance with operating rules the Mallee Cliffs SIS was shut down from July 2022 to April 2023 as instream flows exceeded 20,000 ML/day. Once flows dropped below the threshold, it took time to access flood affected sites, with power retailers also slow to reconnect the system to the grid. The bore field was restarted in April, except for Bore 1 which was started at the end of June due to a connection issue.

Similarly, to the production bores, a large portion of the monitoring bores were unable to be accessed due to inundation of the floodplain. Following the floods, inspection of loggers at key monitoring sites indicated that a number of these had failed due to prolonged inundation. In total, 13 Aqua trolls, 27 rugged trolls and two Barro trolls were replaced, with spare instrumentation purchased to manage the risk of supply chain issues if further loggers failed in the future.

An external contractor has been engaged to undertake minor monitoring bore maintenance following post-flood inspections. Works include extending PVC pipes, replacing concrete pads, painting, and replacing protector lids.

Disposal basin and Enhanced leakage pit condition assessment

The Disposal Basin at Mallee Cliffs is solely supplied by the seven Mallee Cliffs production bores. Several areas of concern including embankment seepage in Bays 1 and 3; and sediment build up and erosion of the Enhanced Leakage Pit embankments were identified in the 2021/22 annual report. Funding was secured to address these issues in 2022/23 and progress the development of a Business Case. GHD were engaged to undertake further investigations to support disposal basin remediation options and to develop an interim works plan for the pit.

Results from the geotechnical investigations indicated that the embankments were generally functioning well at limiting saline water flow through the wall, with saline water from the storage seeping beneath the wall at several locations around the perimeter through sand-rick horizons or macro-scale structure such as fissures, tubes, sand dykes within the Blanchetown Clay.

In addition, GHD also undertook a water balance assessment to further inform the viability of including an additional enhance leakage pit as part of evaluating the lining of disposal basins to prevent further seepage as an option as part of the broader business case development. The outcomes are currently being assessed alongside other options proposed to finalise the business case.

Asset Register and condition assessments

Key insights from this piece of work for the Mallee Cliffs SIS include:

- 19 per cent of assets are due to reach end of useful life over the next 15 years
- 78 per cent of assets are in either good or very good condition, with 83 per cent of asset condition ratings rated as 3 (fair) or higher
- an annual operations and maintenance budget of $1.43M is required to maintain the asset base
- an additional $12.6M is required over the next 10 years in order to meet condition and renewal backlogs
- additional funding related to renewals (based on asset lifecycle) is expected to peak in 2029/30 (~$5.2M).

These outcomes will be used to inform future budget requirements and service delivery.

Groundwater Monitoring Review

The groundwater review proposed 32 sites are decommissioned within the Mallee Cliffs SIS. The locations and justification for these proposals can be found in the review.

Table 8 Summary of proposed changes to the Mallee Cliffs Salt Interception Scheme Monitoring Plan

Monitoring Aspects	Current monitoring plan	Proposed monitoring plan	Difference between monitoring plans
Number of monitored bores	176	144	-32
Number of loggers	76	40	-36
Number of manually monitored sites	100	104	+4
Number of JV bores swapped to IPART		9	
Number of IPART bores to be swapped to JV		0	
Number of bores to be decommissioned		32	-32
Proposed new bores		0	0

Mallee Cliffs SIS Performance Review

In 2021, DPE Water commissioned a *Five-year Performance Review* of the Mallee Cliffs SIS under the responsibilities of the Murray Darling Basin Agreement – Schedule 1 of the Water Act 2007. During this reporting period, 23 of the 43 recommendations have been completed or are in progress.

c. SIS Responsive Management Trial - Mallee Cliffs SIS

A significant component of BSM2030 is the introduction of Responsive Management of SIS. With salinity targets in the superseded Basin Salinity Management Strategy (BSMS) achieved, the opportunity to consider further opportunistic economic efficiencies of the SIS Program was recognised. Responsive management seeks to reduce operating costs by reducing operation of salt interception bores during periods when flow and/or water source with low salinity provide adequate dilution, for in-river salinity to remain below the level at which water remains “fit for purpose”. It has the potential to provide an acceptable trade off of operating cost against minimising actual in-river salinity.

In NSW, the Mallee Cliffs SIS was selected as a site to participate in the trial. The scoping of the SIS Responsive Management trial identified seven knowledge gap initiatives (KGI); the following four apply to Mallee Cliffs SIS:

- KGI 2 - How long do schemes take to respond?
- KGI 3 - History of Vegetation Benefits of SIS
- KGI 4 - Relationship between pumped volumes and extent of Low Salinity Lenses
- KGI 7 - Relationship between groundwater salinity and vegetation health.

Key knowledge gap initiatives for the Mallee Cliffs scheme are KGI 2 and KGI 4. An improved understanding of the response time of the groundwater system in the vicinity of the scheme to erosion and re-establishment of the lower salinity lens will inform how frequently and long the scheme can be shut down.

KGI 3 will assess what vegetation benefits (if any) have occurred from the operation of the scheme. The outcomes of the assessment will determine if additional activities are performed to investigate and assess KGI 7.

Commencement of the trial was delayed due to the 2016 floods. The trial was extended to 2025 to enable more floodplain monitoring data to be collected and further development and refinement of assessment techniques to support knowledge gap initiatives.

Responsive Management of SIS activity has continued with all fieldwork for freshwater lens study completed, with an assessment completed post implementation.

The aim of the 'Freshwater Lens Study' was to analyse how freshwater lenses along the Murray River may respond to a temporary shutdown of SIS. The Mallee Cliffs Salt SIS was selected for this study in part due to its extensive historical monitoring dataset including:

- geophysical surveys
- lithological logs
- groundwater and river levels
- groundwater and in-stream salinity.

Additional monitoring equipment and parameters were included to inform the trial including:

- extra salinity and water level loggers to increase frequency of data collection at key sites
- interpretation of existing raw data from geophysical surveys (EM34-3, downhole and gamma)
- river bathymetry geophysical survey
- water quality sampling for major cations, anions, metals and isotopes.

The intensified monitoring program was designed to characterise the freshwater lenses and monitor expected deterioration, during the trial from 8 January to 16 September 2020. Initial findings were:

- freshwater lenses recharged from regulated rivers are more resilient than initially thought (it was previously thought that the operation of the SIS has led to an artificial enhancement of the freshwater lens allowing the riparian vegetation to expand and that shutting down schemes for periods at a time could lead to the deterioration of the inland freshwater lenses and vegetation that relies on it). Data implies that cycling between drought and major flood events has led to the expansion of the freshwater lens more than pumping rates at the Mallee Cliffs SIS
- freshwater lenses are more resilient than initially thought and the Mallee Cliffs SIS could be safely operated on a part-time basis in a responsive management style of operation as proposed under the BSM2030
- Mallee Cliffs SIS could be operated at a lower rate during periods of drought. During the Millennium Drought the pumping rate declined while the Parilla Sand aquifer hydraulic head continued to decline with the prevailing dry weather allowing the freshwater lens to grow at a slow rate
- a new conceptual model for freshwater lenses was created as a result of this study. It was recommended that scheme operating rules be revised considering improved sophistication of numerical modelling capabilities and the new conceptual model be used in a local scale numerical model to optimise pumping rates of each Production Bore in the Mallee Cliffs SIS.

It is anticipated the results of this study will provide opportunities to inform the operation of salt interception schemes that are similar to the Mallee Cliffs SIS, (i.e., adjacent to a regulated river where the saline groundwater originates from a semi-confined aquifer with an upward gradient toward the surface) including Buronga, Woolpunda, Waikerie, Bookpurnong and Mildura-Merbein SIS.

In addition, to further inform vegetation response to SIS operations, the CSIRO were engaged in 2021 to investigate transpiration of Black Box at the Mallee Cliffs SIS. The data collected will form a baseline dataset and be used to underpin the development of a remote sensing tool enabling broader scale monitoring of SIS responsive management.

Key findings from this study were:

- the reduction or cessation of SIS pumping has shown that Black Box trees rapidly moderate their transpiration rates in response to environmental change
- Black Box stands further back in the floodplain and behind the SIS bores are also positively influenced by SIS operation
- both sudden increased saline and fresh groundwater into the root zone of trees leads to a reduction in tree transpiration
- over time, the trees have the capacity to adapt and grow new roots to support their water requirements in relation to the groundwater situation they exist in (i.e., fresh or saline). However, this is strongly influenced by rainfall
- a 'control' plot on the same floodplain may not provide the information required to monitor tree response to responsive SIS management. An alternative control plot location is recommended.

A proposal from CSIRO to extend vegetation monitoring as part of the responsive management trial until June 2023, was received and accepted. This work commenced in June 2022 and, as recommended in the initial trial study, includes the collection of multiple lines of evidence to advance conceptualisation of tree response to SIS management. This includes:

- continuation of tree sap flow data collection
- introduction of soil and tree leaf potential data collection for determination of soil water potential.

Collectively this data, when analysed with depth to groundwater and groundwater salinity data, will help to further the understanding of tree responses to SIS management and identify where, from within the soil profile, these trees access water.

High river flows and resultant flooding of the trial site impacted data collection. The project resumed in May 2023 and will continue throughout 2023/24. NSW, through representation on the Basin Salinity Management Advisory Panel (BSMAP), supported the inclusion of a provisional item on the Register for the salinity impacts of Responsive Management of SIS (12.0EC debit).

3. Salinity management in NSW

DPE Water is the overarching body managing in-stream salinity and is responsible for observing BSM Procedures and complying with accountability requirements as set out in Schedule B of the Murray-Darling Basin Agreement (Schedule 1 of the *Water Act, 2007*).

Responsibility for land and water management activities addressing or impacting on salinity risk are shared amongst several agencies and implemented through:

- NSW Water Resource Plans (Basin Plan) and water sharing plans
- NSW Water Quality and Salinity Management Plans (Basin Plan)
- NSW Long Term Environmental Water Plans (Basin Plan)
- NSW State and Regional Water Strategies
- Basin Salinity Management 2030 (BSM2030) Strategy (Murray-Darling Basin Agreement)
- NSW Native Vegetation Reform
- NSW water policies
- NSW planning instruments and policies.

In the last reporting period, work has continued the finalisation of the Regional Water Strategies and State Groundwater Strategy and their implementation plans.

Significant work was done by the BSM Team on the Lachlan and Macquarie Regional Water Strategies providing salinity hazard information and understanding of landscapes, and participation in working groups.

a. Flow-based management

Water for the environment

Water for the environment is a share of the water available in NSW dams and rivers that is managed to support the ongoing health of rivers and wetlands. Water for the environment comes from a variety of mechanisms including:

- NSW licensed environmental water
- Commonwealth licensed environmental water
- environmental water allowance accrued under water sharing plans
- The Living Murray
- River Murray increased flows.

Annual Environmental Water Plans for each valley are prepared based on best available science, management experience and local knowledge to identify priority watering sites. The Environment and Heritage Group within DPE works with local communities to deliver water in five regulated river catchments - the Gwydir, Macquarie, Lachlan, Murrumbidgee and Murray-Lower Darling through Environmental Watering Advisory Groups. These groups help inform the decision-making process including which sites to target, the best timing to maximise outcomes, input to strategies for various weather scenarios and provide advice on how to minimise disruption to farmers and communities. Ecological objectives include consideration of salinity targets but also identify where watering events can contribute to other salinity outcomes such as:

- dilution of saline groundwater via recharge areas
- salt export from the Basin (e.g., Edward Wakool system)
- using large floods recharge the groundwater systems and flush salts from the soils
- higher frequency of inundation for vegetation communities with saline soils (such as, lignum shrublands in the Lower Darling and Lower Murray).

Delivery of water for the environment is managed in coordination with WaterNSW and the Commonwealth Environmental Water Office. Managers assess delivery risks, including those associated with water quality, prior to delivery along with appropriate risk mitigation strategies (if required). On completion of a watering event, any issues (including those related to water quality) are identified and documented and used to inform adaptive management.

The total volume of water for the environment used in the reporting period is summarised in Table 9 with events that achieved water quality outcomes described below.

Table 9: A summary of environmental water delivery in NSW for each Murray-Darling Basin catchment.

Catchment(s)	2021/22 delivery	2022/23 delivery
Murray and Lower Darling	447,763 ML (multiple sites)	237,497ML (multiple sites)
Murrumbidgee	683,669 ML (multiple wetlands)	493,768ML (multiple wetlands and instream flows)
Lachlan	34,270 ML (multiple wetlands, rivers and creeks)	82,091ML (wetlands and instream flows)
Macquarie-Castlereagh	71,512 ML (Macquarie Marshes and Macquarie River)	150,730ML (Macquarie Marshes and Macquarie River)
Gwydir	50,229 ML (watercourses and wetlands)	20,752ML (watercourses in wetlands)
Barwon-Darling	45,698 ML (watercourse)	Nil
Border Rivers	Nil	Nil
Intersecting streams	Nil	Nil
Namoi	Nil	1565ML (watercourses and refuge pools)

Murray and Lower Darling - Baaka

During 2021-22 both the Murray and Lower Darling–Baaka catchments experienced many months of high unregulated flows. Environmental water was used at several sites to complement the outcomes achieved by unregulated flows. Of note was the partnership with Murray Irrigation Ltd and several private landholders, that enabled the delivery of over 100,000 ML of NSW and Commonwealth held environmental water through Murray Irrigation Ltd channel escapes, private irrigation outlets and pumps. The program delivered water to creeks and wetlands in the Edward–Kolety-Wakool region, that can assist with managing the risk of salt accumulation due to exposure of saline groundwater and lack of flows.

In 2022-23, major flooding occurred in the Murray River, Edward-Wakool-Niemur system, Lower Darling Baaka River and Great Darling Anabranch. Under an adaptive plan, water managers worked with other agencies and the community to coordinate the delivery of releases and to monitor, assess and manage risks.

Murrumbidgee

During 2022–23, very wet conditions across the catchment were capitalised on to deliver water for the environment to sites including the Gayini Wetlands and instream Murrumbidgee River. Water was used to benefit wetland habitats in the Murrumbidgee and Coleambally irrigation areas as well as the Western Lakes, Forest Creek and Wanganella Swamp.

Lachlan

During 2022–23, the department worked with partner agencies and stakeholders to deliver more than 30 GL of held environmental water and planned environmental water. Water for the environment was pumped into lower Merrimajeel Creek for the first time supporting Dry Lake vegetation and Wiradjuri cultural connections. Two Lachlan River freshes were delivered after flooding receded to reduce the risk of widespread fish kills from poor water quality, particularly blue green algal blooms.

Low flow conditions and use of Lachlan Water Quality Allowance for salinity management – February 2023 to June 2023

In late 2022, monitoring showed electrical conductivity levels increase markedly from November 2022 after dam releases were reduced to and holding at 50ML/day. By January 2023, EC had exceeded 954 µS/cm and was impacting on domestic and commercial water quality at Cowra.

The sub-catchments which enter the Lachlan River below Wyangala Dam, such as the Boorowa River and Hovells Creek, have naturally saline flows and can have a profound impact on salinity levels in the Lachlan River.

A Water Quality Allowance of 20 GL has been set aside in Wyangala Dam to dilute flows from downstream saline tributaries to provide better water quality for towns and industries, particularly Cowra. Use of the Lachlan Water Quality Allowance commenced in February 2023 and continued until June 2023. Use of the Allowance was adaptively used in this period, responding to rainfall events and regulated releases, to meet its objectives of reducing electrical conductivity to less than 800 µS/cm.

This is the first time the Water Quality Allowance has been used for its intended purpose to dilute sub-catchment inflows which impact on water quality at Cowra.

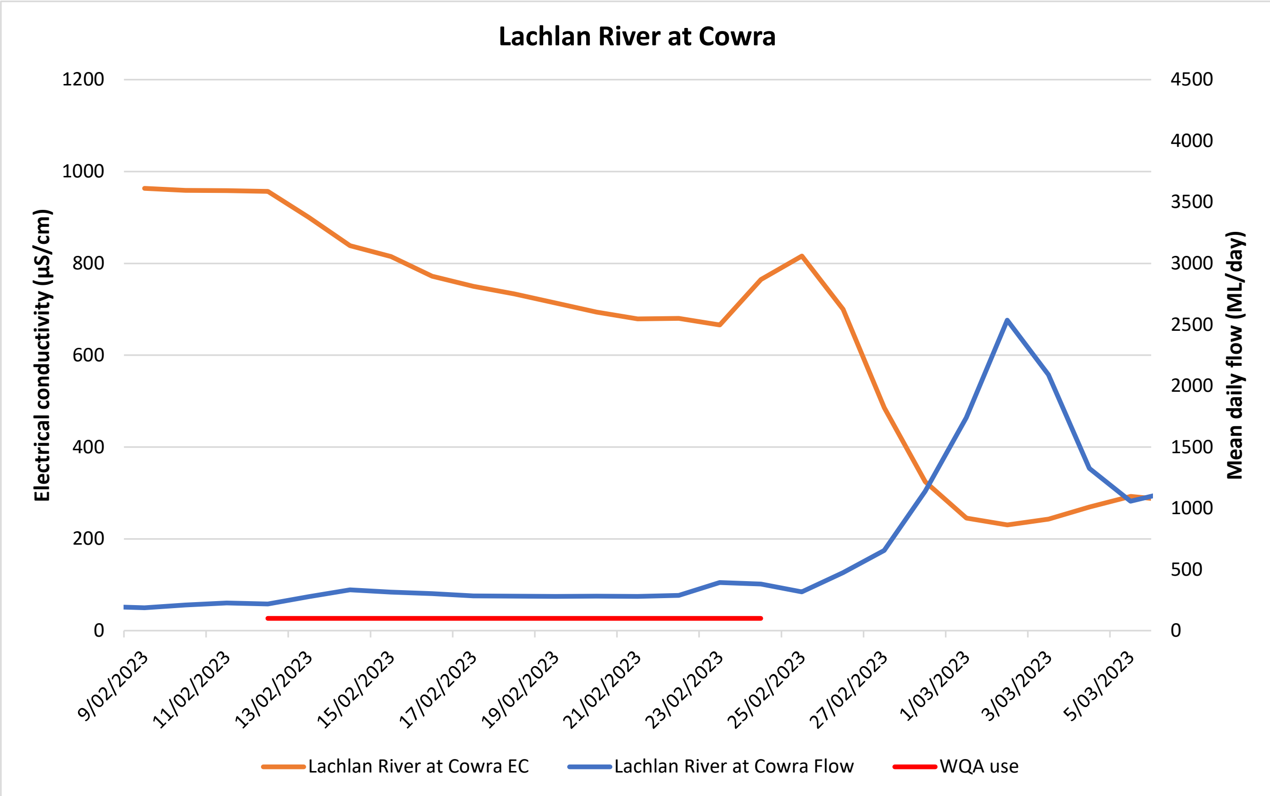

Figure 5: Mean daily electrical conductivity (µS/cm) and discharge (ML/day) in the Lachlan River at Cowra from 9 February to 5 March 2023

Weir pool manipulation

NSW continues to provide support for weir pool manipulation (led by MDBA). The aim of this project is to further understand the weir pool influence, operational limits of river operating structures, and now will incorporate ecological processes to inform future river operation decisions. Benefits to the environment from these actions, understanding how the lowering and raising of weir pools can influence the saline groundwater flux and ingress into the Murray, continue to form part of this work.

Weir pool manipulation has been undertaken in varying degrees since 2013/14, with the initial benefits and learnings continually building an acceptance of weir pool manipulation as a component of general river operations. Knowledge on this action is now being used as a tool to assist managing river operations in times of drought, and the capacity of river users to adapt to pool variability.

Valley surface water quality annual reports

In 2021-22, DPE Water initiated annual reporting of water quality parameters defined within each of the water quality management plans that support the water resource plans. The reports give an indication of trend in overall water quality score at select monitoring points along each river system.

b. Land-based management

Land management activities, including how the land is used or the way the water is used, can affect salinity risk at the local or catchment scale. Salinity usually occurs with other natural resource problems such as decreasing soil and water quality, erosion and loss of native vegetation. In NSW, there are several agencies that share responsibility for managing dryland, irrigation, urban, industrial and river salinity:

- Local Land Services – work with landholders and local communities to achieve healthy landscapes and sustainable primary industries
- DPE Environment and Heritage Group – protect, preserve and strengthen the quality of our natural environment and heritage
- DPE Water/WaterNSW – licence and regulate the take of consumptive water use for irrigation, town water supply, commercial and large developments
- DPE Planning and local governments - a key role in approval and conditioning of local and state significant development.

Local Land Services (LLS)

Every five years, local strategic plans for each of the 11 regions are updated to ensure our customers will receive effective, regionally specific support. In 2021 the regional plans were updated to set out how decisions will be made locally and how value-for-money services will be delivered, based on the needs of landholders, stakeholders and investors in each Local Land Services region. This is complemented by other NSW government investments including:

- the Sustainable Land Management Unit (within LLS)
- Biodiversity Conservation Trust
- Saving Our Species program
- the Local Landcare Coordinator Initiative
- the Weeds Action Program.

Progress against the regional plans and outcomes in the state Local Land Services State Strategic Plan 2020-2030 is reported annually. Salinity outcomes are captured under the Outcome of Land Management usually via the Soils and Water Programs.

Demand for salinity management and project advice remains, with a need to continue to develop technical support mechanisms of which HGL data is a principal resource, as is specialist training and funded projects. Active training of Local Land Services has continued to enable on-ground project implementation.

A snapshot of activity within each local land service area is summarised below:

Central Tablelands

On ground initiatives to support the delivery of the LLS Vegetation Programs and a specific Soil and Salinity Funding program included:

- three on-line sessions and a face-to-face training session in salinity management for LLS staff
- follow up sessions in individual office locations
- joint landholder inspections of sites which were funded for salinity implementation actions.

Central West

Central West Local Land Services has maintained strong salinity activity with a range of actions including:

- mentoring of staff in salinity management
- including salinity advice into soils, salinity and grazing management projects across the region, including expert training in soils and salinity
- progressing the development of “Salinity Success Stories” video, social and fact sheets development with input from BSM team.

Murray

Murray LLS staff have participated in training programs with West Hume and Holbrook Landcare groups in relation to salinity projects which are targeted at LLS staff, Landcare Group staff and landholders including:

- awareness and training programs
- re-visiting and resampling bore monitoring program implemented in 2000-2010
- demonstration salinity projects
- soils and salinity rehabilitation projects.

North West

Continued significant property planning during this reporting period was undertaken, with a focus on salinity in the Black Soil areas of the North West. Support has been provided by the department for site investigations where there are major land management issues. The North West region maintains a moderate level of salinity technical expertise through former salinity staff in charge of land management programs.

A widespread program of introduction of tropical grasses to landscapes has had large outcomes in reduction of dryland salinity.

Northern Tablelands

Property planning during this reporting period was undertaken, with a focus on salinity in the Inverell areas. This has been primarily achieved through a focus on farm planning and property planning. There has been a shift to major grazing management programs across the catchment.

Riverina

Murrumbidgee Landcare Inc and LLS staff have promoted salinity management programs as part of integrated management. DPI Irrigation staff located in the irrigation areas of the Riverina have also conducted significant activity regarding irrigation practise improvement for cotton, rice and horticulture.

South East

This region has significant areas of salinity, with the LLS using various HGL products to inform catchment management, including the delivery of on-ground works (i.e., suitable grazing management programs and soils/salinity programs).

On ground initiatives to support the delivery of the LLS Vegetation Programs included:

- three on-line sessions and a face-to-face training session in salinity management for LLS staff
- follow up sessions in individual office locations, and
- joint landholder inspections of sites which were funded for salinity implementation actions.

LLS staff have been actively involved in the development of recent HGL products for the Upper Lachlan. The Salinity Team have provided technical local support to staff in Yass, Boorowa and Goulburn with recent on-line support and on- site support.

Western

In the rangelands region, on-ground activities were primarily focused on sustainable grazing management programs, livestock health, (feral) predator control and riparian (waterway and wetland) restoration.

Saline scald reclamation programs have been funded through water ponding programs coupled with re-seeding of native species including salt bush.

Department of Planning and Environment - Environmental and Heritage Group and Water Division

DPE Water are responsible for water security and managing NSW water resources, including the sustainable management of surface and groundwater resources. New developments and irrigation water use applications require technical input to ensure the resource and ecological values are protected. DPE have a role in the assessment of development applications but also have a key function in maintaining and providing access to information and advice that help to inform sustainable management of the State's resources.

There has long been a collaborative link in understanding landscapes within the department, with complementary and joint activities undertaken between soils and salinity staff of DPE Water and EHG. This has continued within the reporting period in several key project areas:

DPE Environment and Heritage Group (EHG) are the custodian of state-based environmental information on the SEED portal and eSPADE, which is the department's online platform to display NSW soils information and houses the Hydrogeological Landscapes (HGL). The Soils Unit is responsible for management and upload of new data to the site.

Staff collaborate to provide specialist input to development applications to ensure natural and cultural values are protected, liaising with DPE Planning to ensure soils constraints to development are integrated with salinity information. The recent Aerotropolis at Badgery's Creek in Western Sydney is an example of effective collaboration of soils and salinity leading to effective planning decisions:

- using collective knowledge from across the department to complete HGL field mapping in the Upper Lachlan and Murrumbidgee catchments
- soils mapping in the Alpine National Park areas, integrating landscape understanding of water management and salinity
- support to the Soils Knowledge Network of retired soils professionals, who have recently uploaded a Salinity Page to their website
- support to partnership projects with Landcare groups such as the Soils and Salinity Project of Little River Landcare Group
- provide advice to local councils on strategic planning including Local Environmental Plans and the development of baseline understanding for local government staff in salinity management.

There is a slow and steady demand for urban salinity information to assist in planning. A project initiated in response to urban development in a high salinity risk landscape in Scone resulted in the development of Urban Salinity Planning, Development and Management Guidelines which has the potential to be adopted in other urban areas experiencing the same issue.

Two resources developed by the department are proving particularly valuable to inform land (and water) management activities including:

Hydrogeological Landscapes (HGL) mapping

This program aims to support catchment salinity management in NSW by making information on salinity hazard publicly available that will enable decision makers to select appropriate land management activities for both production and sustainability across NSW.

The program commenced in 2007 and has continued to operate and expand during this reporting period (refer to Section 5).

This platform enables the community to access major HGL work as well as the State-wide HGL spatial dataset. This resource has informed rural and urban salinity management plans, catchment action plans and natural resource management plans and has been utilised by:

- staff in a range of uses including individual infrastructure projects, water resource plans and regional water strategies.
- consultants and local councils (both rural and urban)
- Landcare groups and networks
- modellers and university institutions.

Complementary to this, in 2022 EHG released the Soils Near Me app that takes the most widely accessed datasets from the NSW Government's online soil information system eSPADE to provide information on soil type, land and soil capability and the risk of encountering acid sulphate soils. The app brings land and soil capability groups landscape and soil hazards together to describe how capable the land and soil are of being developed without significant problems being encountered. Soil types are explained in terms of their basic characteristics and fertility. The aim is to provide anyone access to foundational knowledge, with the app linking to more technical soil information on eSPADE.

Salinity Technical Reports

Salinity Technical Reports were completed as part of the Basin Plan Water Quality Management Plan requirement for nine Basin Catchment in NSW. The reports define the cause and (spatial) risk of salinity and measures to manage salinity impacts and are used as resource material in a range of regional and state planning activities.

Land and Water Management Plans and irrigation development

Land and Water Management Plans (LWMP) ensure long term economic and environmental sustainability of large-scale irrigated landscapes in NSW. NSW irrigation companies' annual compliance/environment reports are available on-line by 31 October each year. These reports include LWMP implementation details for the year and are independently audited. Annual reports are available at:

- Murray Irrigation Limited – www.murrayirrigation.com.au
- Coleambally Irrigation – www.colyirr.com.au
- Murrumbidgee Irrigation – www.mirrigation.com.au
- Western Murray Irrigation – www.westernmurray.com.au

NSW monitors change in irrigation footprint through detailed crop mapping, combining historic and current data. This data informs salinity register reviews and policy development.

NSW continues to monitor the extent of irrigation development and status in the NSW Sunraysia region with a report formally updated in 2022 using latest SunRISE data (2021). The report provides accurate information on irrigation status and development in the Lower Murray-Darling region of New South Wales from 1997 (the 1996-97 irrigation season1) to 2021 (the 2020-21 irrigation season) to be used for verification of water usage data in the water sources of the Lower Murray and Darling region.

c. End of Valley Target outcomes

Schedule B to the Murray-Darling Basin Agreement (Schedule 1 of the *Water Act, 2007*) requires all States and the ACT to monitor salt loads and salinity at End-of-Valley Target (EOVT) sites. This monitoring plays an important role in building an understanding of salinity trends and risks to the shared water resource arising from tributary catchments.

An evaluation of flow and salinity monitoring over the reporting period for each of NSW's 10 EOVT sites has been summarised below in accordance with BSM2030 Salinity management in catchments procedure. The new reporting method requires data to be presented as five-year rolling salinity and salt load exceedance curves for comparison against an estimate of baseline conditions. Exceedance curves display the probability that salinity or salt load will remain below a concentration or amount over a period (percentage of days). Rainfall mass balance graphs indicate where rainfall is either increasing or decreasing, denoting wet or dry periods.

Rainfall stations were selected for reporting are targeted in areas where stream salinity is generated by saline landscapes within each catchment.

In this reporting period, above average rainfall and wetter conditions has been a major driver of salinity processes and increased instream salinity. The cumulative mass rainfall curves for selected locations within catchments indicate two main points for the reporting period including:

- a rising salinity trend in catchments since 2020 as a response to wet periods centred around November 2021 and 2022 where major flooding occurred in some catchments. In 2021 the northern catchments had increased flood conditions, and lesser flood conditions in 2022. In southern areas, November 2022 was a considerably wetter period with major flooding in Lachlan and Macquarie catchments particularly
- since the November 2022 period, the northern catchments have experienced drying conditions, whilst the southern catchments have experienced continuing wet conditions. This is reflected in the rainfall curves.

Murrumbidgee EOVT – Murrumbidgee River at Balranald (410130)

The Murrumbidgee system is a highly regulated irrigation system with the capacity to dilute salinity inflows from sub-catchments. This is fortunate as many sub-catchments have seen major increases in land salinity, load and EC during the reporting period. The Ordovician (Upper Murrumbidgee) and Silurian Volcanic geology (Mid Murrumbidgee) areas in sub catchments above Wagga Wagga are experiencing exceptional decadal increase in land salinity and groundwater levels which is translating into higher EC and salt load within sub-catchments entering the Murrumbidgee. Salt sites are expanding into cropping areas. High saline groundwater is impacting land and stream with increased EC. This is driven by seasonal increase in rainfall and increase in cropping, particularly on the red soils of the Young Granodiorites, and other Silurian Volcanics and Cambrian metasediments (Jindalee Group).

The upland catchments have become increasingly wet with increased rainfall starting in November 2021 to January 2022 and then relatively above average rainfall from August 2022 to March 2023. After the millennium drought, flooding occurred in Wagga Wagga during October to November 2023.

The wetter period with increased inflows to regulated storages has facilitated the capacity to dilute the increased EC being discharged from mid catchment sub-catchments.

The mid catchment sub-catchments (Jugiong and Muttama) which enter the Murrumbidgee below the dams have had very high local impacts on EC, with notable high EC in flood events and high residual EC for significant periods of time after flooding has receded. This would suggest that through flow and groundwater are connected and discharging to streams.

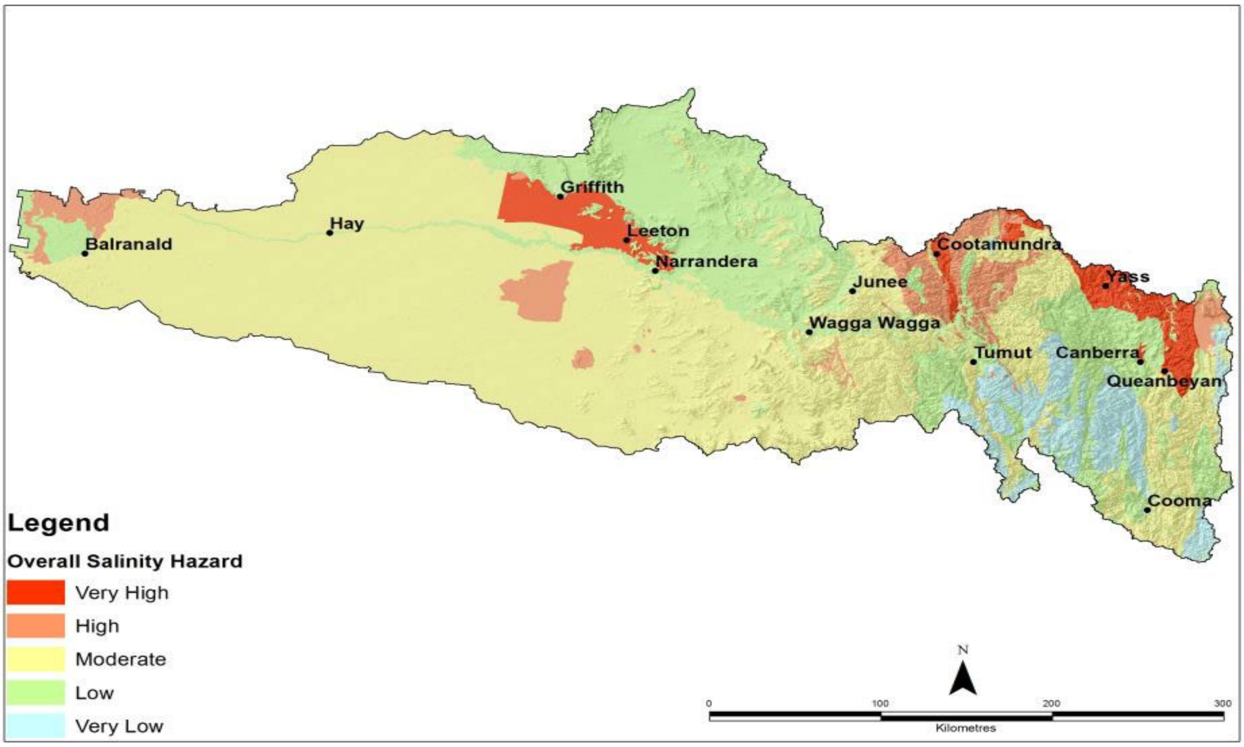

Figure 6: Overall Salinity Hazard for Murrumbidgee River catchment

Salt load and EC exceedance curves

The following graphs show exceedance curves for EC and salt load at the EOVT site - 410130- Murrumbidgee River @ Balranald.

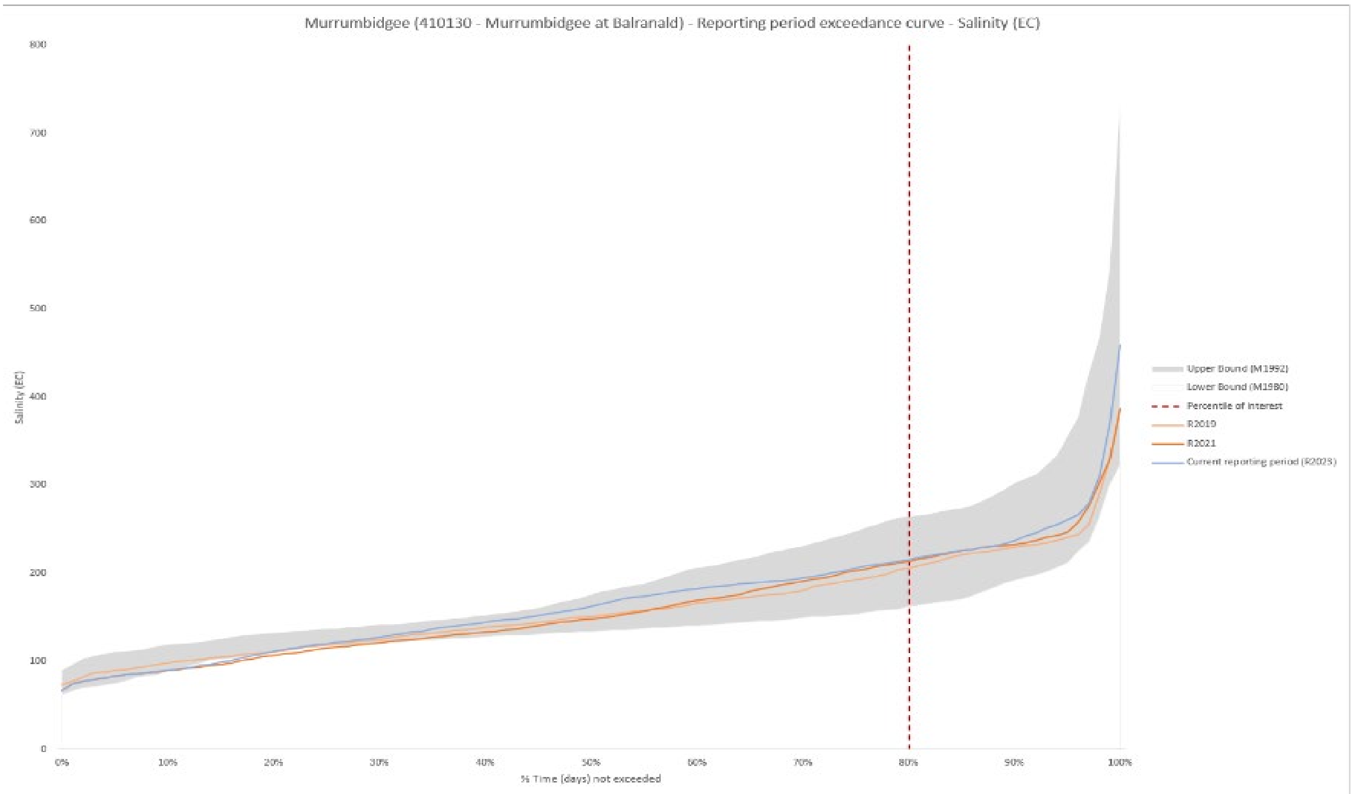

Figure 7: Salinity EC - Exceedance Curves for Murrumbidgee River @ Balranald (410130) for reporting years 2019, 2021, 2023.

The EC curves for the current reporting year is within the upper and lower bounds reflecting increased flow conditions. The ability to dilute saline sub-catchments maintains good water quality to irrigators as well as low EC at the EOVT.

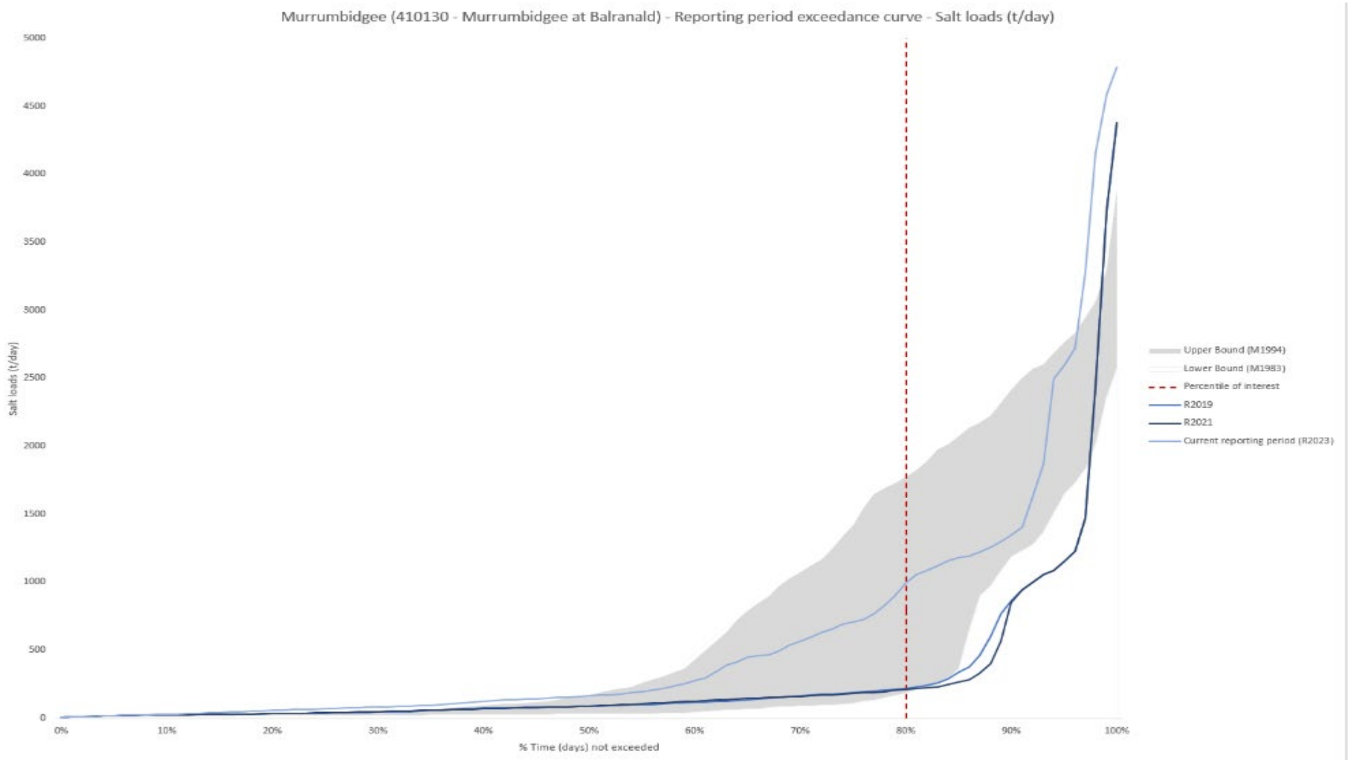

Figure 8: Salt Load - Exceedance Curves for Murrumbidgee River @ Balranald (410130) for reporting years 2019, 2021, 2023

For salt load the higher flow and higher EC have resulted in higher load than previous periods. This is due to higher inputs of salt from saline upstream sub-catchments coupled with larger flows. Previous years indicate less flow closer to lower bounds.

Rainfall

The residual mass rainfall graph (Figure 9) for Wagga Wagga shows increasing trend from 2020. Catchment rainfall started to increase in November 2021 to January 2022 after the millennium drought, with major flooding occurring in October until November 2022. The Murrumbidgee has received relatively good rainfall in 2023, leading to wet landscapes where impact on cropping has occurred.

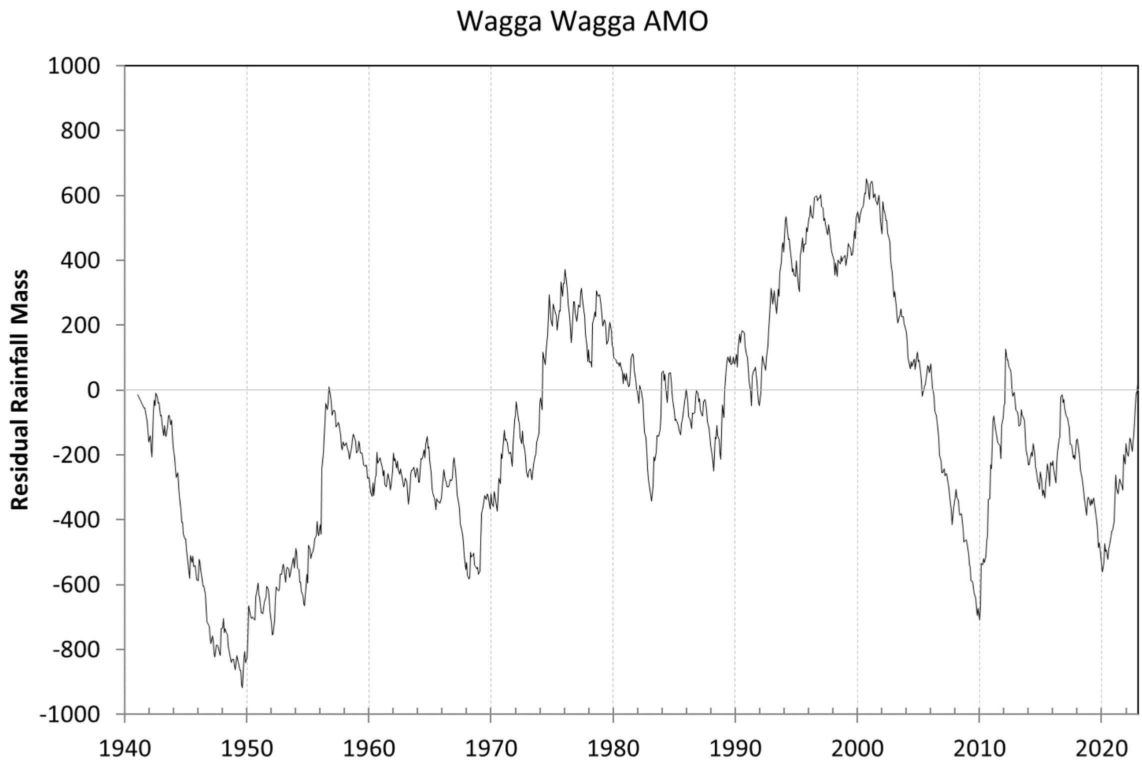

Figure 9: Residual mass rainfall for Wagga Wagga AMO

Lachlan EOVT – 412004 Lachlan River at Forbes (Cottons Weir)

The Ordovician and Silurian Volcanic geology areas in sub catchments above Forbes are seeing a decadal increase in land salinity and groundwater levels which is translating into higher EC and salt load. This is driven by a seasonal increase in rainfall and an increase in cropping, particularly on the red soils of the Silurian Volcanics.

The upland catchments have become increasingly wet with increased rainfall starting in November 2021 to January 2022 after the millennium drought and areas such as Cowra, Forbes and Eugowra undergoing major floods from September to November 2022. In contrast to catchments further North, the Lachlan has received relatively good rainfall in 2023.

The sub-catchments which enter the Lachlan River below Wyangala Dam such as the Boorowa River and Hovells Creek have had a profound impact on EC. The higher EC entering below the dam has impacted on domestic and commercial water quality at Cowra, requiring the use of Water Management Allowance stored in Wyangala Dam for dilution of EC. This commenced in February 2023 until June 2023. This is the first time it has been used for its intended purpose to dilute sub-catchment inflows which impact on water quality at Cowra.

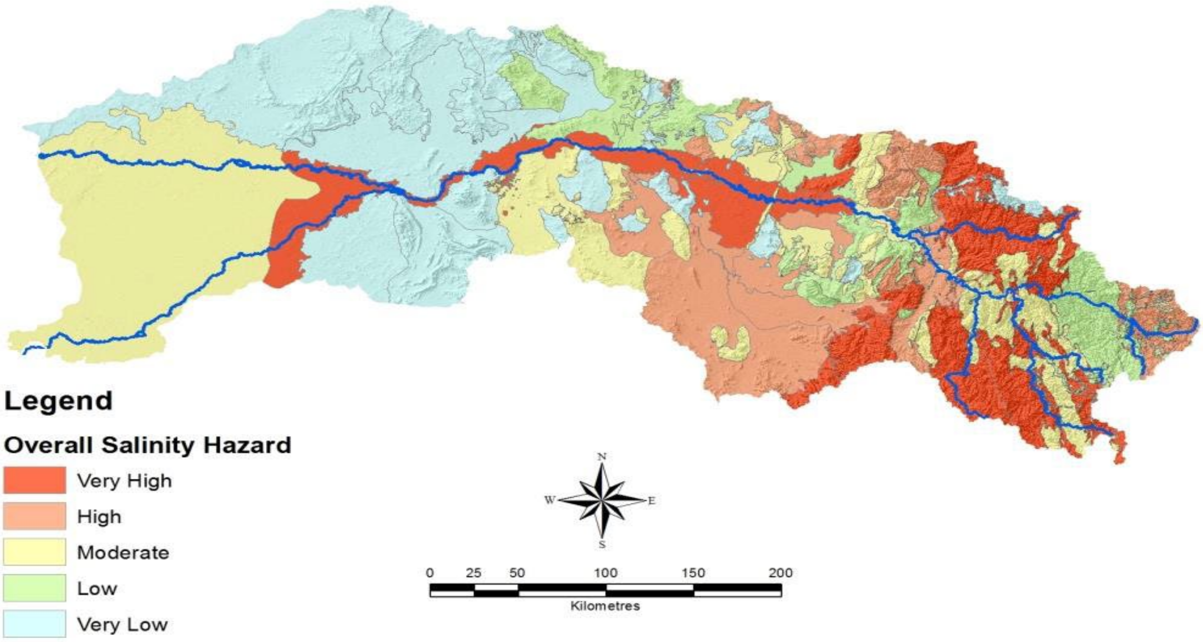

Figure 10: Overall Salinity Hazard for Lachlan River catchment

Exceedance curves

The following graphs show exceedance curves for EC and Salt Load at the EOVT site 412004 – Lachlan River @ Forbes (Cottons Weir).

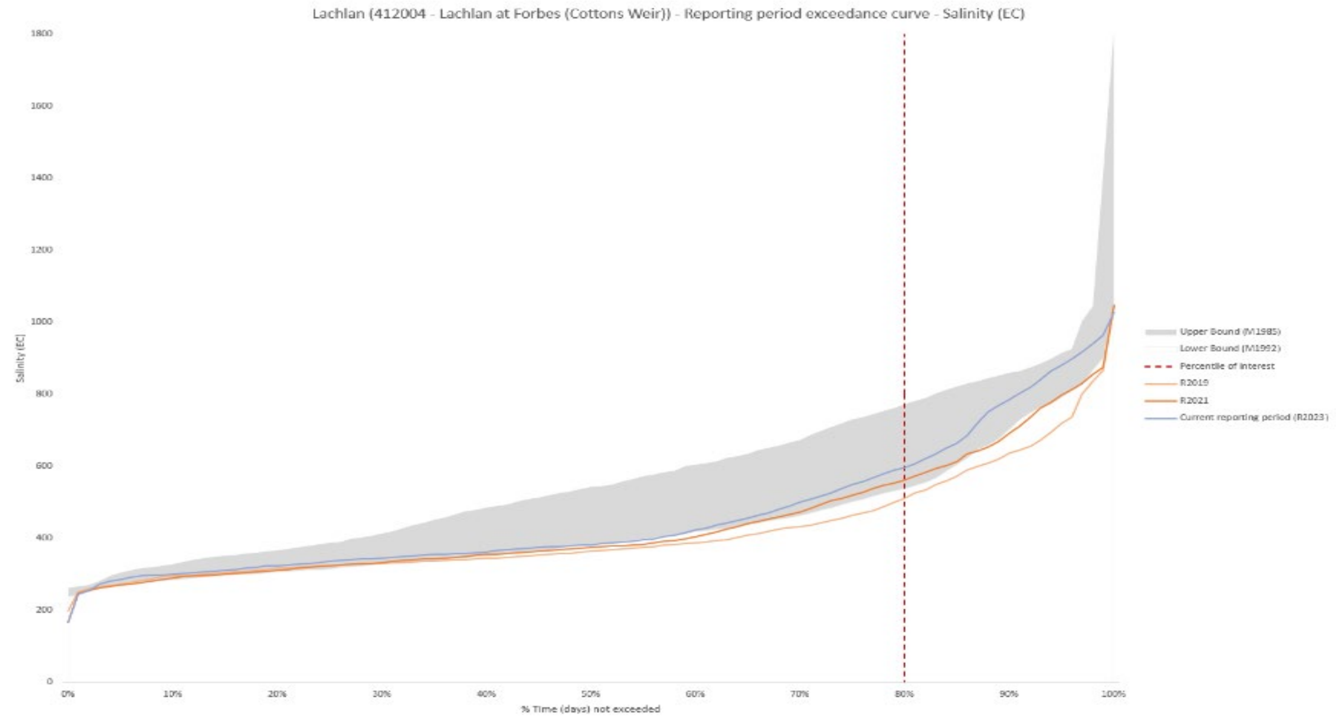

Figure 11: Salinity EC - Exceedance Curves for Lachlan River @Cottons Weir (412004) for reporting years 2019, 2021, 2023.

The EC for the current reporting year is within the upper and lower bounds reflecting increased flow conditions. In previous years there has been flow outside the lower bound conditions.

In the current year, the higher flow and higher EC have resulted in higher salt load. This is due to higher inputs of salt from saline upstream sub-catchments. Previous years indicate less flow closer to lower bounds.

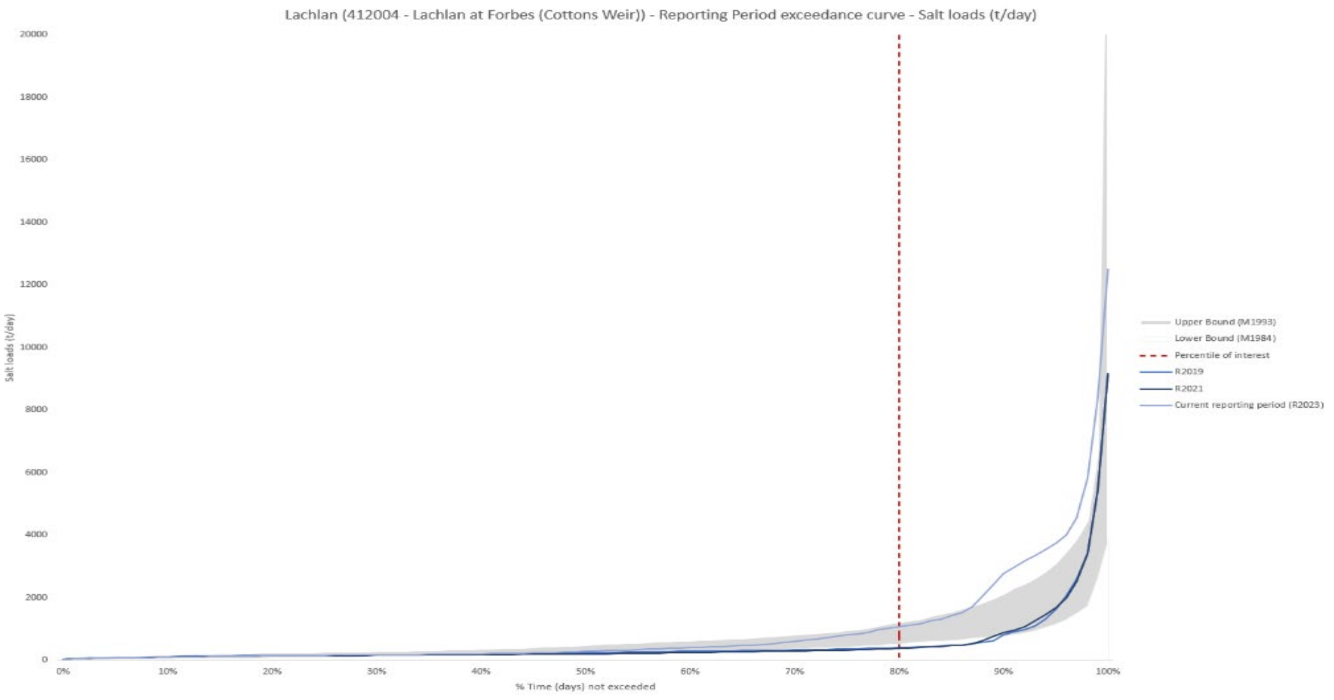

Figure 12: Salt Load - Exceedance Curves for Lachlan River @Cottons Weir (412004) for reporting years 2019, 2021, 2023.

Rainfall

The residual mass rainfall graph (Figure 13) for Cowra shows increasing trend from 2020. Catchment rainfall started to increase in November 2021 to January 2022 after millennium drought and major floods in September to November 2022. The Lachlan has received relatively good rainfall in 2023.

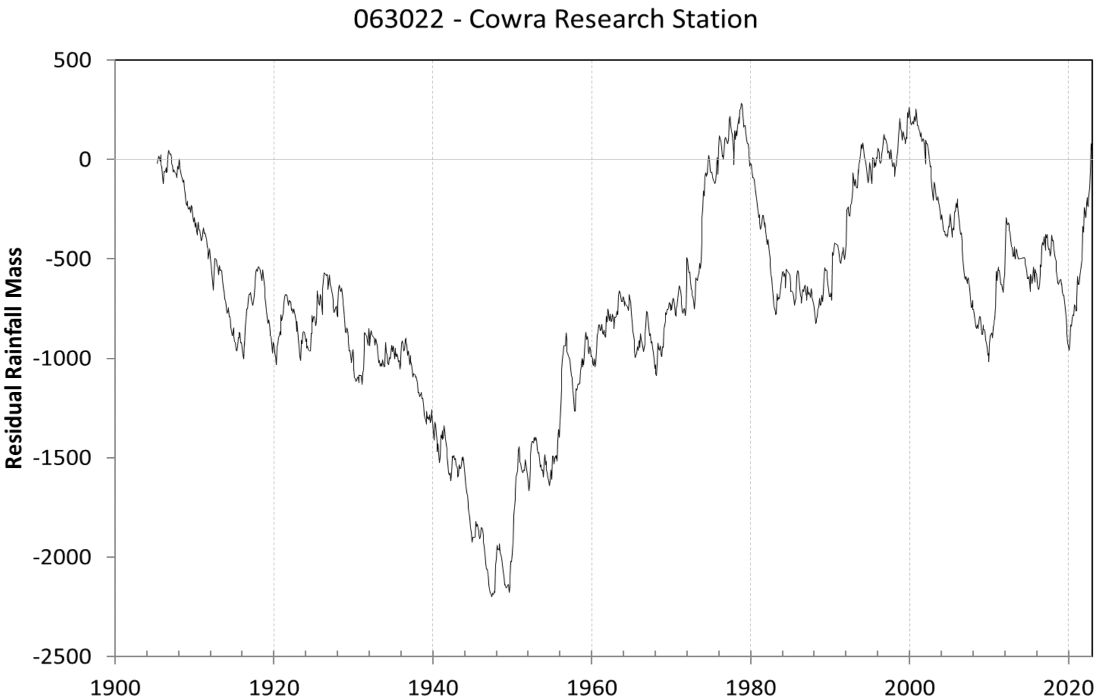

Figure 13: Residual mass rainfall for Cowra research Station

Bogan EOVT – 421023 Bogan River at Gongolgon

There is significantly saline land salinity in the uppermost area of the catchment on the catchment divide, west of Parkes in the Cooks Myall and Bruie Plains area. The Bruie Plains HGL is based on the mapped occurrence of Jurassic age sediments. Areas are usually surrounded by Palaeozoic geology or Cainozoic land surfaces. Occasionally rises and low hills of Palaeozoic geology occur within this landscape. The higher saltier areas such as Bruie Plains and Cooks Myalls are drained by very intermittent streams with high EC.

The Neurie Plains EC site (421039) captures the salinity behaviour of the saline of Cooks Myalls and Bruie Plains areas. After flooding in September to November 2022 there has been an increase in EC, due to wetter periods mobilising salts and the catchment drying up.

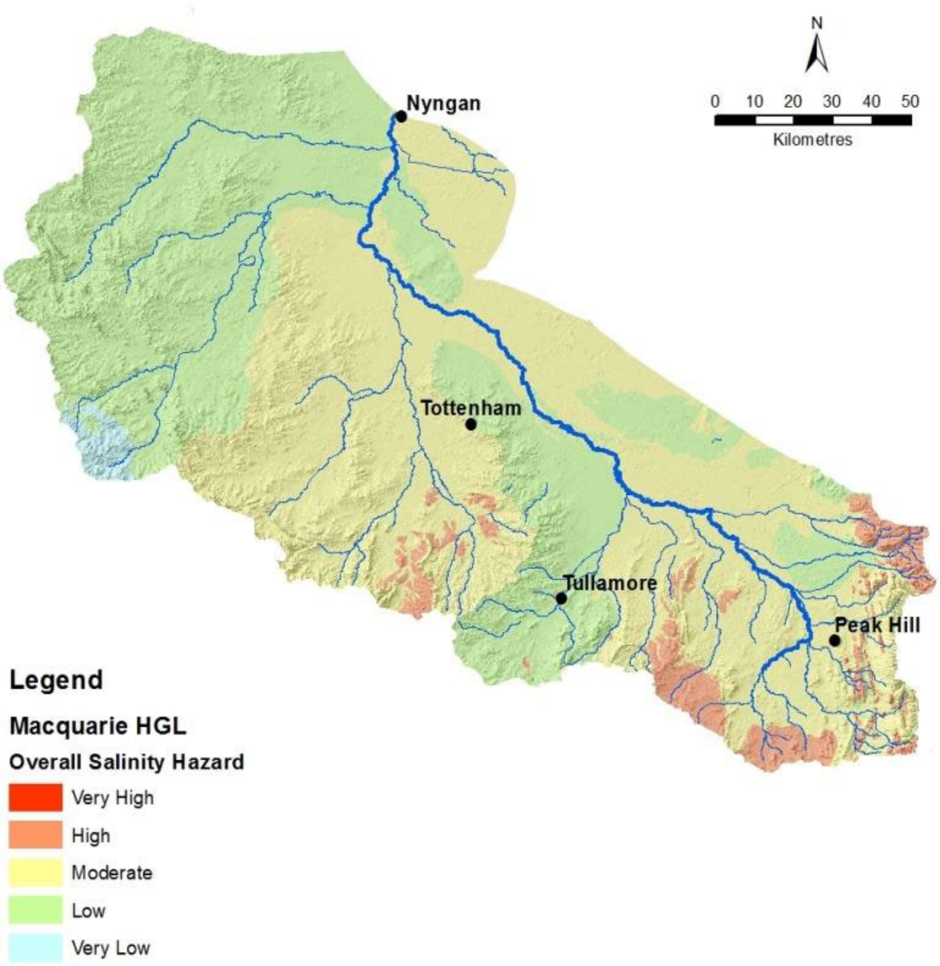

Figure 14: Overall Salinity Hazard for Bogan River catchment

The EOVT site at Gongolgon also shows an increase in EC after flooding as the catchment dries out. Initially the wet period may have mobilised salt stores that are seeping into streams, giving rise to increased EC.

Exceedance curves

The following graphs show exceedance curves for EC and salt load at the EOVT site - 421023-Bogan River @ Gongolgon. Noting that modelled data was not available to plot an envelope of upper and lower bound conditions.

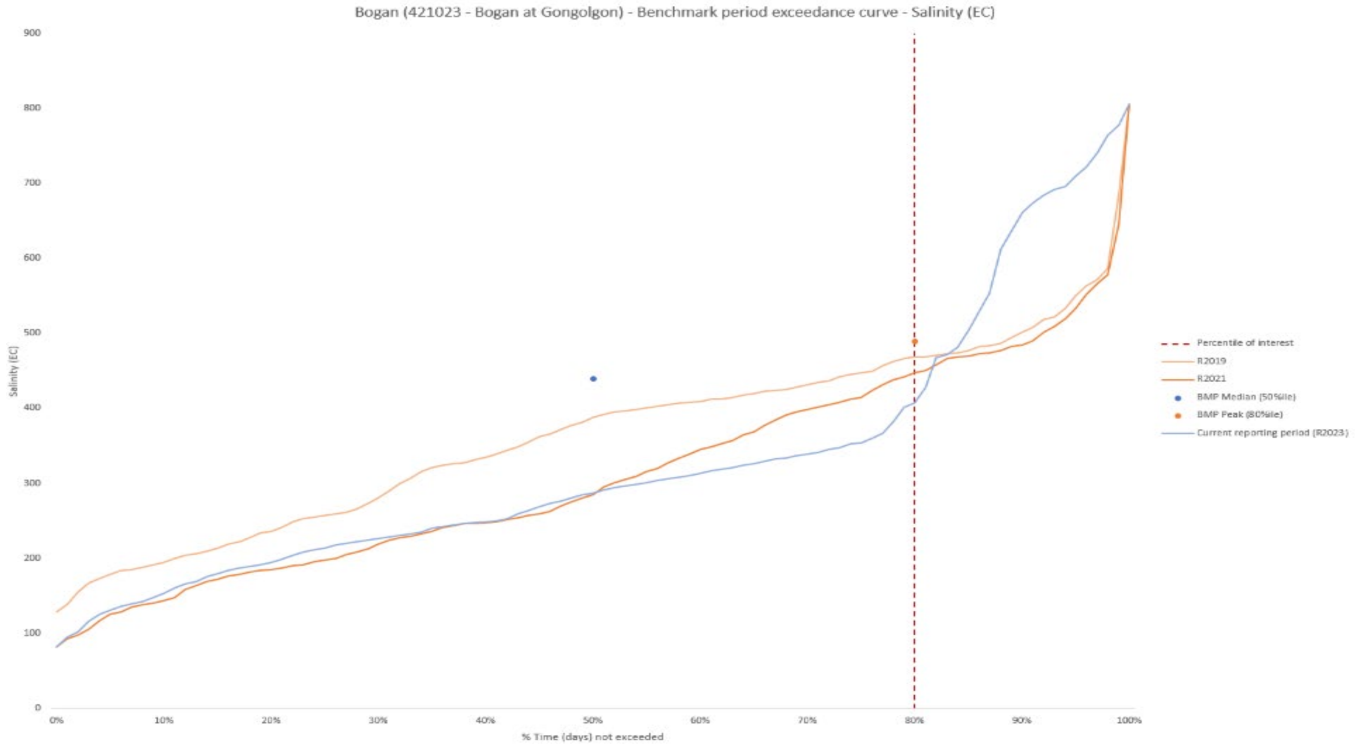

Figure 15: Salinity EC - Exceedance Curves for Bogan River @ Gongolgon (421023) for reporting years 2019, 2021, 2023.

The EC in the current reporting year is outside the normal bounds which is likely due to both high salinity from upland catchments of Cooks Myalls and mobilisation of the salt store. In previous years there has been much reduced EC (Figure 15).

In the current year, the higher flow and higher EC have resulted in higher salt load. This is due to higher inputs of salt from saline upstream sub-catchments. Previous years indicate less flow closer to lower bounds (Figure 16).

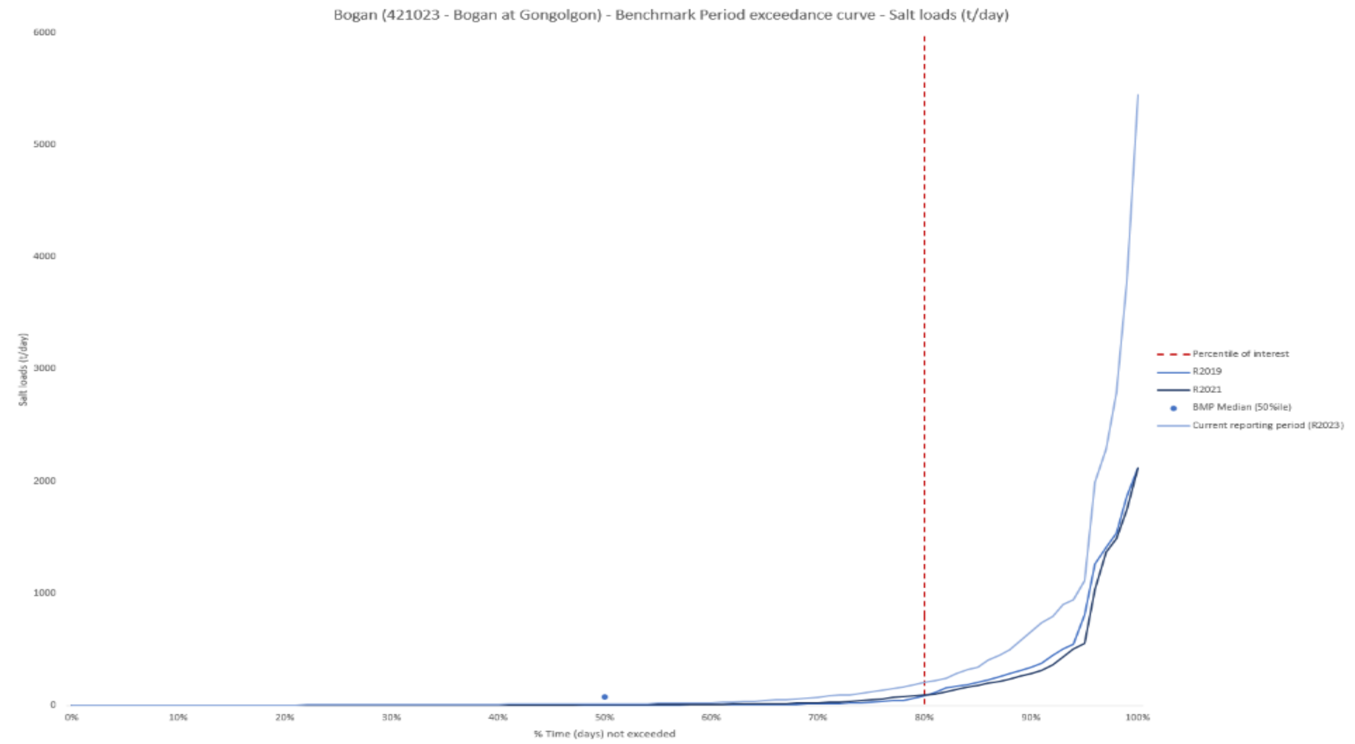

Figure 16: Salt Load - Exceedance Curves for Bogan River @ Gongolgon (421023) for reporting years 2019, 2021, 2023.

Rainfall

The residual mass rainfall graph (Figure 17) for Nyngan shows increasing trend from 2020. Catchment rainfall started to increase in November 2021 to May 2022 after millennium drought and minor floods in October to November 2022. Since that period, rainfall has decreased.

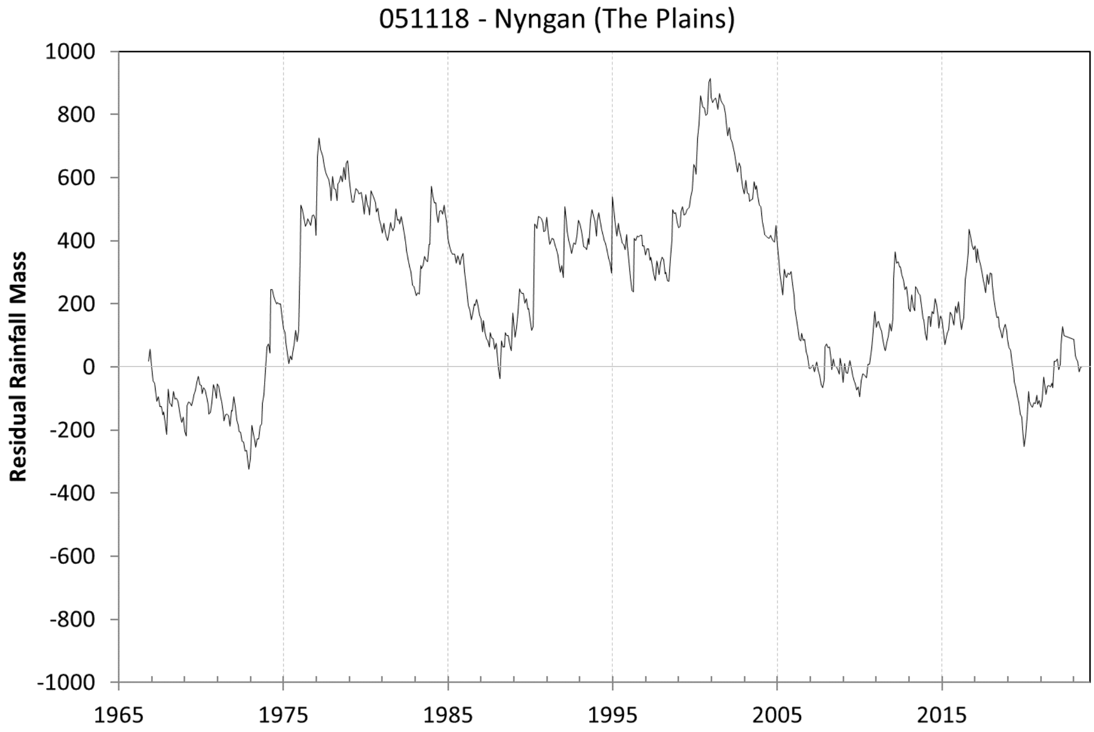

Figure 17: Residual mass rainfall for Nyngan (The Plains)

Macquarie EOVT – 421012 Macquarie River at Carinda (Bell's Bridge)

In the Molong Geanticline geologies as well as Ordovician and Silurian geologies, there has been a marked increase in land salinity, EC in streams increased and groundwater levels increased. The catchments were wet and the through flow of near surface has led to elevated salinities, even after high flow events have receded. This is manifesting in mid-2023 as the catchments dry out.

The sub-catchments which enter the Macquarie River below Burrendong Dam such as the Bell, Talbragar and Little Rivers have all had an impact on EC. Little and Bell Rivers have fluctuated due to flood conditions, with the Little River showing marked increase in elevated ECs as conditions dry out in 2023. The Bell River at Wellington experienced 7 flood events in the period July to Nov 2022.

Data from the EOVT site at Carinda illustrates the depression in EC after flooding and shows the impact of sub catchment salinity increase, with corresponding increase in EC in 2023.

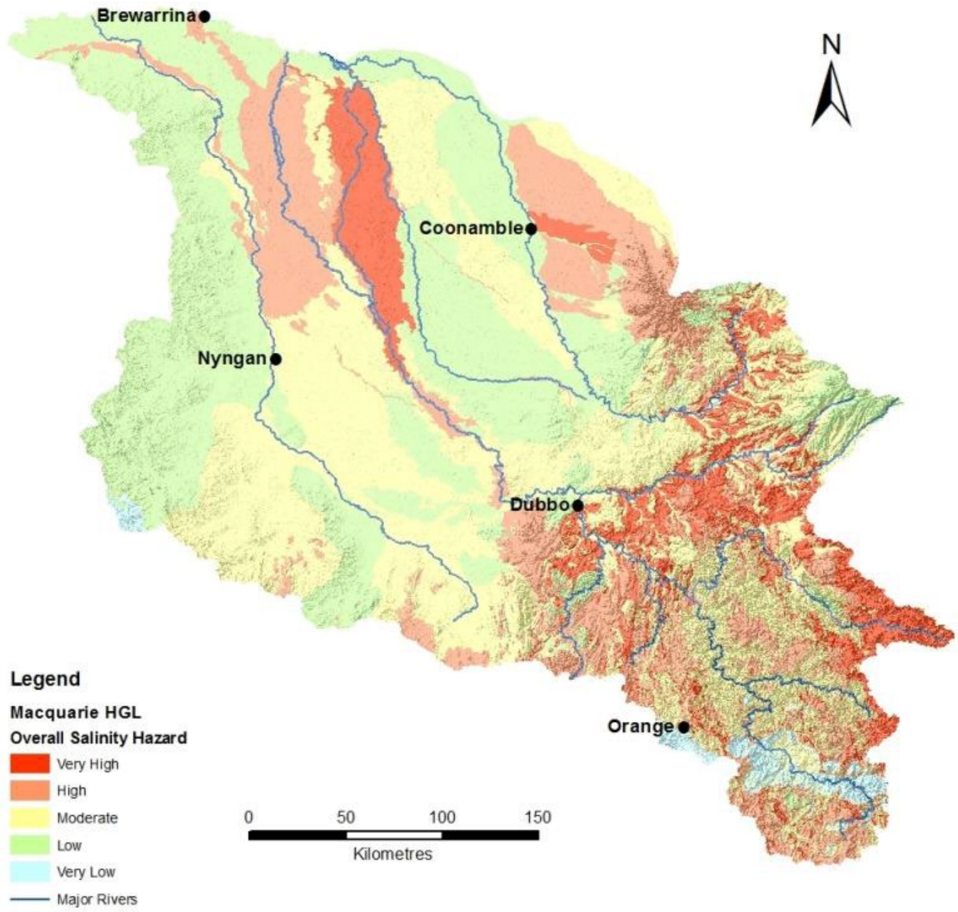

Figure 18: Overall Salinity Hazard for Macquarie River catchment

For salt load (in the current year) the higher flow and higher EC have resulted in higher load. This is due to higher inputs of salt from saline upstream sub-catchments and high flow. Previous years indicate less flow closer to lower bounds.

Exceedance curves

The following graphs show exceedance curves for EC and Salt load at the EOVT site - 421012- Macquarie River @ Carinda (Bell's Bridge).

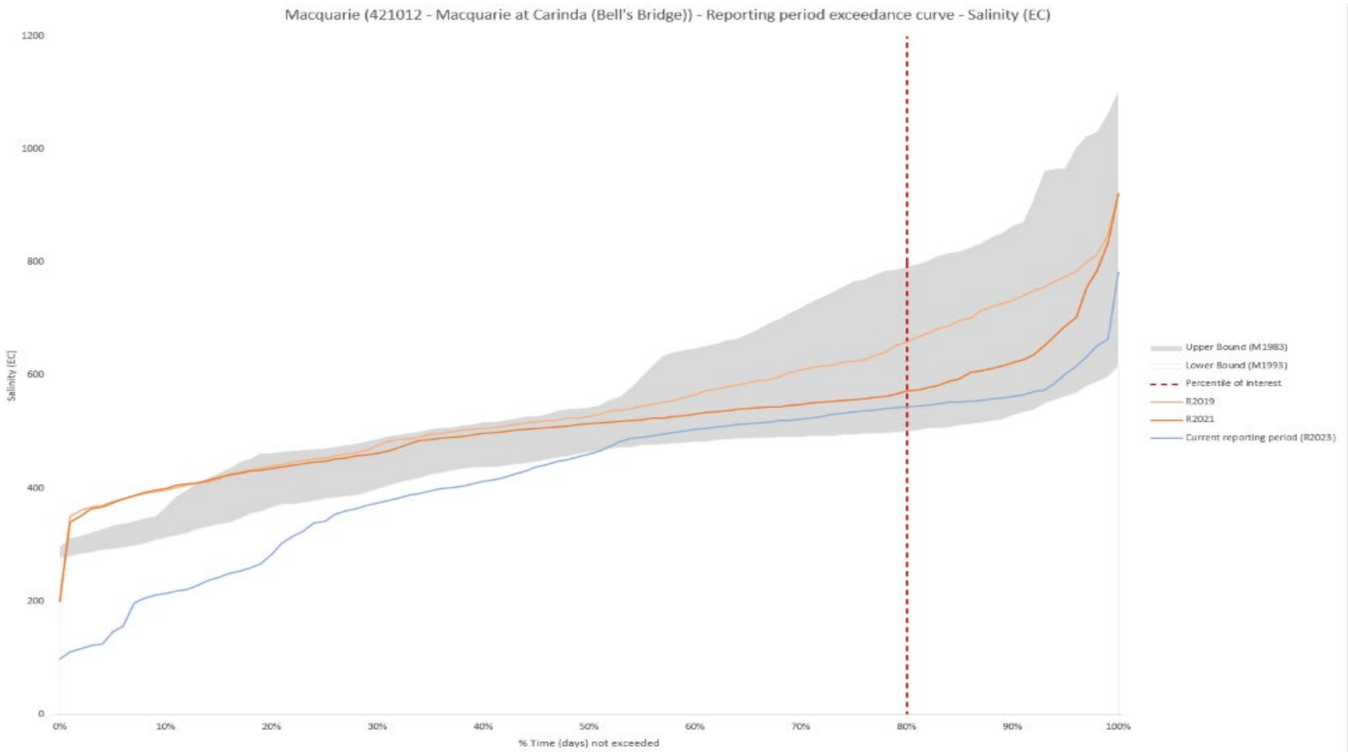

Figure 19: Salinity EC - Exceedance Curves for Macquarie River @ Carinda (Bell's Bridge) (421012) for reporting years 2019, 2021, 2023.

The EC in the current reporting year is close to the lower bounds reflecting increased flow conditions. In previous years the EC has been relatively higher (Figure 19).

In the current year, the higher flow and higher EC have resulted in higher salt load (Figure 20). This is due to higher inputs of salt from saline upstream sub-catchments as well as high flow. Previous years indicate less flow closer to lower bounds.

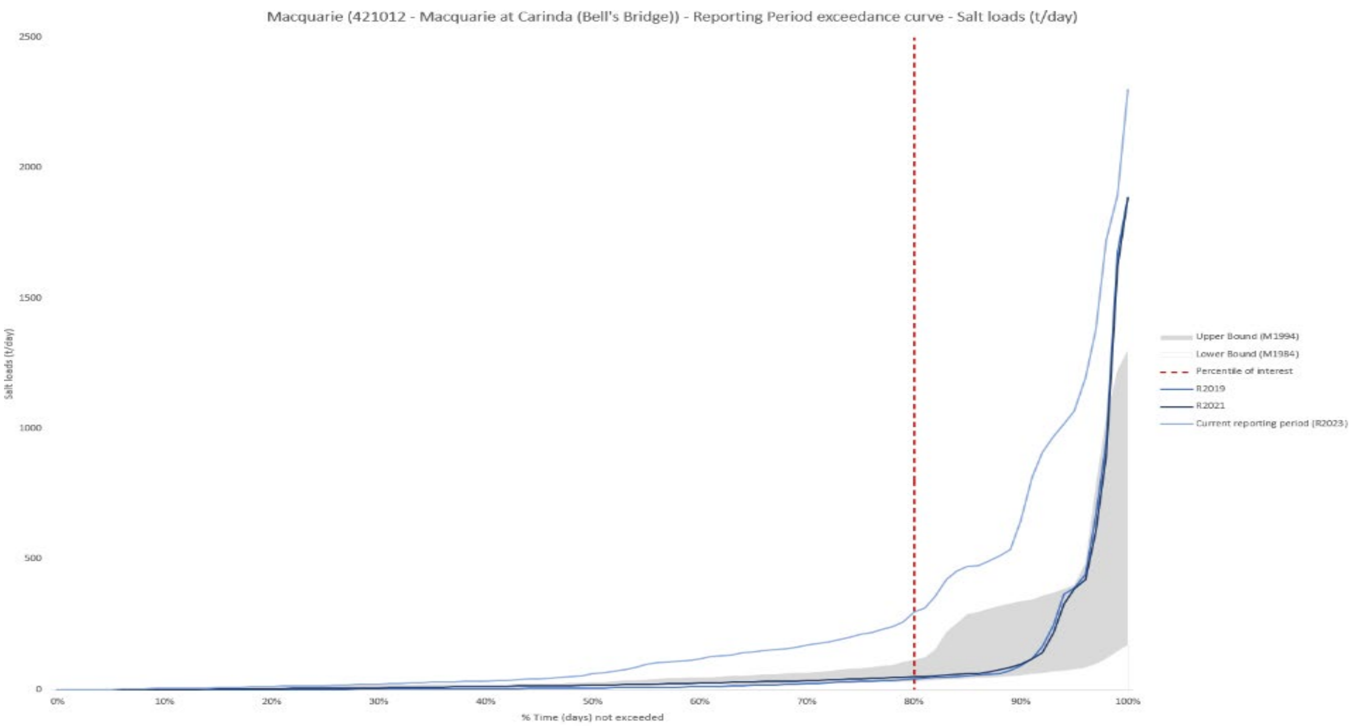

Figure 20: Salt Load - Exceedance Curves for Macquarie River @ Carinda (Bell's Bridge) (421012) for reporting years 2019, 2021, 2023.

Rainfall

The residual mass rainfall graph (Figure 21) for Wellington shows increasing trend from 2020. Catchment rainfall started to increase in November 2021 to January 2022 after the millennium drought and major floods in July to October 2022. The Macquarie has been dry since December 2022 and moving to drought conditions in mid-2023.

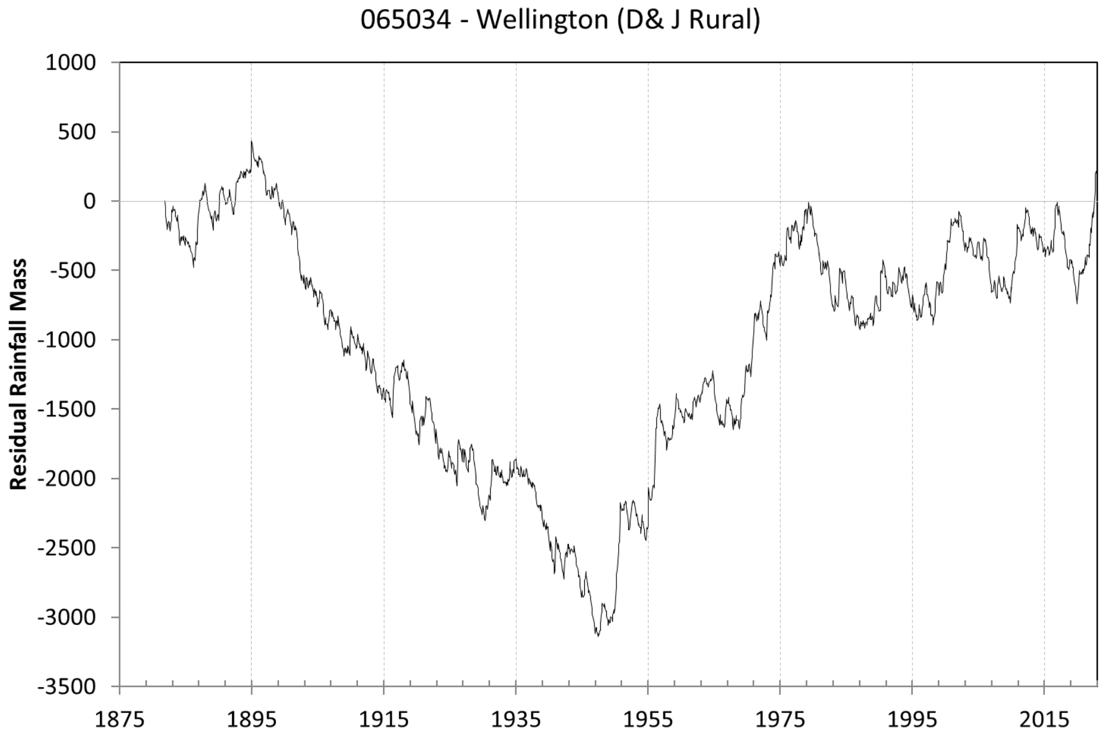

Figure 21: Residual mass rainfall for Wellington

Castlereagh EOVT – 420020 Castlereagh River at Gungalman Bridge

The geology of the area is varied and presents many situations for salinity to occur. These are influenced by land use and seasonality. There has been a noted increase in land salinity in the upland areas after the wet period of November 2022. Salt sites are expanding and becoming more obvious as the catchment dries out in 2023.

The Purlewaugh and Binnaway area is characteristic of flat-lying Triassic and Jurassic sandstone, siltstone and mudstone, conglomerate bedrock areas in the Coonabarabran district where large salt sites occur. This Upper Castlereagh region has had elevated EC's which were impacted by wetter conditions in August to November 2022 and recent drying phase in the catchment. The impact of the November 2021 wet period saw a reduction in EC then variable response until the next major rainfall period.

Outwash areas of Teridgerie, Gular and Warrumbungle usually only have localised impacts, but the wetter flood periods may have mobilised salt from large scalds and shallow salt store.

Data from the EOVT site for Castlereagh at Gungalman illustrates the flood events and resulting impact on EC. The EC is approaching 1,000 EC, with the higher EC reflecting low flows in dry times after the wet period.

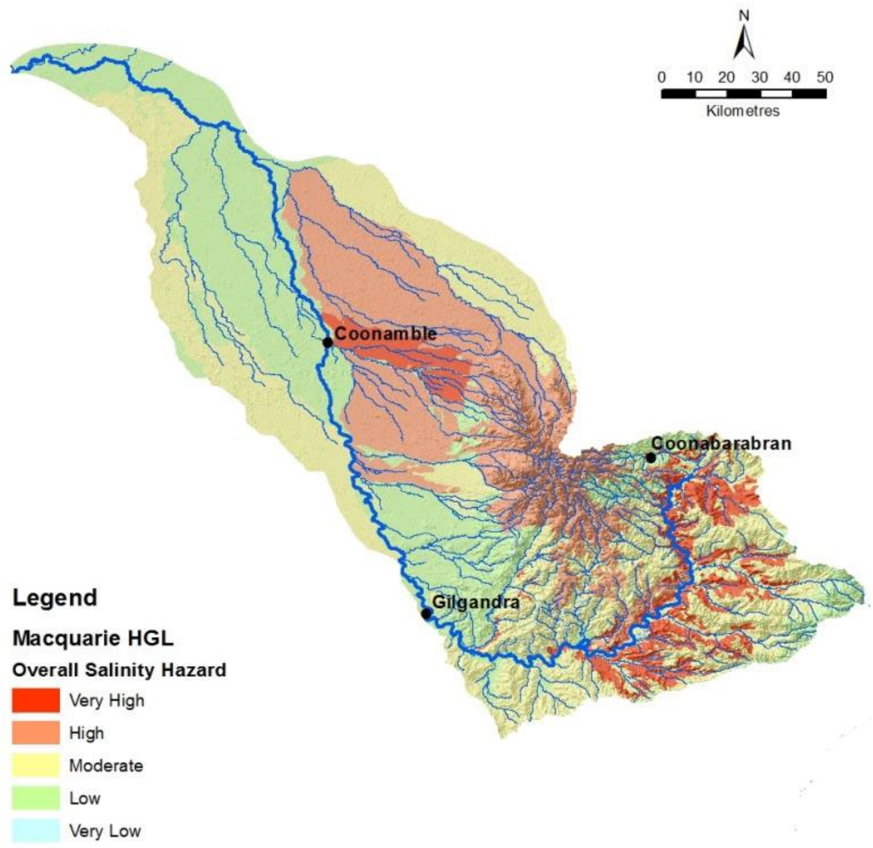

Figure 22: Overall Salinity Hazard for Castlereagh River catchment

Exceedance curves

The following graphs show exceedance curves for EC and salt load at the EOVT site – 420020 - Castlereagh River @ Gungalman Bridge.

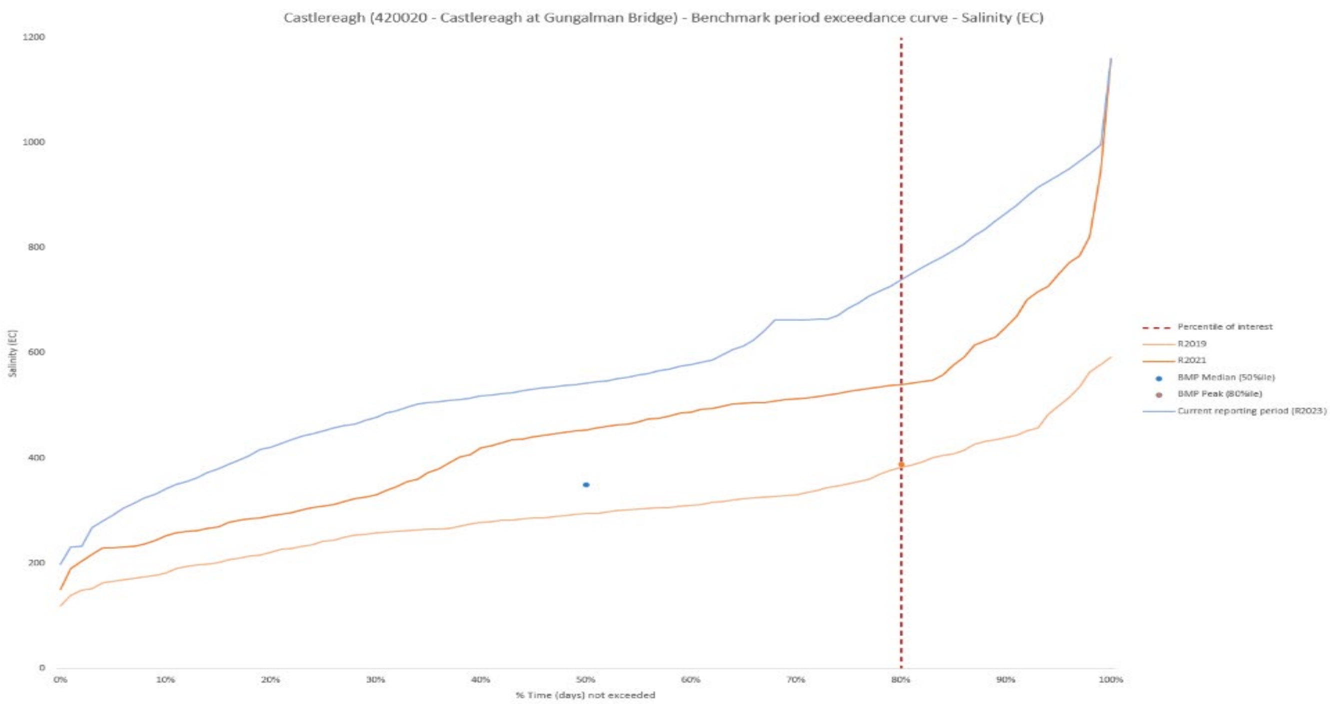

Figure 23: Salinity EC - Exceedance Curves for Castlereagh River @ Gungalman Bridge (420020) for reporting years 2019, 2021, 2023.

The EC in the current reporting year is above the upper bounds reflecting increased flow conditions and mobilisation of salt from upstream flat lying saline areas (Figure 23). In previous years there has been flow outside the lower bound conditions.

In the current year, higher flow and higher EC have resulted in higher salt load. This may be due to higher inputs of salt from saline upstream sub-catchments becoming wetter and mobilising more salt. Previous years indicate less flow closer to lower bounds.

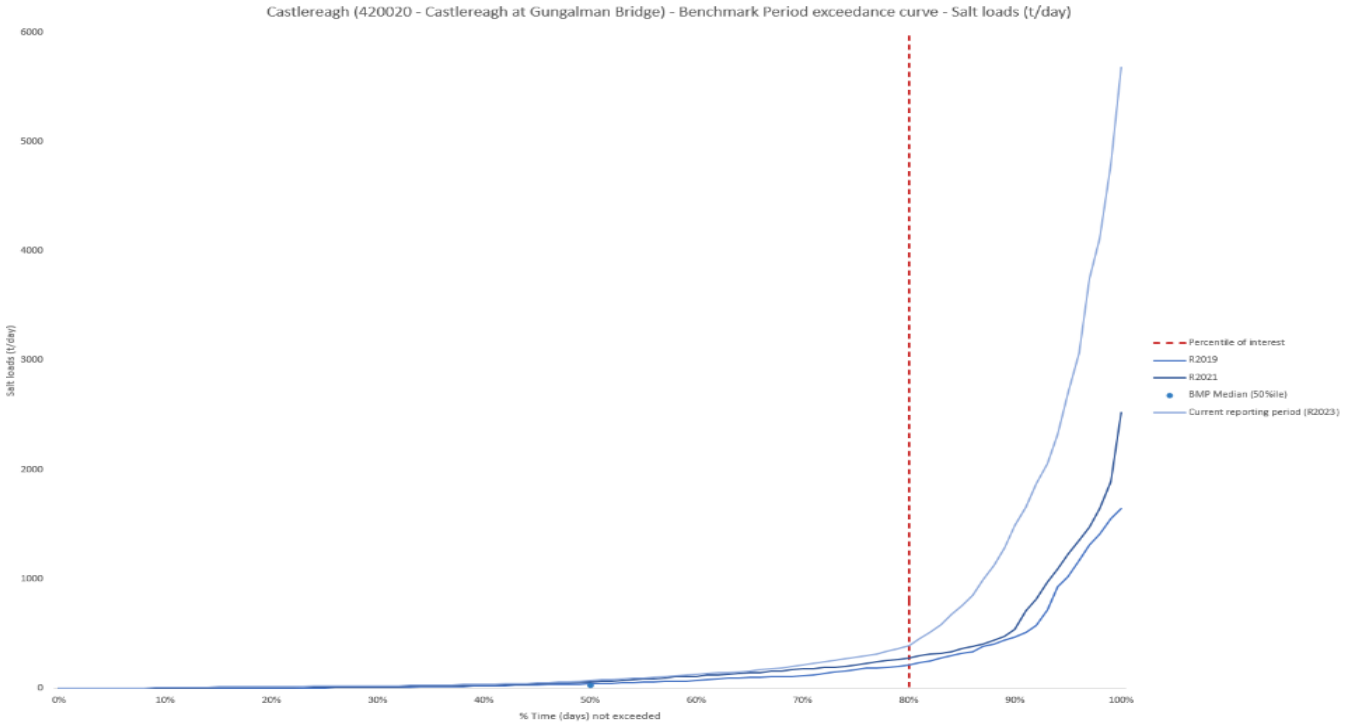

Figure 24: Salt Load - Exceedance Curves for Castlereagh River @ Gungalman Bridge (420020) for reporting years 2019, 2021, 2023.

Rainfall

The residual mass rainfall graph (Figure 25) for Coonamble shows increasing trend from 2020. Catchment rainfall started to increase in November 2021 to December 2021 after the millennium drought and minor floods in November to December 2022. Since that period the catchment has remained dry during 2023.

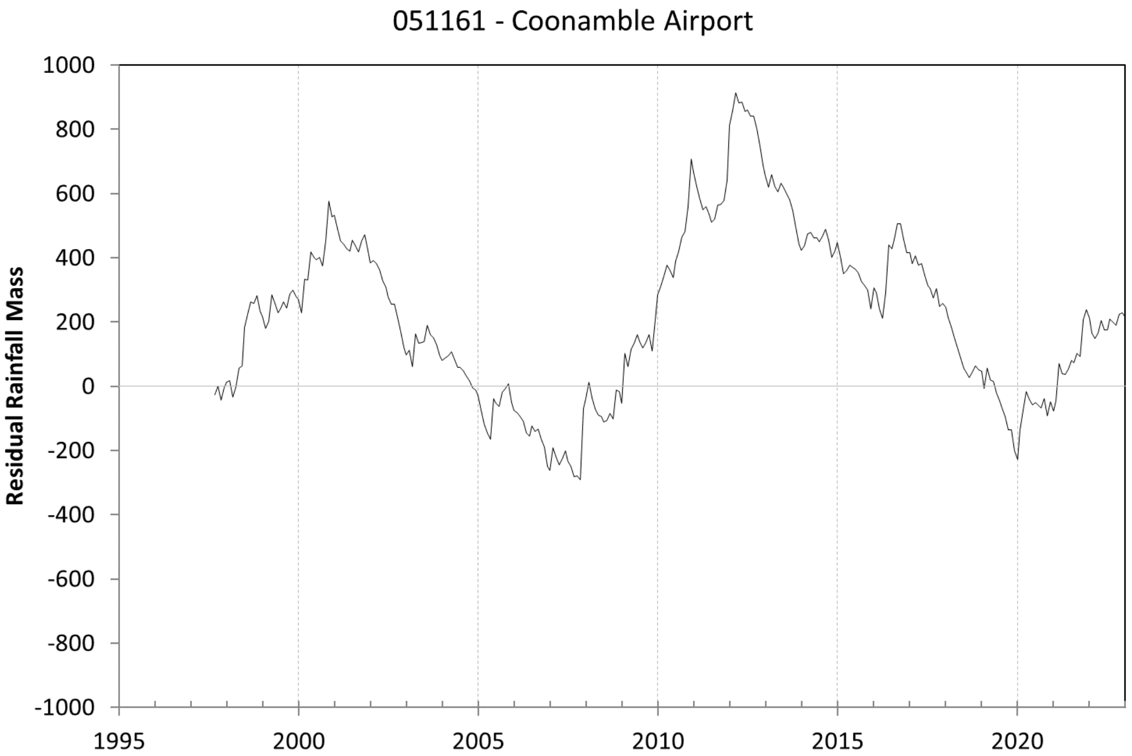

Figure 25: Residual mass rainfall for Coonamble

Namoi EOVT – 419026 Namoi River at Goangra

The Namoi is very complex geologically with the Peel Fold Belt, Liverpool Plains, Triassic, Jurassic and Permian volcanics and sediments represented on the geological mapping of the area. The Devonian and Carboniferous geologies are particularly important in salinity development across the region, with high salt store.

The Liverpool Plains has significant salinity issues in both the Mooki River and Coxs Creek. Round Island area has long been recognised for its extreme salinity and has been a focus for salinity research for some time. The Coxs Creek and Mooki River both have had high flow and low EC periods in November 2021 and August to November 2022 followed by increasing EC. Since December 2022 the EC has climbed as the catchments have dried out. The Permian, Jurassic and Triassic sediments in the Coxs Creek catchment also have combinations which lead to large salinity impacts and increasing EC in 2023.

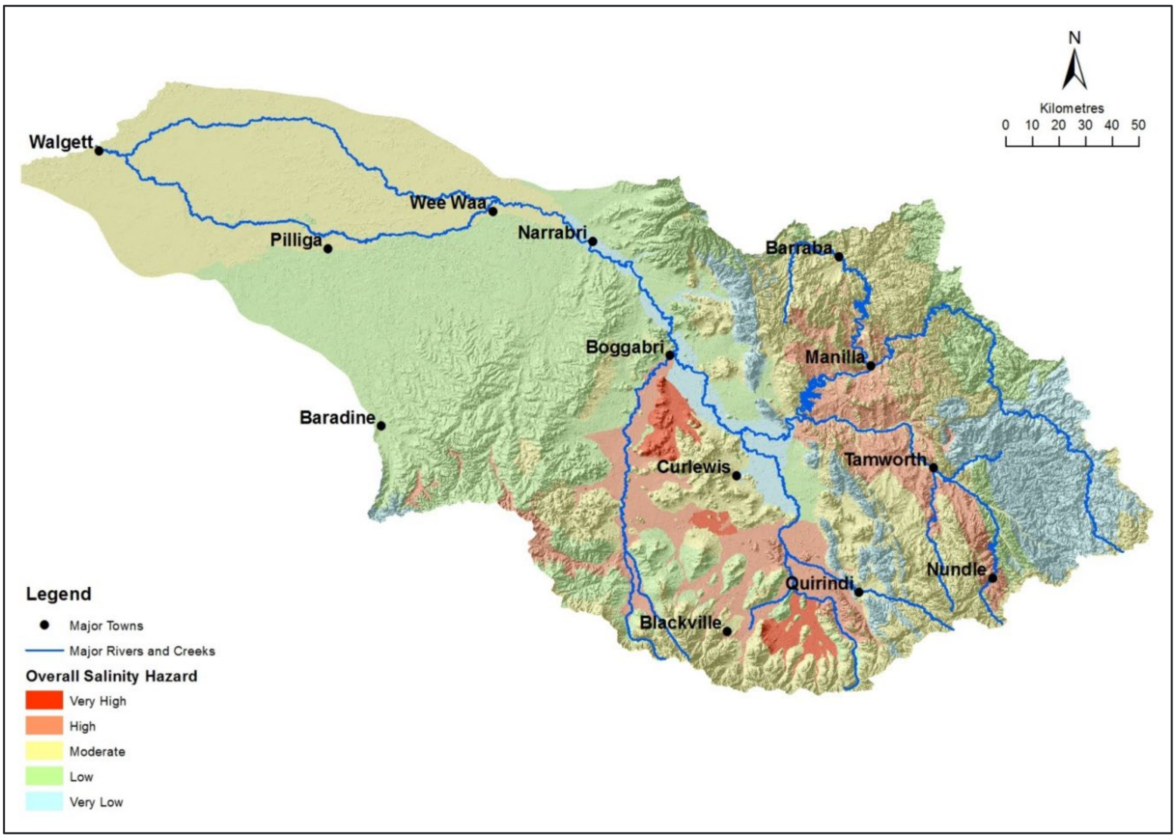

Figure 26: Overall Salinity Hazard for Namoi River catchment

Exceedance curves

The following graphs show exceedance curves for EC and Salt Load at the EOVT site - 419026-Namoi River @ Goangra.

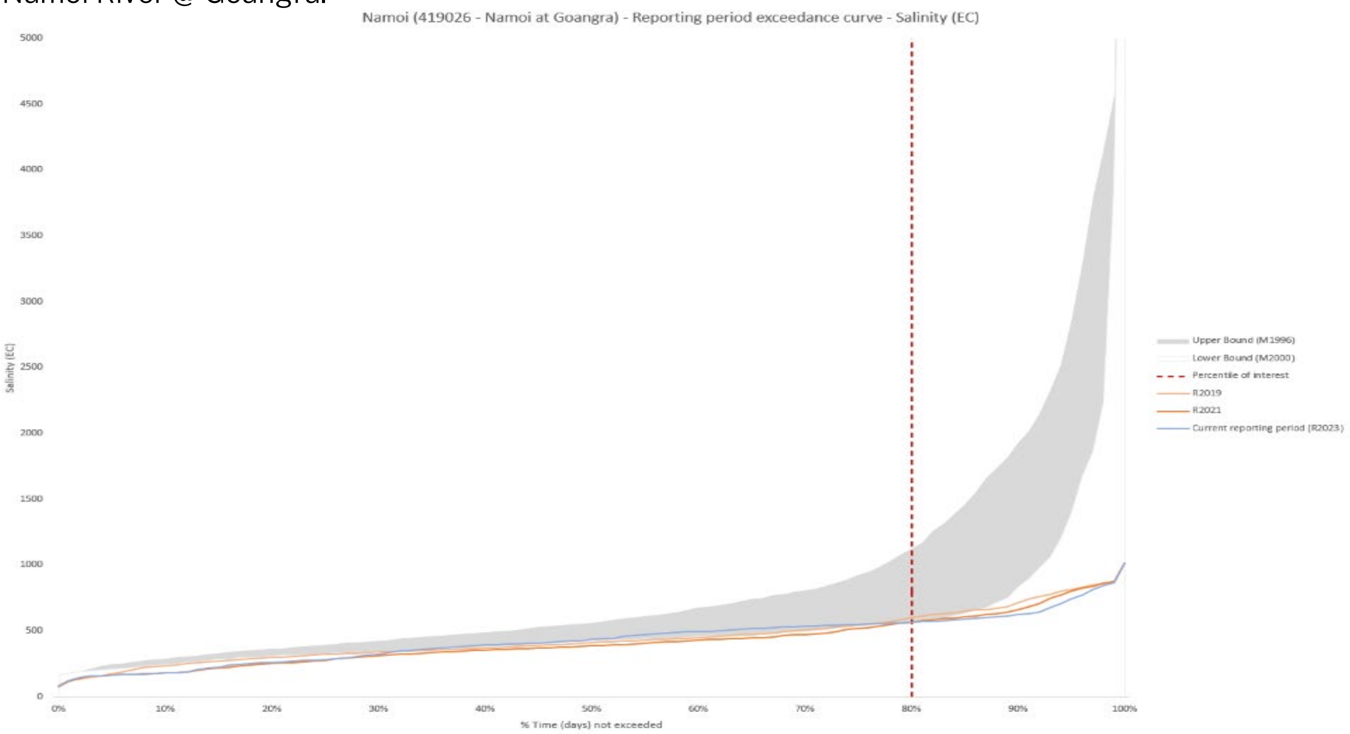

Figure 27: Salinity EC - Exceedance Curves for Namoi River @ Goangra (419026) for reporting years 2019, 2021, 2023.

The EC in the current reporting year is below the lower bounds reflecting increased flow conditions (Figure 27). There is possibly a land use impact due to increased level of tropical grasses in the catchment. Results are like previous years were there has been flow outside the lower bound conditions.

In the current year, the higher flow and higher EC have resulted in higher salt load (Figure 28). This is due to higher inputs of salt from saline upstream sub-catchments, as well as the catchment drying out and EC increasing. Previous years indicate less flow closer to lower bounds.

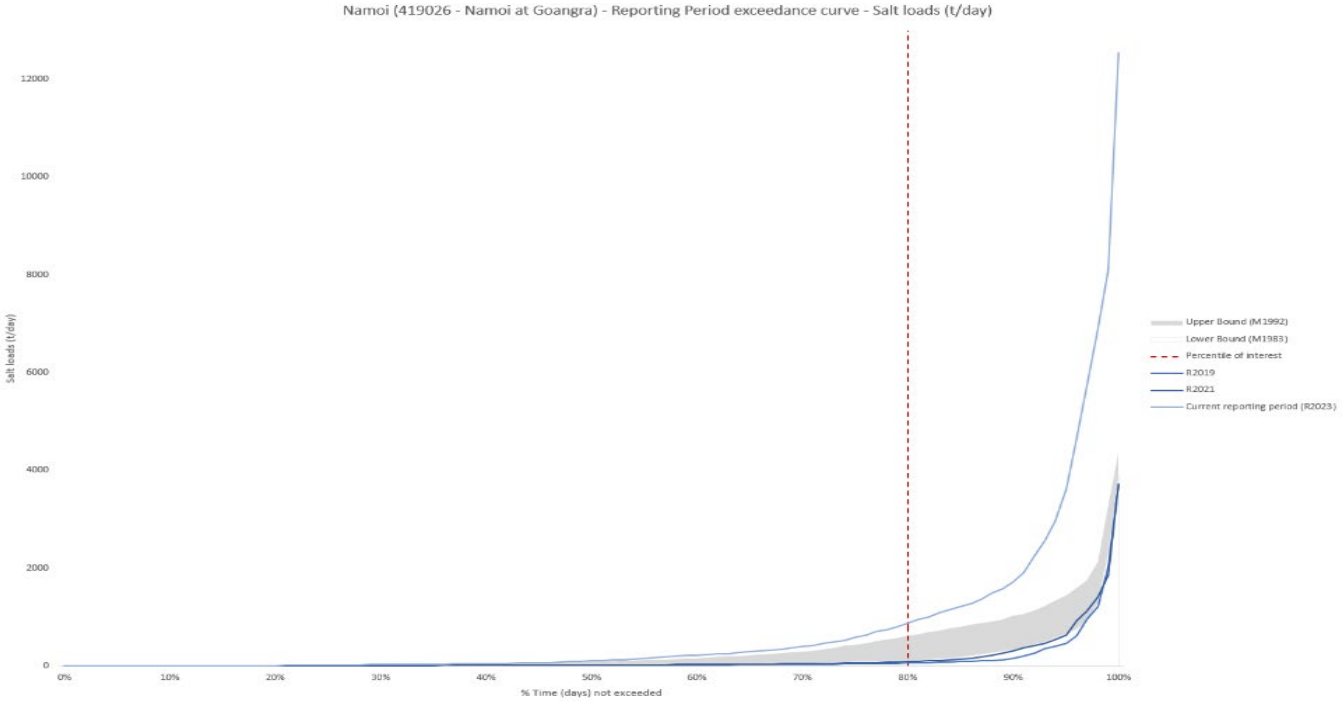

Figure 28: Salt Load - Exceedance Curves for Namoi River @ Goangra (419026) for reporting years 2019, 2021, 2023.

Rainfall

The residual mass rainfall graph (Figure 29) for Gunnedah shows increasing trend from 2020. Catchment rainfall started to increase in November 2021 after millennium drought and major floods in August to November 2022. After good rainfall in March 2023 the catchment has dried up.

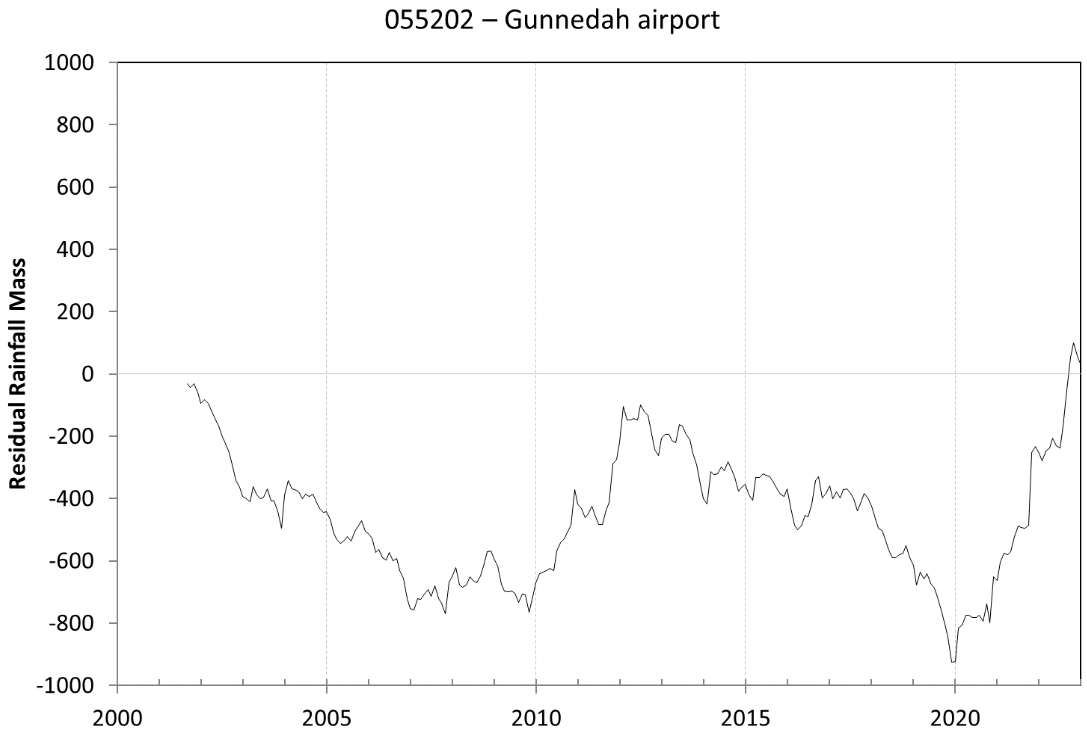

Figure 29: Residual mass rainfall for Gunnedah airport

Gwydir EOVT – 418058 Mehi River at Bronte

The Gwydir catchment is geologically diverse. The cause of salinity is a complex interplay between landform, geology, soils, regolith, climate and land use. Identification of problem areas, such as the mid Gwydir catchments of Myall, Warialda and Halls Creeks, and Horton River, has shown EC and load impacts are widely distributed across the Gwydir, but a few sub-catchments (such as Myall Creek) are very saline.

Situations where basalt geologies flow over other geologies (granites, flat lying sediments) are a major salinity cause such as in the Myall Creek catchment. Myall Creek has had recent elevated EC's (approaching 1,600EC) as the catchment has dried out. The two former flood periods saw a short reduction in EC due to high flow, but the sub-catchment has responded with increases in EC to minor rainfall events between the two flood periods. There has been an expansion in cropping in the area on the black cracking clays of the catchment.

The EOVT site Mehi at Bronte responded with low EC to the large flood in November 2022 and a very high EC subsequently. This may be due to increased through flow and the cropping landscapes wetting up. Recently the catchment is drying out, leading to increase in EC.

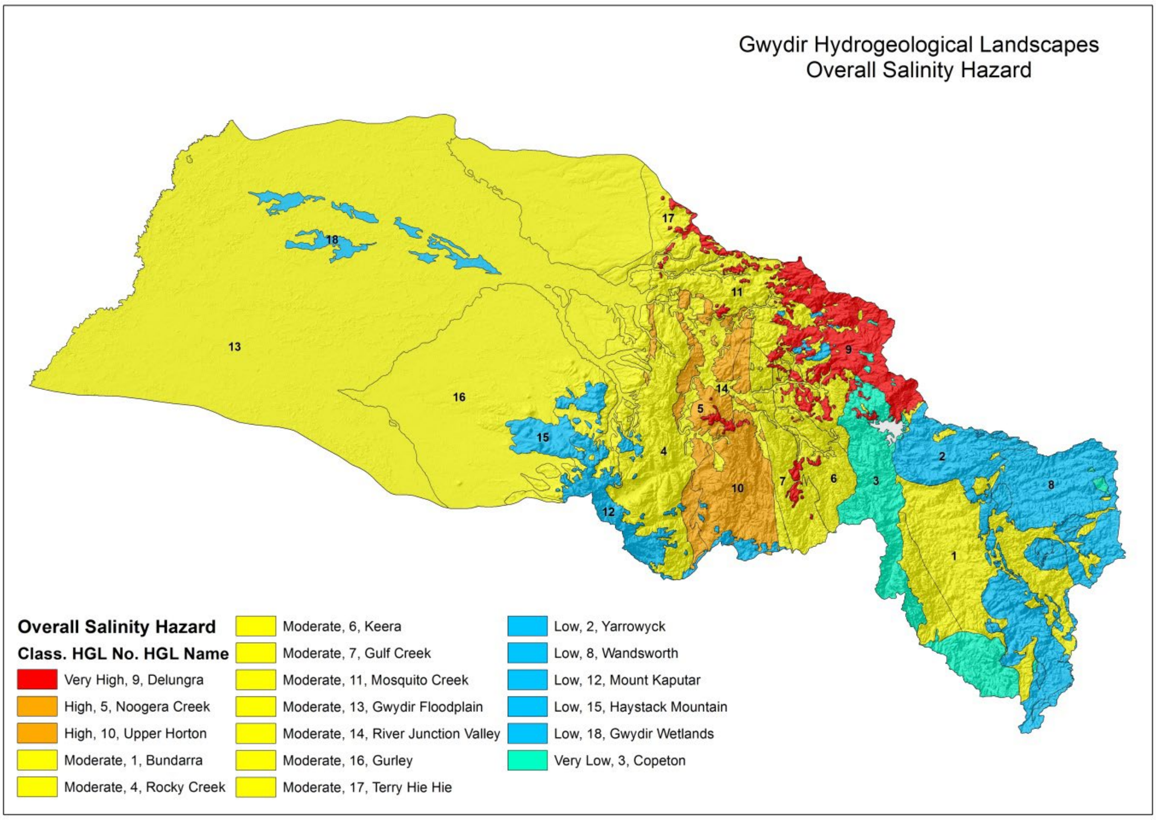

Figure 30: Overall Salinity Hazard for Gwydir River catchment

Exceedance curves

The following graphs show exceedance curves for EC and salt load at the EOVT site - 418058 Mehi River @ Bronte.

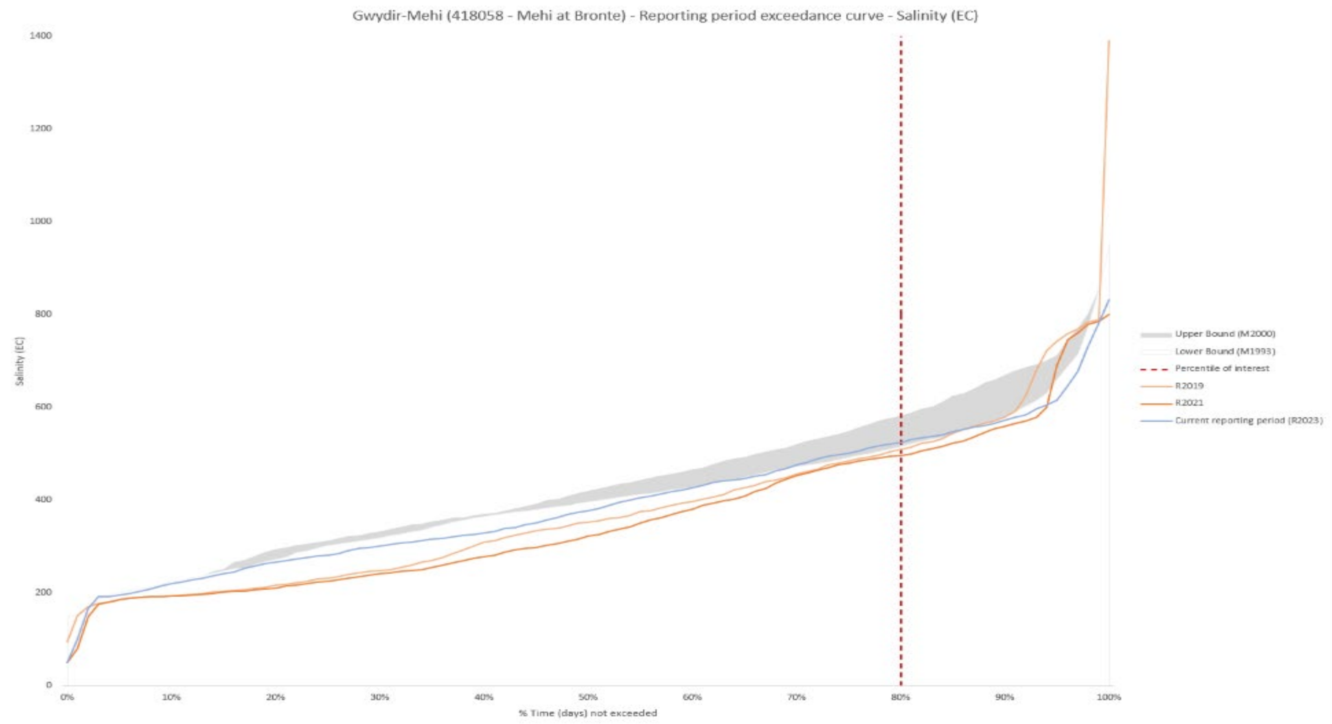

Figure 31: Salinity EC - Exceedance Curves for Mehi River @ Bronte (418058) for reporting years 2019, 2021, 2023.

The EC in the current reporting year is below the lower bounds reflecting increased flow conditions, and little impact from a small number of saline catchments (Figure 31).

In the current year, the higher flow and higher EC have resulted in higher salt load (Figure 32). There may be some increased load from saline catchments.

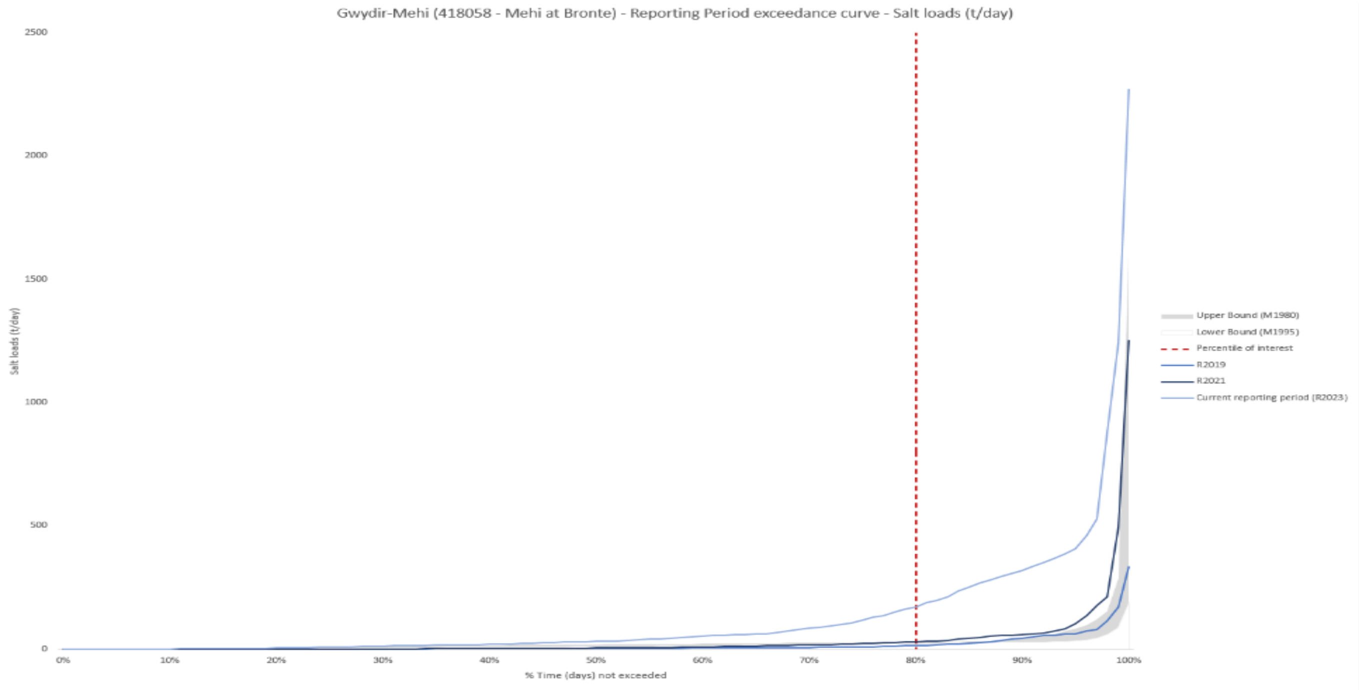

Figure 32: Salt Load - Exceedance Curves for Mehi River @ Bronte (418058) for reporting years 2019, 2021, 2023.

Rainfall

The residual mass rainfall graph (Figure 33) for Bingara shows increasing trend from 2018. Catchment rainfall started to increase after millennium drought in November 2021 with minor floods. A wet period from August to October 2022 also caused flooding. Since March 2023 the area has been dry, limiting pastures and crops.

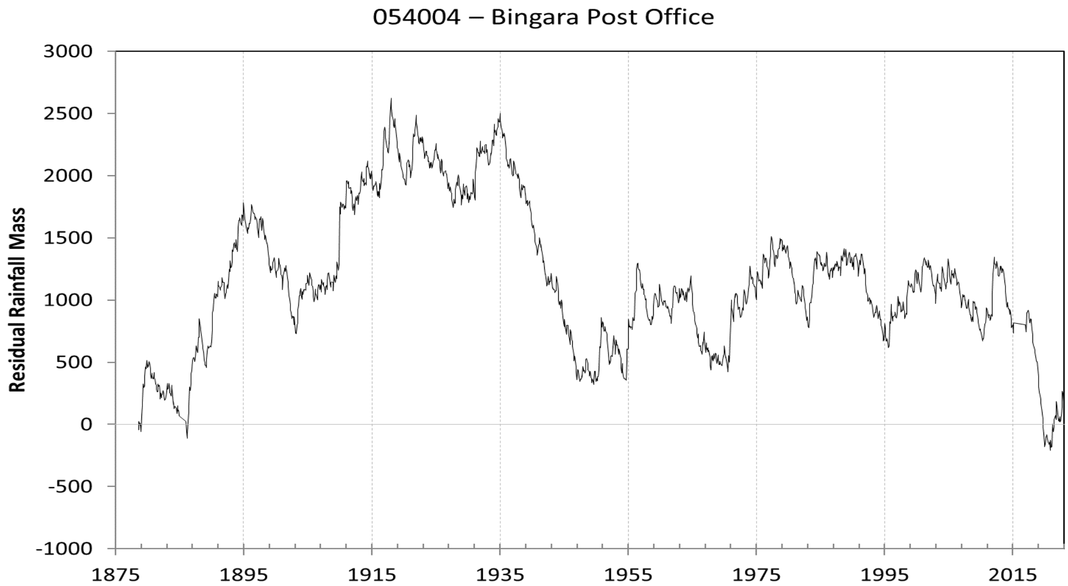

Figure 33: Residual mass rainfall for Bingara Post Office

Border Rivers - Macintyre EOVT – 416001 Macintyre River at Mungindi

Major flood events of November and December 2021 and September to December 2022 have impacted salt load as well as sub catchment EC which has been increasing since December 2022, A combination of wet catchments, which are now drying, with reduced rainfall in 2023 is seeing fluctuation and elevated ECs in several mid valley catchments, especially around Inverell where basalt landscapes dominate.

The Border River's catchments are highly geologically variable and have a range of salinity risk. The catchment is highly variable in EC and load across the catchment, with high EC emanating from the Macintyre-Severn Rivers catchment in recent times. The EC stations at Holdfast and Inverell are responding to rainfall and fluctuate in response to flow. Since the start of 2023 there has been a slight upward trend. An increase in cropping on basalt landscapes has occurred which may be a factor.

Pindari Dam has limited capacity for dilution and the EOVT site at Mungindi is impacted by many catchments including the Dumaresq River, Severn Macintyre, and the Weir River and Macintyre Brook catchments in Queensland.

Data from the EOVT site at Mungindi has widely fluctuating EC and a slight upward trend recently as the catchments become drier under recent dry conditions. The two flood periods in November 2021 and November 2022 are evident in discharge data.

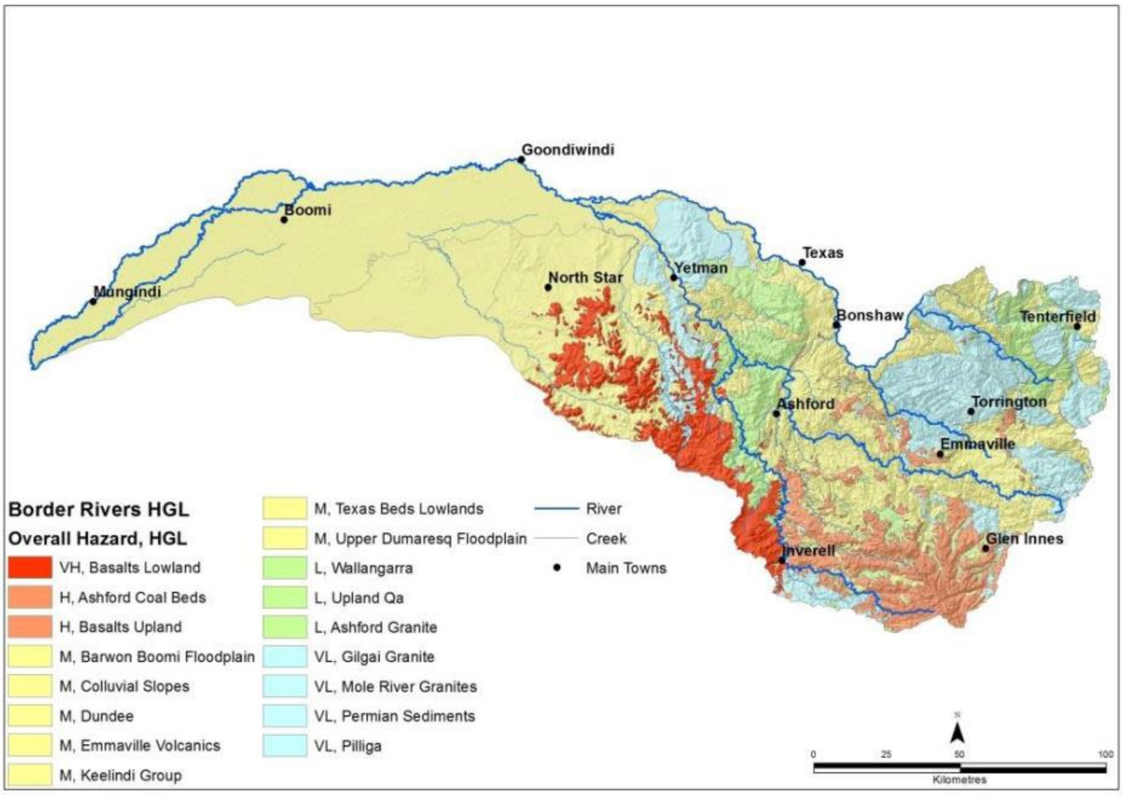

Figure 34: Overall Salinity Hazard for Border Rivers catchment

Exceedance curves

The following graphs show exceedance curves for EC and Salt Load at the EOVT site - 416001-Macintyre River @ Mungindi.

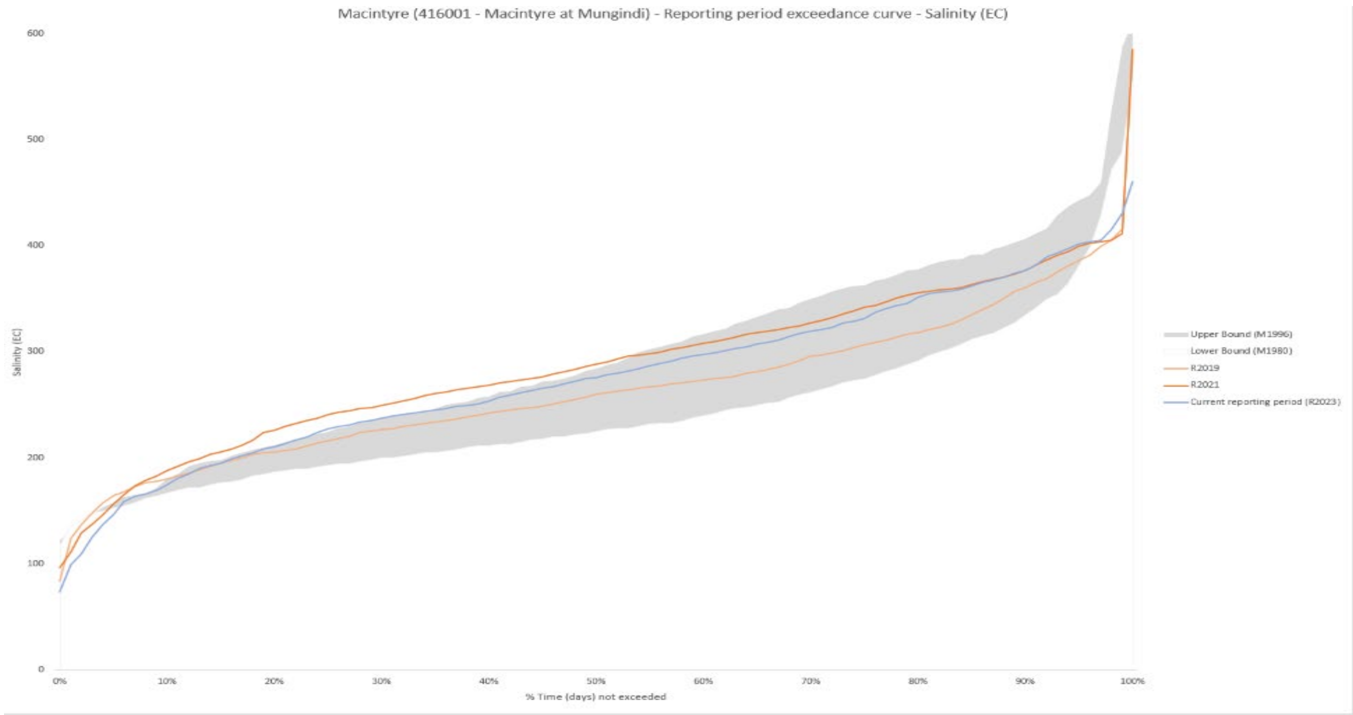

Figure 35: Salinity EC - Exceedance Curves for Macintyre River @ Mungindi (416001) for reporting years 2019, 2021, 2023.

The EC exceedance curve for the current reporting year is within the upper and lower bounds reflecting increased flow conditions (Figure 35). In previous years (2021) there has been higher EC outside the upper bound conditions as the catchments became wetter after drought period.

In the current year, the higher flow and higher EC in flood periods have resulted in higher salt load (Figure 36). This is also due to higher inputs of salt from saline upstream sub-catchments. Previous years indicate less flow closer to lower bounds.

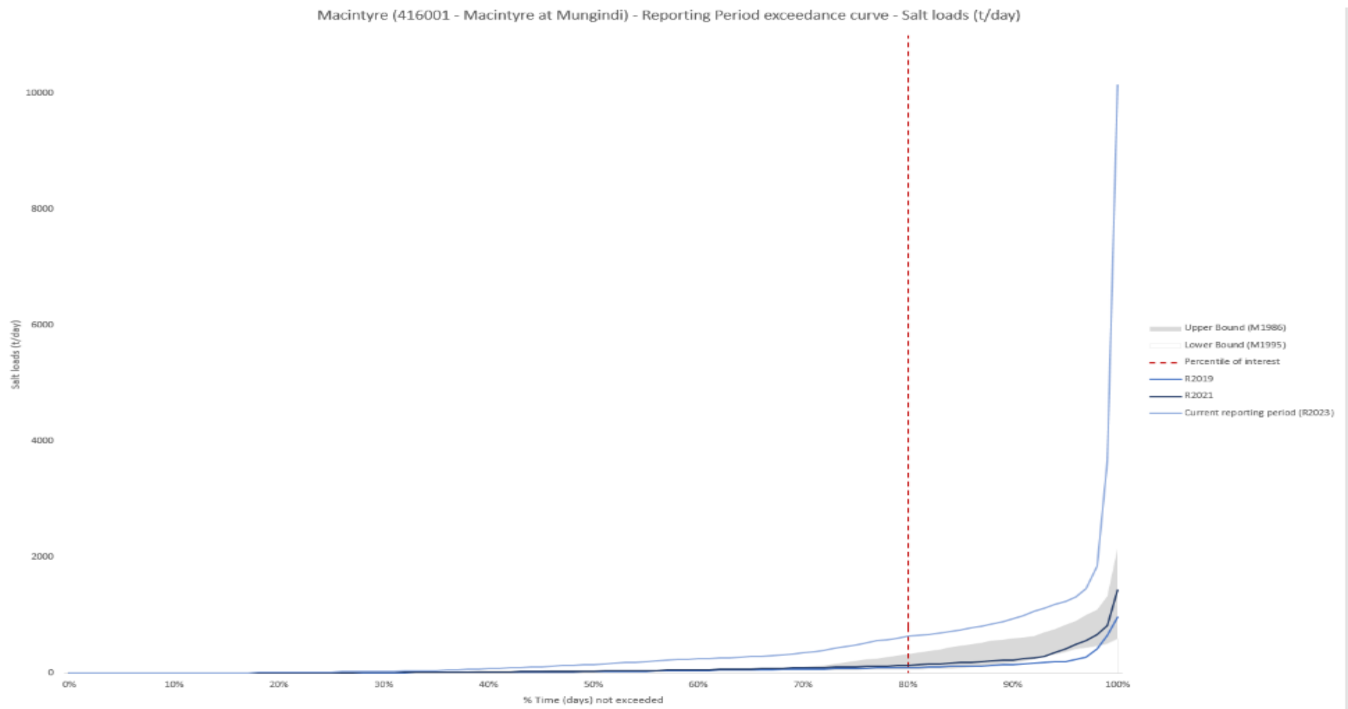

Figure 36: Salt Load - Exceedance Curves for Macintyre River @ Mungindi (416001) for reporting years 2019, 2021, 2023.

Rainfall

The residual mass rainfall graph (Figure 37) for Inverell shows increasing trend from 2020. Catchment rainfall started to increase in November 21 with flooding. November 2021 to March 2022 saw generally good rainfall. A wet period with some floods in September to November 2022 increased flows. The catchment is currently under dry conditions from March 23.

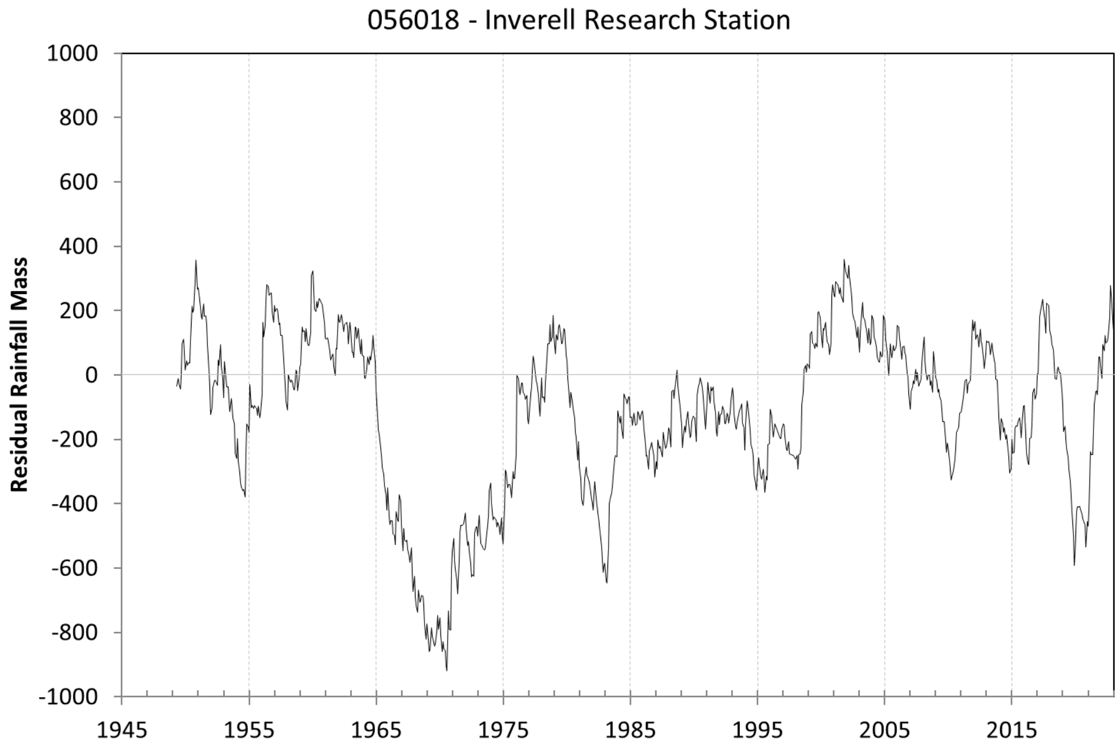

Figure 37: Residual mass rainfall for Inverell Research Station

Barwon-Darling EOVT – 425008 Darling River at Wilcannia (Main Channel)

The Darling River is a major transmitter of water from upstream catchments and is only marginal impacted by local conditions.

Upstream of Bourke, inflows are received from all the major river valleys in the northern Murray Darling Basin, including from the Intersecting Streams, Border Rivers, Gwydir, Namoi and Macquarie and Castlereagh rivers. Downstream of Bourke and further west, the Paroo and Warrego are the only major tributaries that contribute intermittent flows but can provide significant volumes during flood events.

In the reporting period, catchment rainfall started to increase in September 2021 to November 2021 after the millennium drought and major rainfall occurred in September to November 2022.

In the reaches above Wilcannia, the river has responded to local rainfall and flows resulting from rainfall upstream in northern NSW and Queensland. In October to November 2022, flood conditions arose with a depression in EC levels, then an increasing EC trend occurred in all sites at Bourke, Weir 19a and Louth. The flow from upstream catchments, which are wet and the through-flow of near surface is leading to elevated salinities, even after high flow events have receded.

The data for the Darling EOVT site at Wilcannia illustrates the variable flow in the Darling River in the reporting period. Since start of 2023 there has been an increasing EC trend.

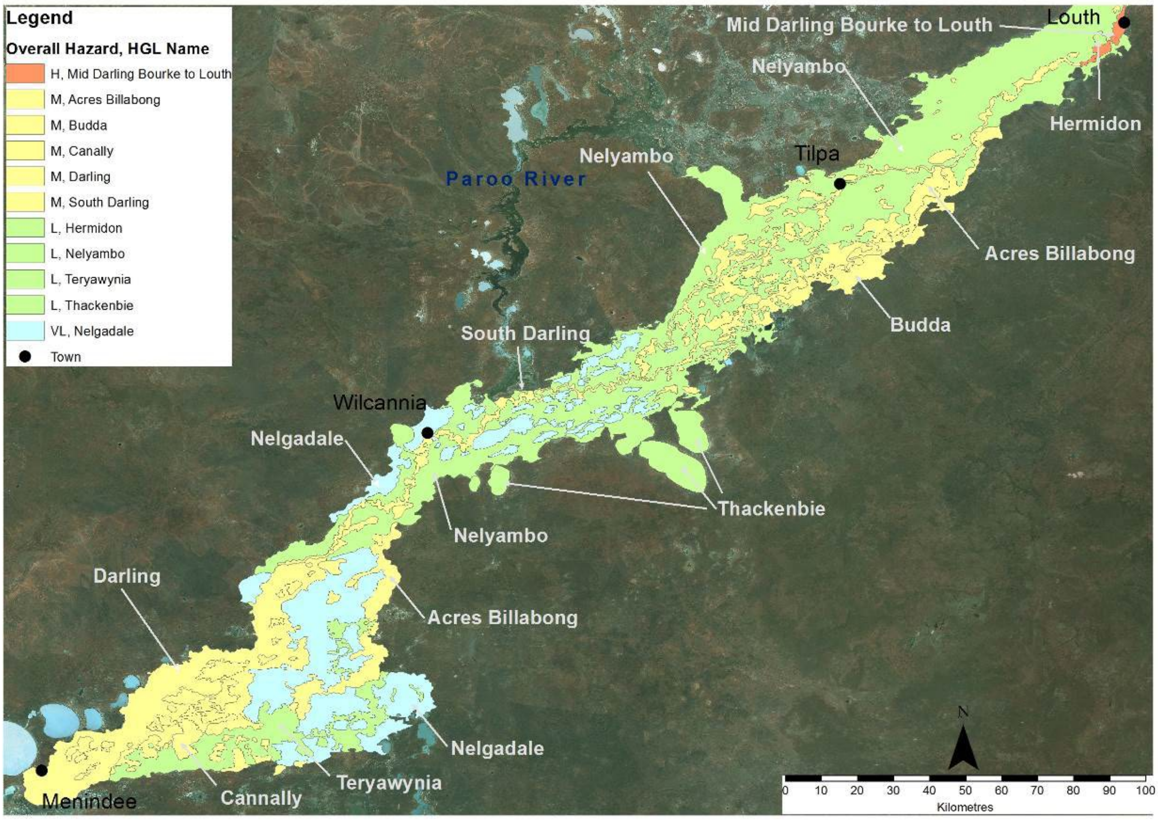

Figure 38: Overall Salinity Hazard for by reach form Mungundi to Wilcannia in the Darling River catchment.

Exceedance curves

The following graphs show exceedance curves for EC and salt load at the EOVT site - 425008- Darling River @ Wilcannia (Main Channel).

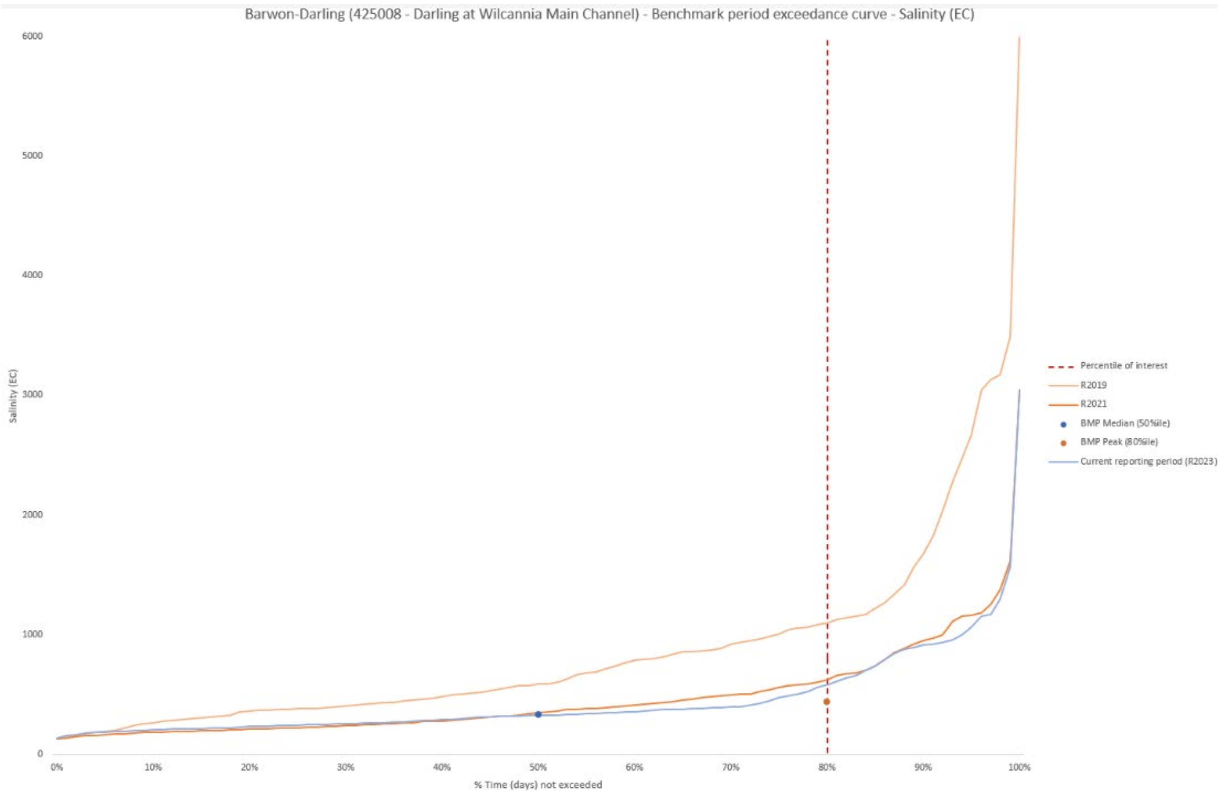

Figure 39: Salinity EC - Exceedance Curves for Darling River @ Wilcannia (425008) for reporting years 2019, 2021, 2023.

The EC in the current reporting year is within the normal bounds increased flow conditions and wet catchments upstream (Figure 39). In previous years there has been flow outside the lower bound conditions.

In the current year, the higher flow and higher EC have resulted in higher salt load (Figure 40). This is due to higher inputs of salt from saline upstream reaches. Previous years indicate less flow closer to lower bounds.

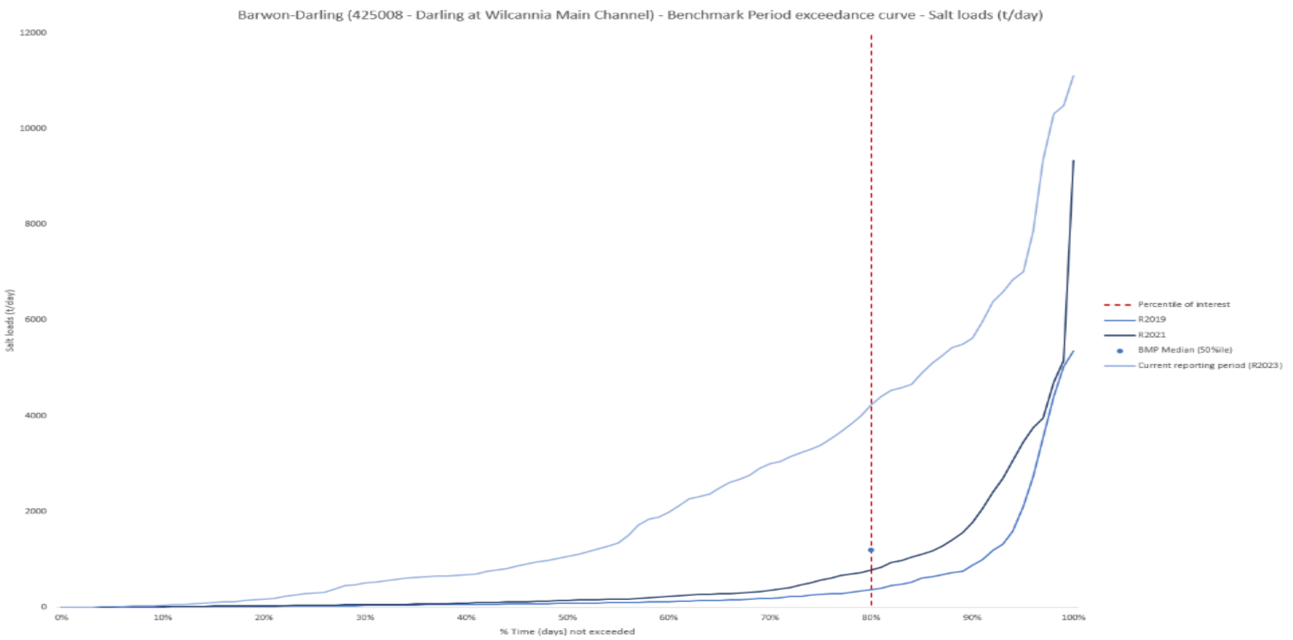

Figure 40: Salt Load - Exceedance Curves for Darling River @ Wilcannia (425008) for reporting years 2019, 2021, 2023.

Rainfall

The residual mass rainfall graph (Figure 41) for Bourke shows increasing trend from 2020. Catchment rainfall started to increase in September 2021 to November 2021 after the millennium drought and major rainfall occurred in September to November 2022.

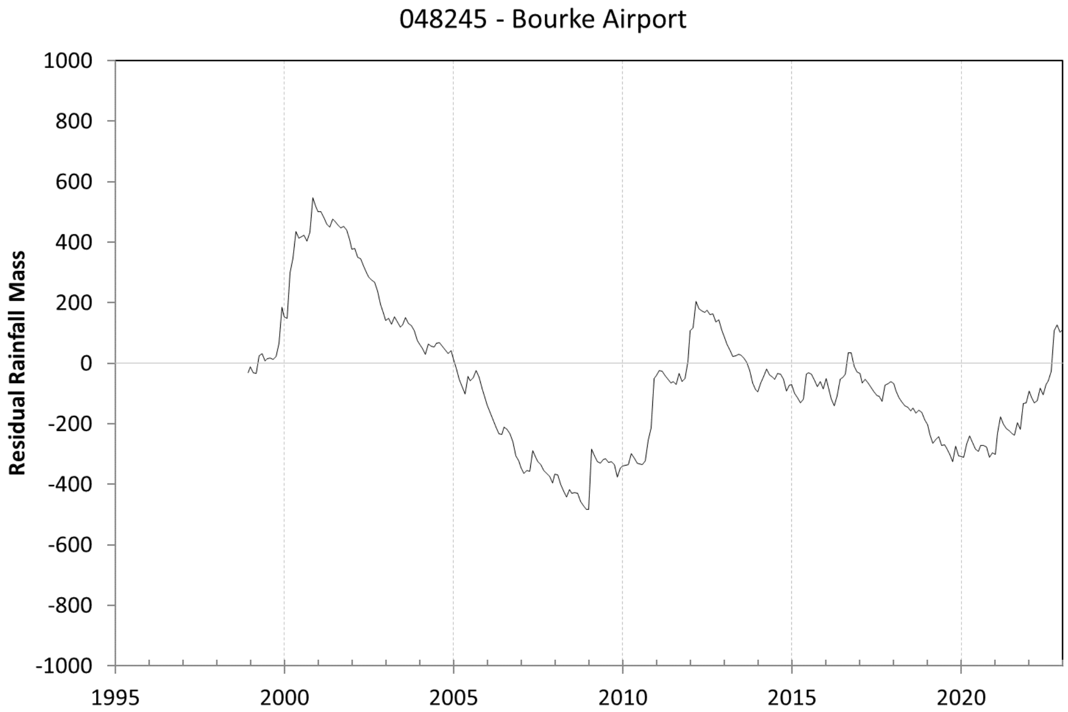

Figure 41: Residual mass rainfall for Bourke Airport

Upper Murray EOVT – 409016 River Murray at Heywoods

The catchment above Hume Dam is the major source of water for the Murray River. The natural flow regime is characterised by high winter/spring flows and low summer/autumn flows resulting from run-off derived from its alpine headwaters and associated tributaries.

The Upper Catchment – Jingellic Creek site is representative of the upper catchment sites with very good quality water from steep, vegetated alpine areas.

The data from the Murray River EOVT site at Heywoods illustrates the volume of water and the good water quality encountered below the Hume Dam. Flood flows were experienced in November 2022.

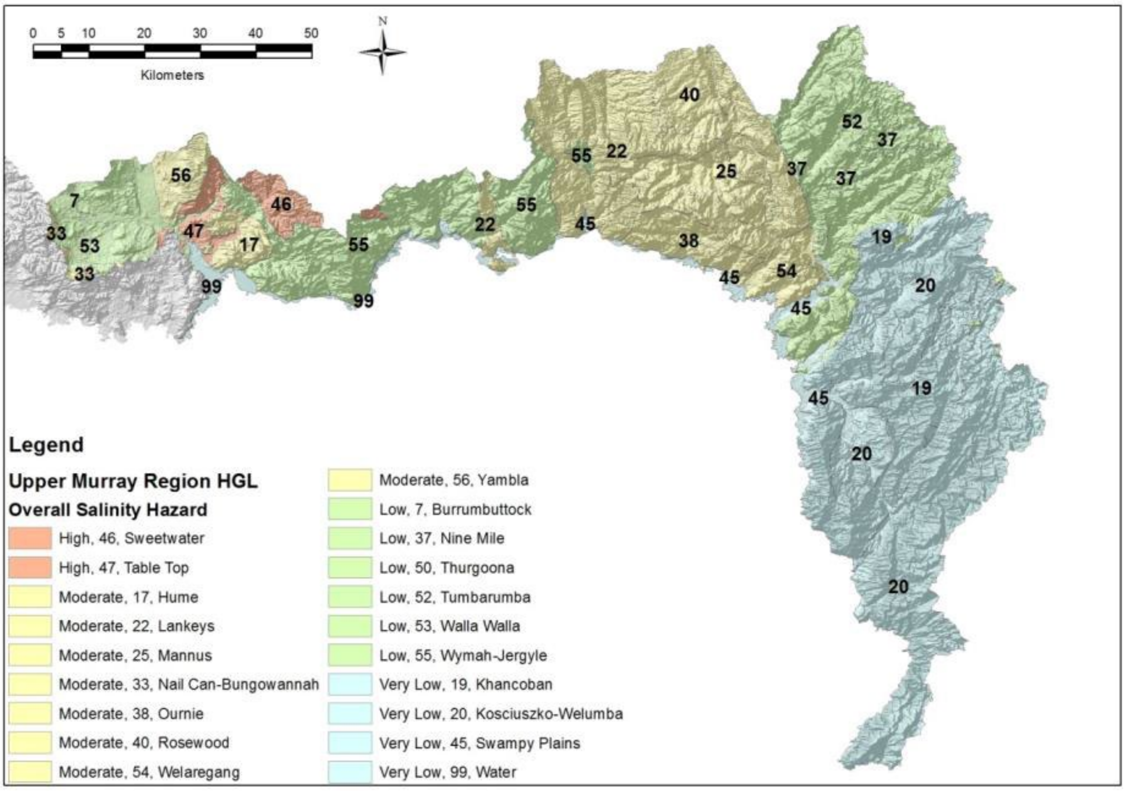

Figure 42: Overall Salinity Hazard for upper Murray River catchment

Exceedance curves

The following graphs show exceedance curves for EC and salt load at the EOVT site - 409016- River Murray @ Heywoods.

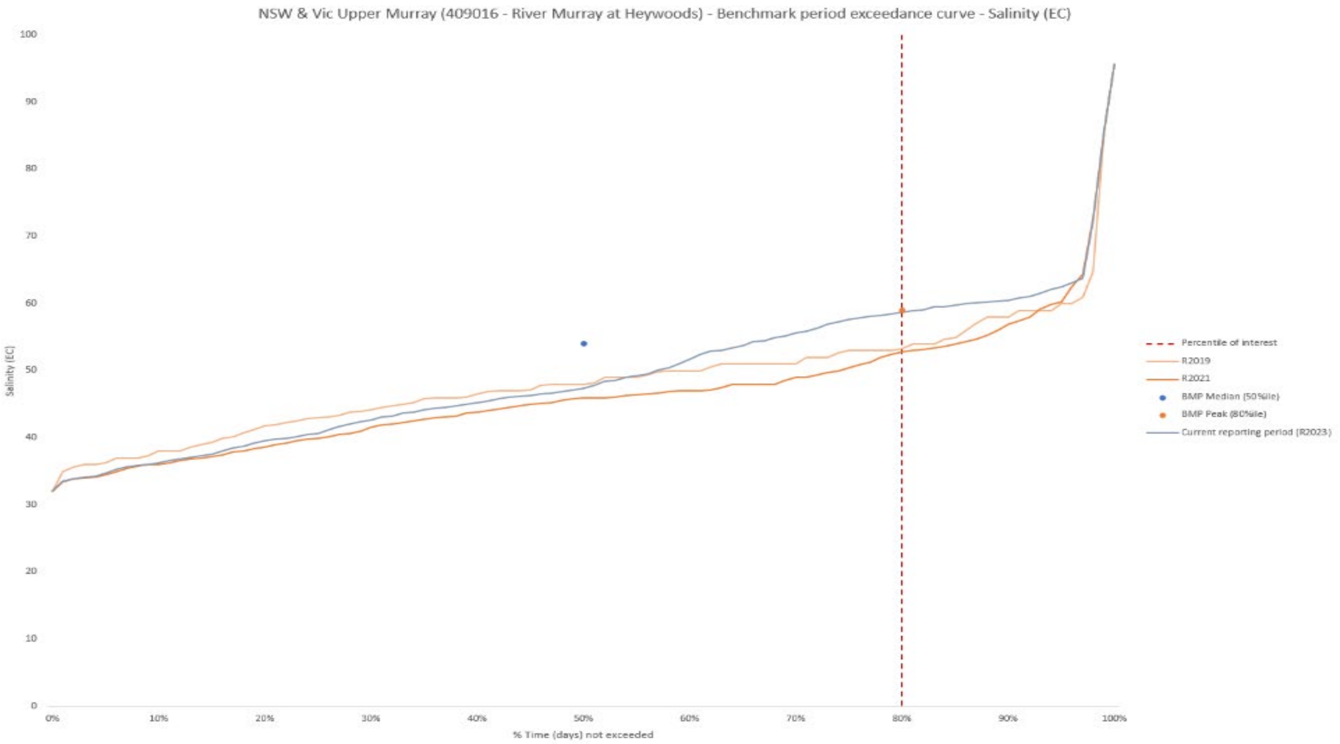

Figure 43: Salinity EC - Exceedance Curves for River Murray @ Heywoods (409016) for reporting years 2019, 2021, 2023.

The EC exceedance curve in the current reporting year is above previous years within the upper and lower bounds reflecting increased flow conditions (Figure 43). In previous years there has been flow within the lower bound conditions.

In the current year, the higher flow and higher EC have resulted in higher salt load (Figure 44). There may be minor input of salt from saline catchments close to the dam where salinity is evident in 2023.

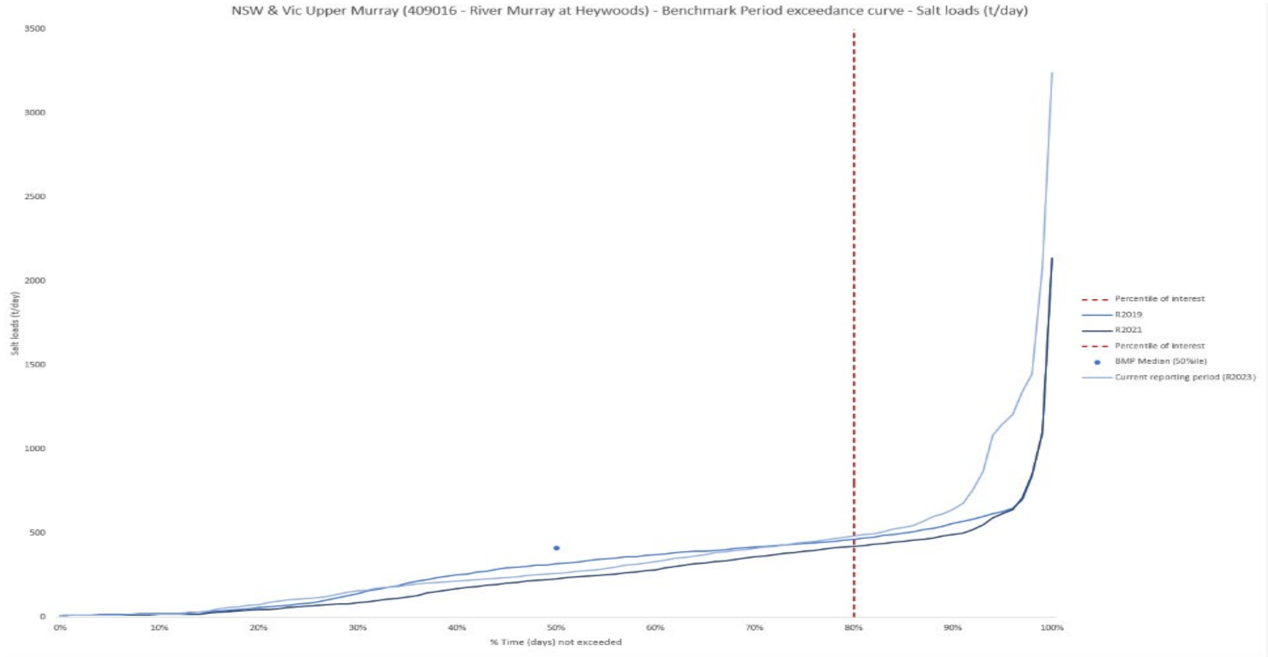

Figure 44: Salt Load - Exceedance Curves for River Murray @ Heywoods (409016) for reporting years 2019, 2021, 2023.

Rainfall

The residual mass rainfall graph (Figure 45) for Albury shows increasing trend from 2020. Catchment rainfall started to increase from July 2021 to January 2022 after millennium drought and increase August to November 22. Higher rainfall in January 2023 was followed by moderate rainfall.

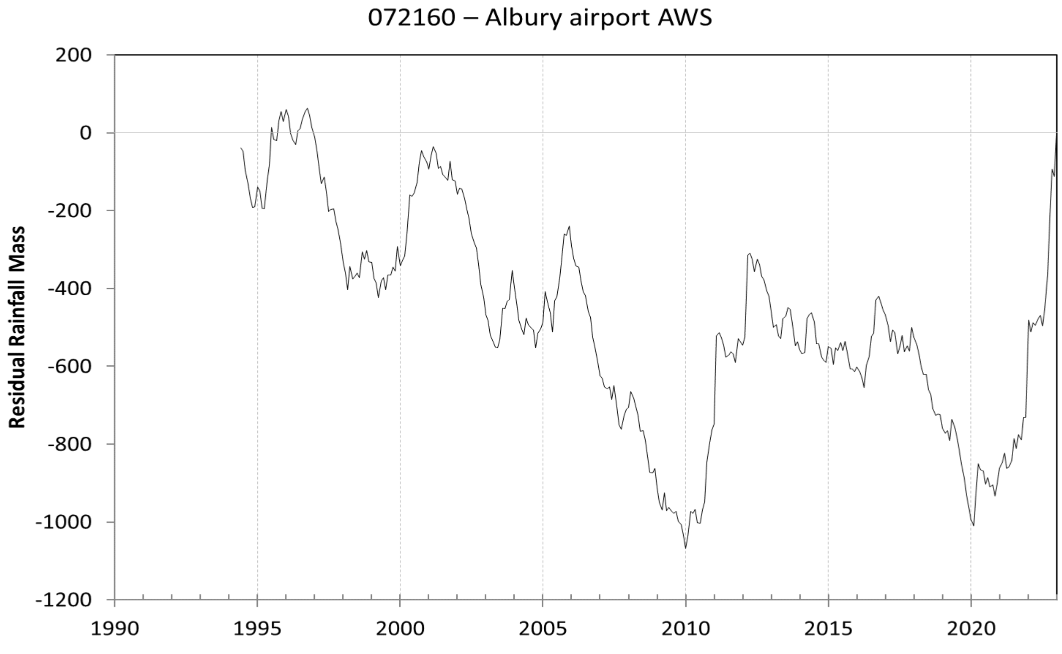

Figure 45: Residual mass rainfall for Albury airport

4. Efficient governance

There has been significant progress during the reporting period to ensure NSW Government's obligations as set out in BSM2030 are met with a particular focus on improving NSW BSM program delivery through:

- implementation of revised BSM Program Plan 2022-2025, with a prioritised program based on an independent evaluation by RMCG (2022) and IAG recommendations (2022) to deliver on BSM2030 commitments within available time and resources
- evaluation of program progress and oversight through regular meetings of the Basin Salinity Management Steering Committee, that includes membership from different business units within the department to provide direction, guidance and support to enable delivery of NSW BSM2030 program
- active participation in the Basin Salinity Management Advisory Panel (BSMAP) and assistance and support for the delivery of multiple interjurisdictional BSM2030 tasks.

BSM Program Plan

In 2021, NSW initiated an independent review of its BSM Program Plan to identify and focus resources to the highest priority tasks based on analysis of reputational, financial and regulatory compliance risks. The independent review was completed by RM Consulting Group (2022) in consultation with the departmental BSM Steering Committee and the MDBA.

A revised program plan to ensure delivery of priority projects by 2025-26 has now been adopted. The MDBA and BSMAP members have been consulted on the new plan with the revised delivery schedule for NSW accountable actions reflected in the BSM2030 Review Plan template.

Under the revised program plan, NSW has focused its efforts on this reporting period to:

- quantify and secure program funding, including development of business case for the highest profile accountable action – Sunraysia irrigation development (1997-2006 and 2007- 2018)
- increase project management capacity to complete register reviews
- progressing initiatives to embed Schedule B obligations across departmental programs and processes.

Internal governance

Implementation of this program is reliant upon maintaining effective governance structures (including the BSM SC), continued engagement on BSM2030 requirements and addressing policy/procedural gaps in the current water management framework. This has been achieved through:

- regular meetings of the Basin Salinity Management Steering Committee have been held with increased participation through RMCG evaluation, scoping of the Sunraysia register review and various projects involving catchment salinity monitoring
- engaging with members of the Basin Salinity Management Steering Committee and other divisions across DPE Water to ensure that water quality risks and actions are included in water plans and strategies and to secure support for the revised BSM Program Plan and identified salinity projects.

Establishing internal project working groups for register reviews and the development of an internal preliminary salinity assessment process for SDLAM infrastructure projects. One of the recommendations from RMCG review was to “develop a clear process for proponents of new land and water management actions to take responsibility for salinity assessments consistent with the polluter pays principle”. This principle could be applied to department led projects (such as SDLAM and state infrastructure projects) and embed a procedure within the project management framework. It could also assist in actioning on another recommendation from the RMCG review, “to transparently evaluate the salinity risks posed by environmental watering of southern basin sites".

Several projects were selected that represented a range of project scales and types that were ready for an initial assessment. The aim was to use these projects to pilot the development of a preliminary salinity assessment procedure that defined steps, roles and responsibilities and escalation process to link other BSM Procedures should an accountable action be identified. The initial results from the preliminary assessment of the SDLAM projects are described in Section 1b and an overview of the procedure scope and development is detailed below. The potential for the procedure to applied to external development projects or supplement the BSM Procedures will be explored in the next reporting period.

NSW Preliminary salinity risk assessment and procedure

BSM Procedures exist to ensure salinity impacts are accounted for once a potential accountable action is identified. However, there is no guidance as to how to undertake the preliminary assessment to determine whether an action has a significant effect. NSW does not have a procedure in place to describe how and when this assessment should happen or who is responsible.

The likely types of projects identified to be in scope of the procedure included:

- environmental watering, such as weir pool manipulation, floodplain inundation or changed flow regime
- new/changed Salt Interception Scheme (SIS) operation
- new dams or changed river operations.

This project used several SDLAM projects as case studies in developing a preliminary assessment procedure for identifying projects that may qualify as ‘accountable actions’ under Schedule B. This procedure can form part of the Departmental Project Management Framework as a guidance tool before BSM Procedures become applicable.

The objectives of the project were:

- to complete a preliminary salinity risk assessment of identified projects
- to develop a BSM preliminary salinity risk assessment procedure for future projects to assess for salinity impact, including responsibilities and linkages to BSM procedures.

The outcomes for the project ensured that:

- Schedule B obligations are met under the WINSW Project Management Framework and Environmental Management Syste.
- salinity impact of new accountable actions are included on BSM Salinity Registers within specified timeframes.

<u>Challenges / Opportunities</u>

Several challenges were faced in the development of this procedure, including ensuring the procedure is commensurate with risk and can be applied to a range of different projects. Other activities that may cause salinity impacts such as new irrigation, or changed irrigation method, changed irrigation return drains, vegetation clearing, new plantations or changes in groundwater extraction may also benefit from the assessment procedure. This project created an opportunity to increase staff and management awareness and understanding of NSW obligations to assess salinity impacts of new activities under Schedule B and clarity responsibilities.

<u>Achievements and Outputs</u>

An initial review of assessment approaches conducted in SA, Victoria and NSW projects completed to date was used to inform the development of a proposal. Feedback from the working group was used to refine and clarify the approach that was then applied to the following SDLAM projects (case studies):

- Locks 8 and 9 Weir Pool Manipulation (initial assessment already completed in 2019)
- Murray and Murrumbidgee National Parks (Yanga / Millewa projects)
- Yanco Creek Offtake Modernisation
- Reconnecting River Country Program – Murrumbidgee River

This assessment also compared the results using this methodology with that already reported for Locks 8 and 9 project in the 2019 assessment as part of the validation process.

By June 2023, the procedure and initial assessments were drafted and circulated to the working group for review. The assessment report and procedure will be finalised in September 2023 and the procedure will then go through a process to integrate it into the Departmental project management frameworks. The procedure will then be evaluated and refined over the next 12 months as the current projects and new projects continue to test its application.

Basin Salinity Management Advisory Panel

BSMAP is an interjurisdictional committee established by the MDBA in 2016 to advise the Authority and the Basin Officials Committee in relation to Basin salinity management including:

- fulfil the requirements set out in the Schedule B
- manage reporting and accountability arrangements contained in the Act
- coordinate the implementation of all aspects of the BSM2030 strategy.

During this reporting period, NSW has been an active participant of BSMAP meetings and has worked with other jurisdictions and the MDBA to implement several BSM2030 tasks, namely:

- assisted in the development/review of BSM Procedures including Risk management procedure, Governance procedure, Catchment salinity procedure and new EOV target reporting methodology, process for review of EOVTs, the consolidated procedure document and issues log
- presentation at the 2021 virtual Salinity Forum
- participation in BSM2030 knowledge priority projects, such as Floodplain Body of Knowledge working group and provision of resources for draft webpage
- input to development of the BSM2030 Roadmap and annual Workplan
- Participation in the steering committee for the review into the salinity cost function
- input into the proposed scope for the review of Basin Plan salt export objective and other select Basin plan salinity targets, including Burtundy
- participation as a steering committee member on South Australian register reviews and Sunraysia Model upgrade project.

In addition, NSW has participated as a member of the interjurisdictional Technical Working Group for Salinity Modelling to assist with the transition from the current MSM-BIGMOD to the Source modelling platform, the Salinity Interception Technical Working Group to advise on efficient operation to achieve basin salinity targets; and the Water Quality Taskforce to workshop the review of Murray-Darling Basin water quality targets.

a. Basin-wide Core Salinity Monitoring Network

The BSM2030 Strategy has made a commitment to the operation, maintenance and reporting of key salinity monitoring sites. Collectively, these sites form the Basin-wide Core Salinity Monitoring Network provide critical information that:

- underpins groundwater and surface water models,
- informs Accountable Action reviews and delayed salinity impacts,
- supports river operations, SIS and environmental flow management, and,
- enables an evaluation of outcomes at End-of-Valley Target (EOVT) and Basin Plan reporting sites.

In December 2019, NSW nominated 236 surface water and 614 groundwater sites for inclusion onto the core salinity monitoring network. As part of this process, a further 85 sites were identified as priorities; however, some of these are currently not active and/or unfunded. Work has progressed to reactivate these sites.

In the last reporting period, NSW has progressed the work to improve the salinity monitoring network including:

State-wide groundwater sampling program (2021)

The Statewide Groundwater Sampling Program sampled 588 bores at 332 locations across NSW, in three data sweeps (February, April, May 2021). This exercise is the first of its kind in Australia and will provide some 150,000 data points into the WaterNSW dataset.

The dataset, including a dedicated sampling program with height, EC and analytes, is subjected to a rigorous Quality Assurance process.

The legacy of this investment has led to:

- groundwater management framework being actively initiated within the NSW Water Strategy and the NSW Groundwater Strategy. The NSW Groundwater Strategy provides strategic direction on the key challenges and opportunities facing groundwater management over the next 30 years. Funding is being sought to address groundwater issues identified.
- a program of targeted monitoring at key areas including SIS sites and within Land and Water Management Plan areas for Register Reviews.
- recommendations from departmental hydrogeologists to incorporate new co-funded sites at Upper Darling SIS as part of investigations of the Darling AEM project being undertaken by Geoscience Australia.

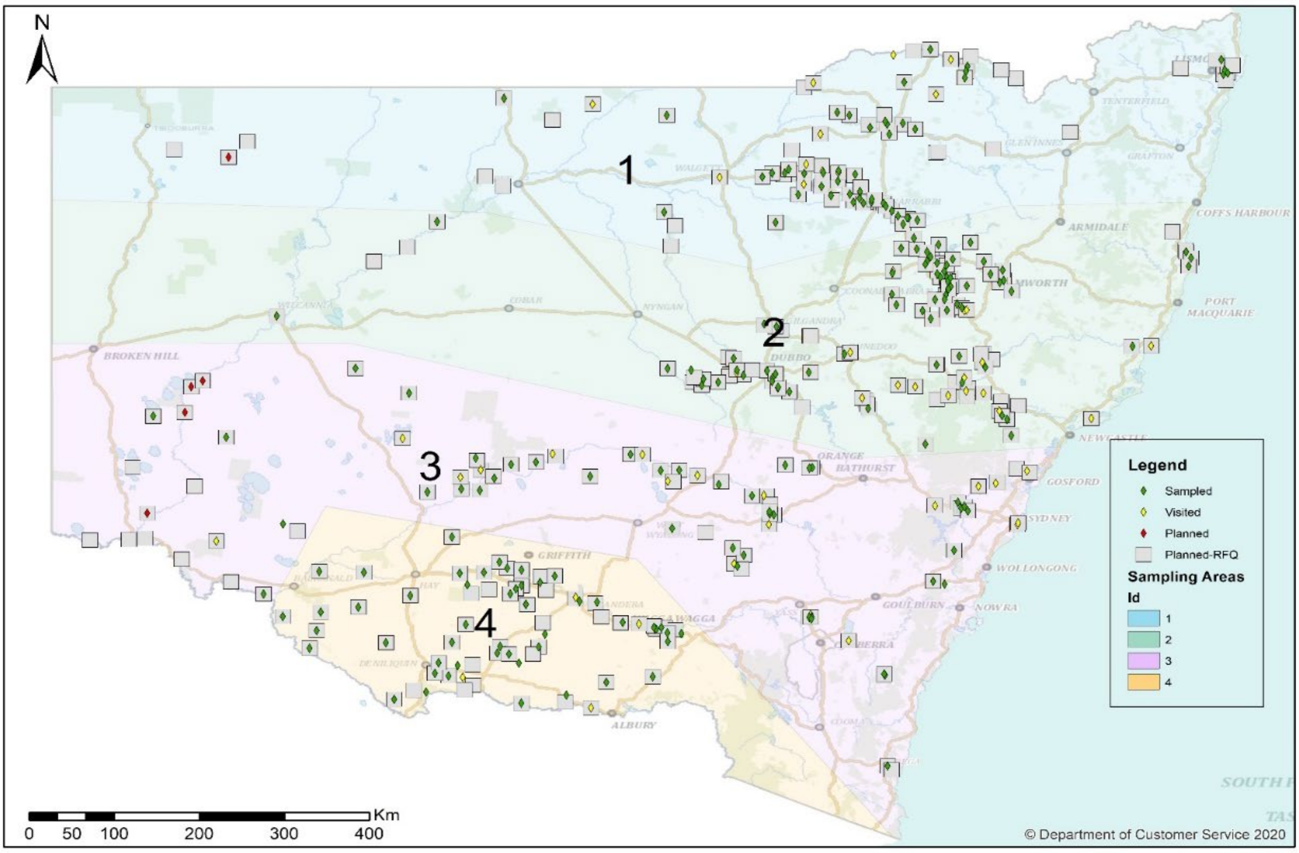

Figure 46: DPE Water – State-wide Groundwater Water Quality Sampling Program (2021)

Hydrometric review

DPE Water and Water NSW have implemented outcomes of 2021 review of operating licences and service deeds, including sites monitored for the purposes of salinity/water quality, environmental watering activities and modelling requirements.

In 2022-23, recommendations were put forward for the inclusion of additional EC monitoring sites (in Namoi and Gwydir catchments) as well as to reactivate several other sites. This was part of a multiple use strategy. Several sites in the Darling River were upgraded as part of a dissolved oxygen implementation program.

b. NSW accountable action (register) reviews

In response to the IAG-Salinity 2021 and previous audit outcomes, DPE Water commissioned an independent evaluation of progress against the BSM program plan by RMCG (2022). The report found that NSW was successfully delivering on some key responsibilities but with major risk of critical slippage in high-profile accountable actions under the BSM2030 strategy due to resourcing constraints. NSW adopted the report's recommendations to prioritise the completion of outstanding register entries according to their credit/debit value to maximise the likelihood of a realistic Register balance by 2025/26.

Currently there are 13 outstanding (NSW led) Register and 3 model reviews, noting that:

- register entry reviews for the NSW Reduced Irrigation Salinity Impact (RISI) Stage 1 and Stage 2, Improved Buronga SIS, Improved Buronga Mildura-Merbein SIS and Mallee Cliffs SIS were completed in 2022 as part of the MDBA led Sunraysia EM2 Model Refinement project.
- Upper Darling Salt Interception Scheme (SIS) review was completed 2023.

- Murray Land and Water Management Plan (LWMP) review is in progress and due to be completed in 2024.
- Sunraysia Irrigation Development (1997-2006) and provisional entry for Sunraysia Irrigation Development (2007- 2018) is in progress and due to be completed in 2025.

The remainder of the reviews have been staggered based on their inherent risk profile, existing internal priorities and concurrent knowledge priority work. As a result:

- the Pindari Dam Enlargement review has been assigned as next priority following completion of the current register reviews. Due to commence 2024/25.
- the Boggabilla Weir, Murrumbidgee (70), Darling Catchment (62-68) and Lachlan (69) Legacy of History Register Entries will be completed post-priority one and two reviews as they are considered of lower risk when compared to other Register Entries (cumulatively they equate to <0.5EC debit on Register B). Note: these reviews are required once within a 10-year period.

NSW has advised the MDBA and partner governments through BSMAP of the revised delivery plan.

Table 10: Changes to and status of BSM2030 NSW Register reviews in 2022/23.

Register Entry	Last review year	BOC[6] agreed review year	Revised review date	Status update
RISI Stage 1	2022	2022		Complete
RISI Stage 2	2014	2021	2021	Complete
Improved Buronga SIS	2006 (2013 not finalised)	2021	2021	Complete
Improved Buronga Mildura-Merbein SIS	2005	2021	2021	Complete
Mallee Cliffs SIS	2013	2021	2022	Complete
Sunraysia Irrigation Development 1997-2006	2007	2021	2025	Commenced – in combination with post-2006 (to 2018) irrigation development provisional register entry
Lachlan Legacy of History	2010	2022	2026	Delay
Murrumbidgee Catchment Legacy of History	2010	2022	2025	Delay
Murray LWMP	2010	2020	2024	In progress
Darling Catchment Legacy of History - Macquarie, Macintyre, Gil Gil Ck, Gwydir, Namoi, Castlereagh and Bogan	2010	2022	2026	Delay
Boggabilla Weir	2007	2021	2026	Delay
Pindari Dam enlargement	2007	2021	2026	Delay

6 The Basin Officials Committee agreed review year is the year in which the outcomes from the review of register entries will be brought onto the MDBA Salinity Register. For models and outcomes at EoVT sites, the review date is the year in which the review will be completed

Register Entry	Last review year	BOC[6] agreed review year	Revised review date	Status update
Upper Darling SIS	2014	2019	2022	Complete
Permanent Trade Accounting Adjustment - NSW to SA, NSW to Victoria	2006	2020	2023	MDBA led review - to align with the new MDBA River Source Model
Tandou pumps from Lower Darling	2005	2017	2023	MDBA led review - to align with the new MDBA River Source Model
Changes to Edward-Wakool and Escapes	2005	2017	2023	MDBA led review - to align with the new MDBA River Source Model
Salinity & Drainage Strategy Commitment Adjustment		2020		MDBA led - to align with the new MDBA River Source Model, a once-off adjustment does not require review

Improved Buronga SIS, Improved Buronga Mildura-Merbein SIS, Mallee Cliffs SIS, Reduced Irrigation Salinity Impact (RISI) Stage 1 and Stage 2 - Sunraysia Model (EM2) upgrade project

CDM Smith were engaged by the MDBA to refine and upgrade the Sunraysia groundwater model, otherwise known as the Eastern Mallee Series 2 model (EM2) to be used for the assessment of:

- baseline Salt Interception Schemes (SISs) - Mildura-Merbein (MM) SIS and Buronga SIS
- Register A Actions - Improved Buronga and MM SIS (Salinity and Drainage Upgrade -1990); Mallee Cliffs SIS (1994); Improved Buronga SIS (2005); and NSW and VIC Stage 1 and 2 Reduced Irrigation Salinity Impact (RISI) credit claims.

The project was overseen by a Project Steering Committee of which NSW was a member and concluded in 2022 with the salinity registers updated the same year.

The main changes to register entries due to the review were:

- the revised salinity benefit of the SIS and RISI actions is reflective of lower salt load compared to previous assessments
- significant reduction in the benefits linked to the Mallee Cliffs SIS implementation (1994) due to a new calibration process implemented in EM2.6, which used the BIGMOD unaccounted salt loads as a calibration target, causing some model parameters to be altered from previous model version (EM2.3)
- slightly higher benefit associated with the Improved Buronga SIS (2005) due to the reduced efficiency of the MM SIS resulting in additional groundwater to be intercepted
- significant reduction in NSW RISI benefit due to a new partitioning method and a new method to estimate future irrigation recharge rates

The relative change in EC and salinity benefit attributed to NSW share of register actions because of the review is summarised in Table 11. In total, there was a reduction in NSW credit of 4.49 EC.

Table 11: Changes to NSW Register balance as a result of Sunraysia Model (EM2) upgrade project

Register Action	Change in average EC at Morgan[7]	Change in salinity benefit ($m/yr.)
Improved Buronga and MM SIS	-0.23	0.04
Mallee Cliffs SIS	1.2	-0.24
Improved Buronga SIS	-0.06	0.01
MM refurbishment	-0.13	0.02
RISI NSW	3.7	-0.83
Total Register A	**4.49**	**-1.00**
Improve Buronga SIS		0.004
MM refurbishment		0.012
Total Register B		**0.017**

Murray Land and Water Management Plan (LWMP)

LWMPs were developed in 1995 for the NSW Murray Irrigation Districts: Wakool, Denimein, Cadell and Berriquin. It includes groundwater pumping, sealing supply channels, and improving on-farm management and surface drainage. The new drains have been designed as shallow so that they would not intercept the groundwater table. The spatial model is being used to model change in the depth to the water table over time due to these initiatives. Using a grid GIS approach with 500 metre cell size, the model allows assumptions to be made about the effect of other changes on the depth to groundwater and the volume of salt mobilised.

This salinity register entry has been assigned a high confidence rating, equating to a credit of 4.0EC.

As a precursor to the review, RMCG developed a workplan that considered BSM2030 guiding principles, BSM procedures, NSW policies and past reviews, including any Independent Peer Reviewer (IPR)/ IAG-Salinity recommendations.

[7] Positive EC values (in red) means an increase (from 2021 to 2022) in average river salinity which results in a reduction (negative value) of salinity benefits ($m/yr.).

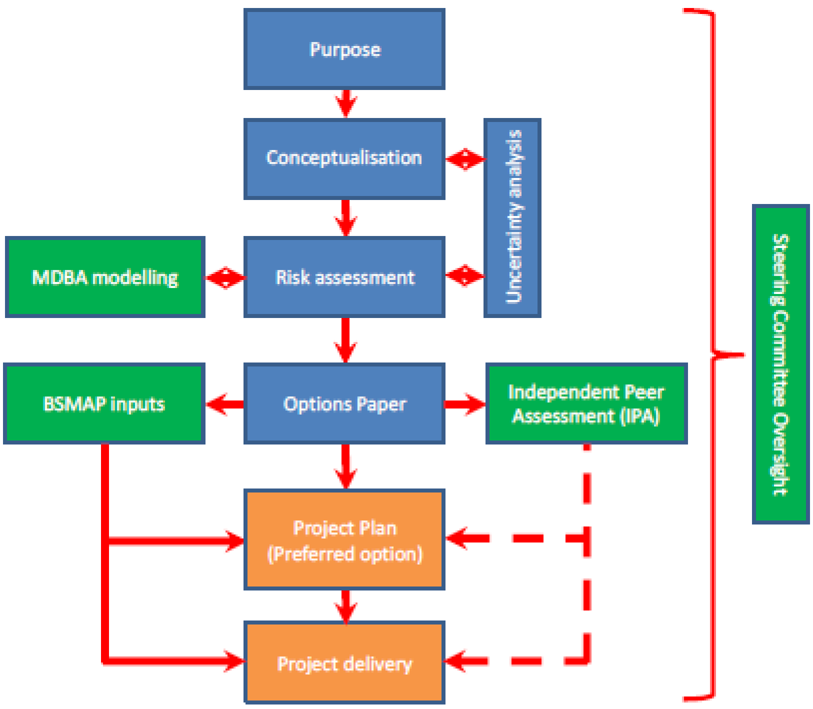

Figure 47: Murray LWMP workplan steps.

The risk assessment and model conceptualisation were completed in the previous reporting period.

The development of an 'options paper', wherein the pros and cons of different modelling approaches would be outlined with a rationale provided for the preferred approach (applying BSM2030 Guiding Principles), has been progressed during this reporting period. In the report, the existing model will be compared to an empirical approach, such as that applied to the Barr Creek Catchment Strategy review.

Initial feedback from the Independent Peer Assessor on the risk assessment identified several issues that needed to be addressed regarding evaluation of an empirical approach and existing numerical model (MIKE SHE).

Additional work has been completed in the current period to better describe the three options: empirical method, upgraded status quo or new model package, and to resolve the discrepancy between MIKE SHE model and original model results from salinity assessment report. A report evaluating a proposed empirical approach, such as that used for the Barr Creek Catchment Strategy has also been completed of input to the Methods report.

The anticipated completion date for this review is 2024.

Upper Darling SIS

The Upper Darling SIS is located approximately 35 km southwest of Bourke. It consists of five submersible pumps that intercept saline groundwater entering the Darling River. The pumps are connected to a disposal pipeline which carries the intercepted saline groundwater nine kilometres to the southeast to a disposal basin in the Jandra depression. The disposal basin is designed to function as an evaporative concentration and re-injection basin and consists of four evaporation bays and an enhanced leakage pit.

The Upper Darling SIS was declared effective in 2014. This scheme is a joint works and measure, with salinity credits shared between VIC, NSW, SA and the Commonwealth.

This Register review consisted of two components: 1) the scheme performance review; and 2) the salinity impact assessment. An external consultant was engaged early 2019 to complete the performance review and estimate of salinity benefit. A second review was completed in 2020 by DPE Water using a different methodology, with very similar results. An evaluation of both reviews was completed in late 2021 by RMCG with salinity impacts (benefits) of the scheme determined to be an average of 50 t/day. It was recommended that the register entry be assigned a low confidence rating due to the lack of available and accurate data as well as the uncertainty of the technical assessment. It was also recommended that a hybrid methodology be used in future assessments, instead of developing a groundwater model due to the considerable investment required. Using empirical and analytical assessment of the groundwater, climatic data sets and other surface water monitoring/IQQM simulation data would provide a broader range of evidence and facilitate moderation of the surface water mass balance estimate, enabling transition towards a higher confidence ranking for a future register entry.

In 2022, Cooke's Consulting Services were engaged to review the Barwon – Darling Salinity IQQM, update changes in salt load inflows using the estimate of benefit from RMCG review and produce daily time series of flow and salt load at end-of-system with and without SIS. The salt load estimates determined by the IQQM were used to provide a preliminary estimate of salinity effect in the River Murray at Morgan of 3.9EC credit. The salinity register entry will be formally updated in October 2023 to replace the current credit of 4.5 EC.

NSW are proposing changes to improve the SIS monitoring network in response to AEM data survey led by Geoscience Australia and the internal review, with additional bores proposed to improve the relevance of the monitoring network. Other recommended areas for improvement include instream monitoring, greater understanding of instream processes, adoption of Source model and audit of the data from the four in stream monitoring sites that to improve the accuracy of future analysis.

Sunraysia Irrigation Development 1997-2006 and (provisional) 2007-2018

The Sunraysia irrigation development (1997-2006) register entry reflects the salinity impacts of additional irrigation occurring in the region between 1997 and 2006. The salinity impacts of 23 individual trades, assumed to have taken place between 1997 and 2003, and another 6 individual trades, between 2003 and 2006, were estimated using SIMRAT and entered on Register A in 2007. Salinity register entry has been assigned a high confidence rating: 3 EC (debit).

The 2017-2019 IAG-Salinity recommended that the MDBA add a provisional register entry of 6 EC debit to account for an estimated 5,800 ha of irrigation development that has occurred in the NSW Sunraysia region since 2007. A follow up SIMRAT analysis estimated a salinity impact of between 1.5 and 4.7 EC by 2100 at Morgan, based on the estimated area of persistent planting that had been created in the period since 2006. Considering the data uncertainties and the available information, at the time it was recommended that a value of 3.3 EC for the period 2006-2018 be adopted for a provisional register entry. This was based on 4,536 ha of new persistent irrigation development since 2007.

BSMAP meeting 46 (August 2020), a new NSW Sunraysia irrigation development 2006 to 2018 register entry of 3.7 EC at 2020 (debit) was endorsed as provisional. NSW also confirmed its intention to combine the pre and post 2006 register entries at the next review.

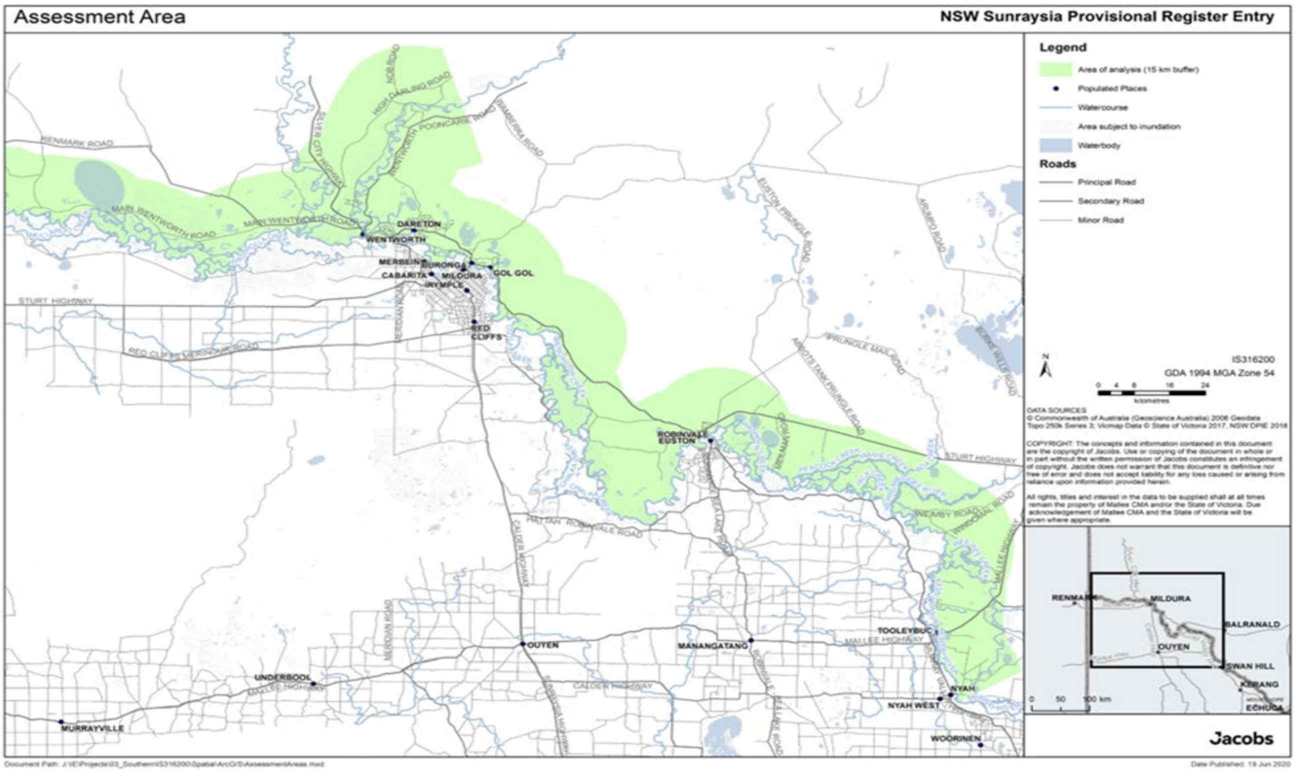

Figure 48: Extent of the combined NSW Sunraysia irrigation development (1997-2018) assessment area

In 2022, an initial investigation into potential methods to complete the combined assessment resulted in a work program detailing information needs, delivery phases and resourcing estimate. This included a review of method and outcomes from the Sunraysia (EM2) Model Upgrade project and the identification of early priorities for NSW to commence addressing knowledge gaps.

Significant progress has been made to deliver on phase 1 (investment case), phase 2 (data inputs) and initiate phase 3 (modelling) during this reporting period including:

- finalisation of investment case and funding approval
- extraction of remote sensing and clustering data of annual irrigation footprints
- development of detailed project plan, schedule and resourcing needs
- investigation into irrigation efficiency and recharge rates assessment
- drafting of technical specifications.

Establishment of project governance, data review, conceptualisation and model development will be the focus for 2023/24. The completion date for this review is June 2025.

c. NSW response to 2019 – 2021 IAG-Salinity Audit recommendations

NSW responses to the previous IAG-Salinity audit (2019-21) were formally submitted to the MDBA in January 2022. A current update on progress/actions undertaken to address all outstanding IAG-Salinity recommendations is included in Table 12.

Table 12: NSW response to the IAG-Salinity audit recommendations and update on progress.

Recommendations from the 2019-2021 Audit	NSW response (2021)	Updated response (2023)
Recommendation 1: The IAG-Salinity recommends that work be accelerated to: *a) review the provisional entries for the TLM works and measures* *b) clarify whether the salinity effects of SDLAM projects are to be a single entry or separate entries for each site* *c) ensure there is a line of sight between the salinity effects of individual actions and the cumulative effects of the TLM and SDLAM programs* *d) update the workplans to include provisional entries for SDLAM projects by the end of 2024*	NSW supports this recommendation given the number of current Register entries relating to environmental water delivery and with SDLAM projects coming on-line. Collaboration between environmental water holders, the Commonwealth and State Contracting Governments is required to ensure a consistent and transparent approach to managing and accounting for salinity impacts not only at the site scale but also in understanding the cumulative impact. NSW would welcome further discussion to develop a consistent approach to representing SDLAM register entries to both manage the number of entries and the assessment of salinity effects.	NSW supports this recommendation given the number of current Register entries relating to environmental water delivery with several SDLAM projects coming on-line. NSW has progressed with preliminary assessment of selected accelerated SDLAM projects and developed a procedure for projects to individually assess impact and record findings – whether accountable or not. This will enable consideration of cumulative impacts and interactions between projects. NSW workplans include assessments for upcoming SDLAM projects as the projects mature.
Recommendation 2: The IAG-Salinity recommends that: a) *the draft procedures be finalised by the end of 2022 (complete)* *b) the review clause in the BSM Procedures be updated by the end of 2022 to require annual endorsement by BSMAP of the BSM Procedures and reviews after experience in applying the BSM Procedure indicates that significant changes are needed (complete)* *c) the BSM Procedure "Developing the Review Plan" be updated by the end of 2022 to ensure that authorised works or measures that are within the baseline are included within the Review Plan (underway)*	NSW supports this recommendation. The development of BSM Procedures has greatly helped clarify roles and requirements, but improvements could be made to improve readability and integrate learnings since they were first developed. However, the review process and frequency of review needs to be proportionate to the time required to complete the review and approval process. NSW would welcome further discussion on how to balance formal review process with other adaptive management mechanisms to keep the BSM Procedures current.	NSW continues to support this recommendation. The finalisation and collation of all BSM procedures (except modelling) have greatly assisted with reading and maintaining a controlled version. NSW has had input to review and finalisation of the risk assessment, review and EOVT/reporting procedures and consolidated procedures. NSW supports publication of these procedures to increase transparency and access by stakeholders and delivery partners. Ongoing discussion at BSMAP on the role of IPA and certification process.

Recommendations from the 2019-2021 Audit	NSW response (2021)	Updated response (2023)
Recommendation 3: The IAG-Salinity recommends that a Basin salinity management risk management procedure be developed when the draft risk management framework is finalised (complete)	NSW supports the development of a comprehensive risk management framework for BSM2030 that includes a risk management procedure. This will provide further clarity and transparency around investment decisions at the Basin-scale and provide consistent guidance to contracting governments on how manage BSM responsibilities, steps and timelines with their own risk management processes.	Complete NSW participated in the development of a comprehensive risk management framework for BSM2030, complementary to the NSW risk management framework, and the development and review of the risk management procedure. NSW highest program delivery risks have been included on the BSM register and will be reviewed in line with new procedure
Recommendation 4: The IAG-Salinity recommends that: *a) direct KPIs (e.g., groundwater levels at designated monitoring sites) should be consistently prepared and applied for all schemes that both align with Register entries and provide operators with the flexibility to optimise operations (underway)* *b) State Constructing Authorities include the SISs in modern asset management systems and that budgets with five-year expenditure outlooks be developed by the next audit (underway)* *c) MDBA work with the South Australian State Constructing Authority to review the Rufus River SIS by 2025 and with BSMAP to consider implications for the Register in advance of the BSM2030 review (outstanding)* *d) MDBA RMO provide an annual briefing to BSMAP about the performance of the SISs (complete)*	NSW is supportive of initiatives that can provide operators with flexibility to optimise SIS operations including the adoption of KPIs to better inform operational decision making and strategic investment. NSW is supportive of improving the asset management and planning of its SISs. However, this represents a significant piece of work that will need to be managed within available resources. NSW is supportive of the recommendation for RMO to provide an annual briefing to BSMAP to improve the exchange of information between SIS operators and others involved in salinity management. Heavily impacted by flood. Viability needed to be explored in modern system	NSW are looking to develop scheme-specific KPIs this year following a review of the groundwater monitoring network. The Responsive Management Trial will further inform applicable KPIs and is due for completion 2025/26. NSW Joint Venture SIS Asset Register and Asset Management Plans have been developed (2023) and sets out financial projections and requirements until 2031/32. Review of the Rufus River SIS has been included on the NSW Review plan with a due date of 2025. NSW supports the review to evaluate the value/ benefit of the scheme; however, resourcing still needs to be agreed by NSW, SA and MDBA.

Recommendations from the 2019-2021 Audit	NSW response (2021)	Updated response (2023)
Recommendation 5: The IAG-Salinity recommends the MDBA: *a) use MSM BigMod to prepare the 2022 Salinity Registers* *b) progress the salinity functionality of Source so that it can produce "shadow" Register entries for 2022 to enable policy issues to be identified and resolved* *c) reactivate the Technical Working Group for Salinity Modelling with surface water modelling experts from the States as a matter of priority to build confidence in the Source model* *d) adopt Source outputs for the 2023 Registers*	NSW supports this recommendation. Further time is required to improve confidence in the ability of Source to model salinity impacts of accountable actions, gain accreditation and for BSMAP to resolve any policy issues. Although there has been delay with development, NSW sees it as critical that Source is able to accurately represent not just current register entries but also environmental watering actions. Testing the model against 2022 register entries will hopefully help identify any issues early and prevent any further delay in its adoption. NSW will continue to participate on the Technical Working Group for Salinity Modelling and given the breadth of salinity modelling issues, supports this recommendation. This Group provides a platform for technical issues to be discussed and resolved (where practicable) enabling improved transparency and consistency, whilst also fostering positive working relationships between the MDBA and Contracting Governments.	NSW supports this recommendation. Further time is required to improve confidence in the ability of Source to model salinity impacts of accountable actions, gain accreditation and for BSMAP to resolve any policy issues. Although there has been delays with development, NSW sees it as critical that Source is able to accurately represent not just current register entries but also environmental watering actions. NSW will continue to participate on the Technical Working Group for Salinity Modelling with a focus on the successful adoption of the Source model.

Recommendations from the 2019-2021 Audit	NSW response (2021)	Updated response (2023)
Recommendation 6: The IAG-Salinity recommends that: *a) the Source model be functional by 2022 to support reviews of register entries relating to river operations and environmental water* *b) the MDBA and Contracting Governments ensure adequate resources are available to complete all scheduled reviews by 2025 in advance of the BSM2030 strategic review* *c) BSMAP review opportunities to amalgamate entries by the end of 2022 and amalgamated entries are included in the 2023 Register* *d) BSMAP ensure that the methods used to undertake reviews are proportionate to the risks.*	NSW would support the adoption of Source as soon as possible, if it has been deemed to be suitable for accounting purposes and any policy issues water are resolved. NSW is currently undertaking an independent review of its BSM program delivery plan. This will be used to develop future budget and resourcing requirements necessary to deliver on its BSM obligations. NSW supports the recommendation for BSMAP to further discuss opportunities that would gain efficiencies in implementing the Review Plan and completing register reviews, including the amalgamation of register entries and the use of appropriate methods, and that this is clearly supported in the BSM Procedures.	NSW would support the adoption of Source as soon as possible, if it has been deemed to be suitable for accounting purposes and any policy issues water are resolved. NSW supports the prioritisation of register reviews in advance of the BSM2030 strategic review and continues to advocate for resources to meet BSM2030 obligations. NSW supports revision of the BSM Review Procedure and adoption of a risk-based approach consistent with outcomes from NSW program evaluation. NSW has invested in state-based procedures to mitigate future activity risk and complement BSM procedures. NSW supports introduction of efficiencies in implementing the Review plan including the amalgamation of register entries where this is appropriate. NSW RISI entries have been amalgamated and there is opportunity to amalgamate Sunraysia irrigation development register entries once the review is complete. Potential for future efficiencies should be considered in the mid-term review and following full implementation of the Basin Plan.

Recommendations from the 2019-2021 Audit	NSW response (2021)	Updated response (2023)
Recommendation 7: The IAG-Salinity recommends that BOC consider including a specific objective in the “Objectives and Outcomes for river operations in the River Murray System” that describes the coordination arrangements for managing short term events including salinity spikes	The occurrence and management of elevated salinity events has many contributing factors, especially extreme climate events. Communication, timing and flexibility in river management have been seen as important in managing risks from these events. NSW considers that any changes to river objectives and operating protocols should provide greater clarity for river operators regarding their responsibility for the management and notification of elevated salinity events.	No further comment.
Recommendation 8: The IAG-Salinity recommends that: *a) progress in implementing IAG-Salinity recommendations continue to be reviewed in future audits (underway)* *b) where possible, future IAG-Salinity recommendations include a suggested date for the recommendation to be implemented (completed)*	New NSW supports processes that provide transparency in demonstrating progress in implementing past IAG recommendations. Also need to acknowledge that changes in priority and direction may be required as part of adaptive and risk management approach. Suggested implementation dates would be welcomed within the context of the delivery of BSM2030 Strategy. NSW BSM priorities and work plans are determined based on application of risk management framework in response to combination of Basin and state priorities and available resources.	No further comment.

Recommendations from 2017-2019 audit	NSW response	Updated response (2023)
Recommendation 1: *The MDBA immediately add a provisional register entry of 6 EC debit to account for the 5,800 ha of irrigation development in the NSW Sunraysia region as this is an accountable action under Schedule B of the MDB Agreement (Water Act (2007)).*	Whilst NSW supports the recommendation and recognises that post-2006 irrigation development needs to be bought onto the Salinity Register, further detailed assessment and certainty surrounding the quantum of the debit is required prior to its addition as a provisional register entry. Modelling approaches/methods, that will assess both the current register entry (Sunraysia irrigation development 1997-2006) and new irrigation development salinity impacts, are currently being evaluated as part of broader irrigation policy development. NSW will continue to work with MDBA to identify the most appropriate method to account for new irrigation development, ensuring that outcomes align to BSM Procedures. Further conversations with MDBA and the Basin Salinity Management Advisory Panel are required prior to the addition of a provisional entry onto the Salinity Register.	Complete. At BSMAP meeting 46 (August 2020), a new NSW Sunraysia irrigation development 2006 to 2018 register entry of 3.7 EC at 2020 (debit) was endorsed as provisional. NSW also confirmed its intention to combine the pre and post 2006 register entries at the next review.

Recommendations from 2017-2019 audit	NSW response	Updated response (2023)
Recommendation 2: *NSW urgently increase resources to meet the BSM2030 Schedule B contractual agreement to complete the register entry and model reviews and reduce the uncertainty of the salinity impacts from the expected new development in the high salinity risk areas of Sunraysia.*	NSW recognise this as a priority and have continued to progress work within available resources. Interruptions with departmental restructure and change of staff. Recruitment is underway to fill existing roles and create new project officer position to assist with register reviews. Efficiencies of aligning with SMU work to take advantage of outputs.	Senior management have supported NSW revised program plan and resources have been secured for next 2 years including investment in new groundwater model for Sunraysia irrigation region. NSW has completed recruitment to increase BSM team capacity with a focus on completing all high priority register reviews. Increased access to skills and expertise through ongoing engagement with staff and experts to assist with project design and delivery. Outcomes from the development of the Sunraysia model will assist the assessment and condition of future new irrigation development and provide an evidence base for any additional policy changes.
Recommendation 3: *The MDBA and Contracting Governments develop a common risk assessment and management framework that is consistent with AS ISO 31000 and develop a risk profile for the basin-wide program.*	NSW has actively participated in several workshops in 2021 to provide input into the development of BSM draft risk framework that works with its own risk management framework, existing obligations and reporting requirements. NSW has provided the project with a list of top 5 significant risks to program delivery. NSW broadly supports the proposed framework and being involved in further and ongoing opportunities to refine and review it further.	Complete. BSM Risk assessment procedure has been adopted complementary to NSW project risk management framework.

Recommendations from 2017-2019 audit	NSW response	Updated response (2023)
Recommendation 4: *The Commonwealth and State Contracting Governments continue to work with environmental water holders to understand the basin-wide salinity risk and the cumulative debit impacts from environmental watering of sites.*	NSW has been supportive of ongoing discussion at BSMAP to better understand the risks and impacts from full implementation of SDLAM projects and environmental water delivery. NSW has progressed the preliminary assessment of Lock 8/9 weir pool manipulation project and is working with other SDLAM project teams to ensure salinity considerations are included in project plans.	NSW is supportive continued work to understand impact of full implementation of the Basin Plan on basin wide salinity risk and the Salinity registers. NSW has progressed work on preliminary assessment procedure and interim results for select accelerated SDLAM projects providing an initial idea of scale of impact and where concerns might be. Source model required to understand how these tributary result impact salinity in the Murray.
Recommendation 5: *The Queensland Government assess the risk to basin rivers from the brine ponds constructed by the CSG industry.*	No further comment.	2020 IAG noted the potential for similar risks to occur with CSG developments in NSW and that ideally the New South Wales regulatory arrangements for managing salinity in groundwater would be consistent with those in Queensland. This issue has been included in NSW forward work plan beyond 2025/26, noting that the NSW Groundwater Strategy includes Action 1.5.3 Improve management of large developments impacting groundwater - revise the Aquifer Interference Policy, including investigating aquifer interference approvals and new approaches to managing unlicensed aquifer interference activities.

Recommendation 6: *In the lead up to the 2026 review of the BSM2030 strategy the following knowledge gaps be explored:* *The impact of climate change on the salinity in the shared water resources* *The economic impacts and opportunities provided to the basin industries and communities from salinity mitigation* *Revisit the cost function framework of the registers* *The usefulness of end-of-valley targets for management decisions and consideration be given to other indicators such as trend analysis and mid-valley targets, and* *Review key entries in the registers to reduce uncertainty and provide improved certainty in relation to available credits by 2080.*	NSW continues to support this initiative and maintains an interest in evaluating current EOV frameworks. In direct response to this recommendation: NSW are currently assessing climate change impacts and risks from a strategic perspective, with a particular focus on water security. A similar approach could be used to inform Basin-wide risks and climate change. NSW notes that estimates of the economic impacts of salinity were last reviewed in 2004, the updating of the Salinity Register cost function framework is overdue. Completion of this piece of work will assist in communicating the importance and relevancy of the BSM2030 Strategy to stakeholders (including the broader community). NSW are interested in evaluating current EOV frameworks, with the relevancy and appropriateness of EOV targets currently being assessed as part of NSW upland catchment audit. The current reporting regime needs to be reviewed so that the interpretation of targets are informative and remain useful in the context of salinity management. 5) NSW recognises that with any model development there is an inherent level of predictive uncertainty in assessing the salinity impact of accountable actions. As reflected in the Schedule, the precautionary principle should be applied, particularly with respect to 'effort commensurate with risk'. Further discussion around this is required and is currently being considered	NSW has assessed climate change impacts and risks from a regional strategic perspective, with a particular focus on water security. A similar approach could be used to inform Basin-wide risks and climate change. NSW is supportive of the MDBA project to articulate benefit of salinity management and BSM, separate to Salinity cost function. NSW support the outcome and recommendations of the cost function review. The current reporting regime needs to be reviewed so that the interpretation of targets are informative and remain useful in the context of salinity management. NSW continues to explore salinity risk in catchments and alternates to current EOVTs and associated modelling needs. The review of NSW register entries has been prioritised to ensure integrity of Salinity registers is maintained.

Recommendations from 2017-2019 audit	NSW response	Updated response (2023)
	in the development of the BSM Modelling Procedures. Noting that continued monitoring and analysis will be undertaken for identified NSW high 'risk' salinity register entries	

Recommendation from 2015-2017 Audit	NSW response	Updated response (2023)
Recommendation 4: *The MDBA and jurisdictions should learn from unexpected short term in-river salinity spikes from events such as occurred at Lake Bonney and the lower Darling, review where these may occur in the Basin in the future, and develop mitigation strategies to reduce the future risk of spikes occurring.*	Monitoring has continued across a wide network of EC gauging sites, with work to assess the effectiveness of target sites. Elevated salinity responses have been reported on as a result of wetting from drought and from recent 2021 rainfall event in the Northern Basin (see sect 3a.) A major program is underway with the "Profiling Catchment Salinity Risk Project" being implemented, which looks at salinity impact from high and very high areas of sub-catchments. Importantly the work defines the processes involved in salinity delivery to streams in the varied landscapes across the sub catchment and landscape positions with the sub- catchment that are of concern for salinity delivery.	Compete. NSW continues to support his initiative through ongoing monitoring and implementation of new operating arrangements to re-commence flows in the Darling River and continued discussion with MDBA and other jurisdictions as water quality issues arise.

Recommendation from 2015-2017 Audit	NSW response	Updated response (2023)
Recommendation 7: *Given the range of modelling issues that need to be resolved quickly and efficiently under the BSM2030 transition, there is a need for an expansion of the role of the Technical Working Group for Salinity Modelling or for similar committee(s) be set up to aid the facilitation of modelling issues in a planned way.*	NSW continues to support this initiative.	NSW continues to support the role of the *Technical Working Group for Salinity Modelling* and its involvement in the finalisation of the Murray Source model.
Recommendation 8: *The MDBA and jurisdictions should consider the development of an approach to assessing the salinity impacts of irrigation, that better represents actual water use; particularly in relation to the reduction in irrigation water use in some established irrigation areas in the southern basin.*	No further comment.	Complete. Actual water use is being used to inform NSW salinity register reviews.

5. Strategic knowledge improvement

During this reporting period, NSW has pursued knowledge improvements with respect to landscape management, modelling adaptation and salinity dynamics and processes. Key projects and innovations include:

- Hydrogeological Landscapes (HGL) program
- Profiling Catchment Salinity Risk project
- EC Trend Analysis
- Urban Salinity advice
- Upper Darling module AEM survey
- Mallee AEM survey proposal.

Hydrogeological Landscapes (HGL) program

The statewide Hydrogeological Landscapes (HGL) spatial dataset has been made available to guide salinity decision making where no detailed mapping exists. HGL mapping has been conducted since 2007 across NSW, at various scales. The work has informed rural and urban salinity management plans, catchment action plans, natural resource management plans, Landcare Network plans and landholder property plans. This innovative program has increased understanding of the landscape, how it works and how to select best management approaches.

The project has utilised several HGL datasets at a range of scales, to develop an integrated overall state-wide salinity hazard map that provides a:

- data capture mechanism for all HGL work
- resource for salinity and landscape planning
- framework for salinity monitoring and project activity
- informs various state-response modelling initiatives.

The focus of the HGL mapping is to provide more detailed coverage of the very high and high salinity hazard areas and provide a key input to the Profiling Catchment Salinity Risk Project (see below).

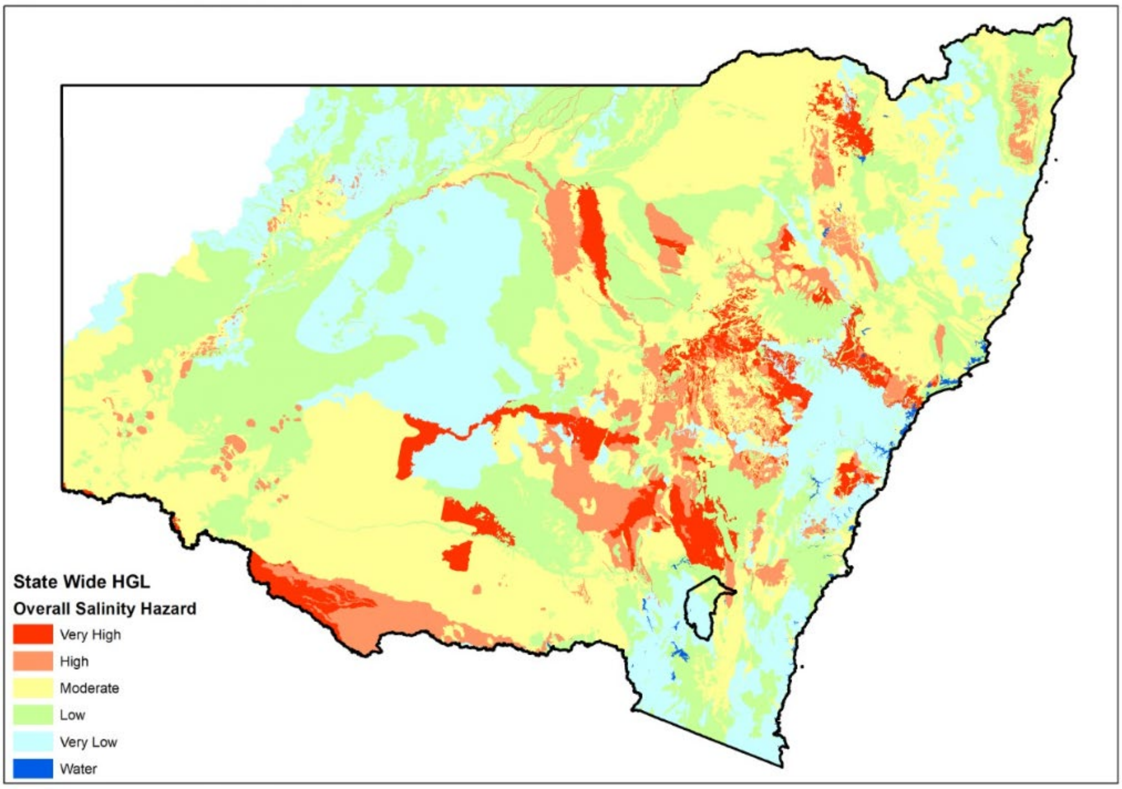

Figure 49: Statewide HGL map layer for NSW

A program of activity continued in the high priority landscapes, completing the catchments listed below where extreme land salinity, high EC and high salt loads emanate. Comprehensive management 'templates' have been developed to guide specific salinity management for each landscape.

Completed:	Commenced:
Upper Lachlan Catchment	Lower Murrumbidgee
Upper Murrumbidgee, Jugiong and Muttama catchments	Lower Murray
Revision of Central West HGL products for publication	Namoi

Profiling Catchment Salinity Risk project

This major project which was initiated in October 2020 as a mechanism to define catchment risk and inform review of EOVT with the purpose to:

- develop an integrated salinity risk framework which considers catchment and sub-catchment salinity impacts and processes
- consolidate past investment and outcomes whilst capitalising on and extend new work, bringing together activity from a range of disciplines to develop and inform the salinity risk management framework
- inform the review End of Valley Targets (EOVT) and their appropriateness to give a true picture of catchment performance
- highlight sub-catchment salinity risk and appropriate management measures for those high-risk landscapes within upper catchments.

The Upland Catchment Salinity Audit (2009) defined a range of sub-catchments with high salinity risk across the NSW Murray Darling Basin. The activity was initially resourced prior to 1999 and from

2000 to 2004 as part of the NSW Salinity Strategy, using a variety of modelling approaches and inferred data. The approach focused on three themes: groundwater, stream EC and land salinity. The project approach aims at taking advantage of the advances in scientific understanding of salinity, data and technology improvements within available resources.

The steps involved in the Profiling Catchment Salinity Risk approach are:

- Step 1 - Produce a Statewide HGL layer with High and Very High HGL areas identified (complete)
- Step 2 - Check MDB gauging stations for EC data and location check (complete)
- Step 3 - Produce a hydrologically sound digital elevation model layer to define sub-catchments to EC gauges (complete)
- Step 4 - Use LF7 Landform Modelling to split landscapes into 7 landform elements (complete).
- Step 5 - Produce an attribute table to match LF7 to MA unit in different HGL landscapes using conceptual cross sections
- Step 6 - Use GIS resources for each EC Gauging station to attribute the salt producing areas of a catchment
- Step 7 - Run a test against mapped salt sites.

A major achievement in the last period was completion of Step 3 - production of a digital elevation model layer for interpretation and attribution. Work has also focused on Step 5 and producing an attribute table to match landform to management area unit in different HGL in the Murrumbidgee, Lachlan and Macquarie catchments.

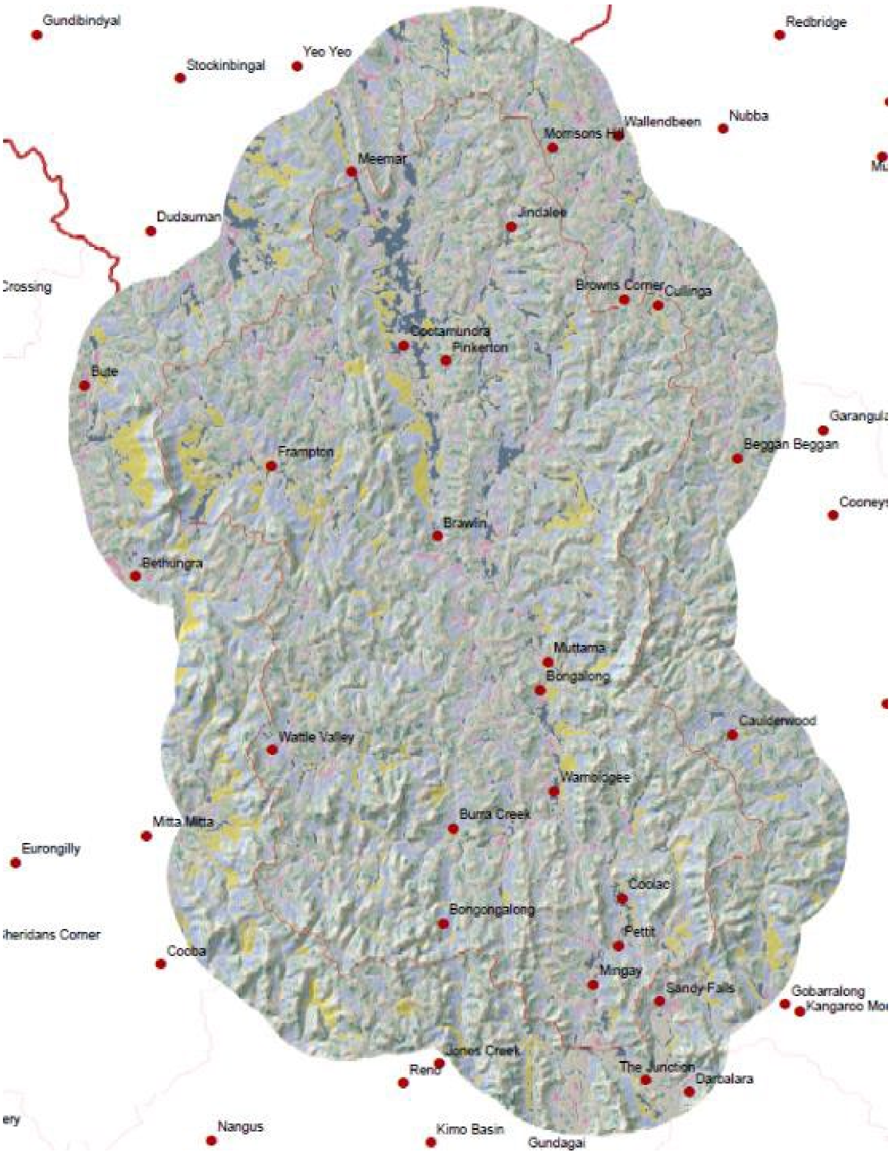

Figure 50: Digital elevation model of Muttama Catchment

Testing of modelled conceptualisation (Step 7) was also undertaken using mapped salt sites in the Jugiong and Muttama sub catchments within the Murrumbidgee. The results demonstrated a close alignment between modelled and mapped results in the Muttama catchment (Figure 51).

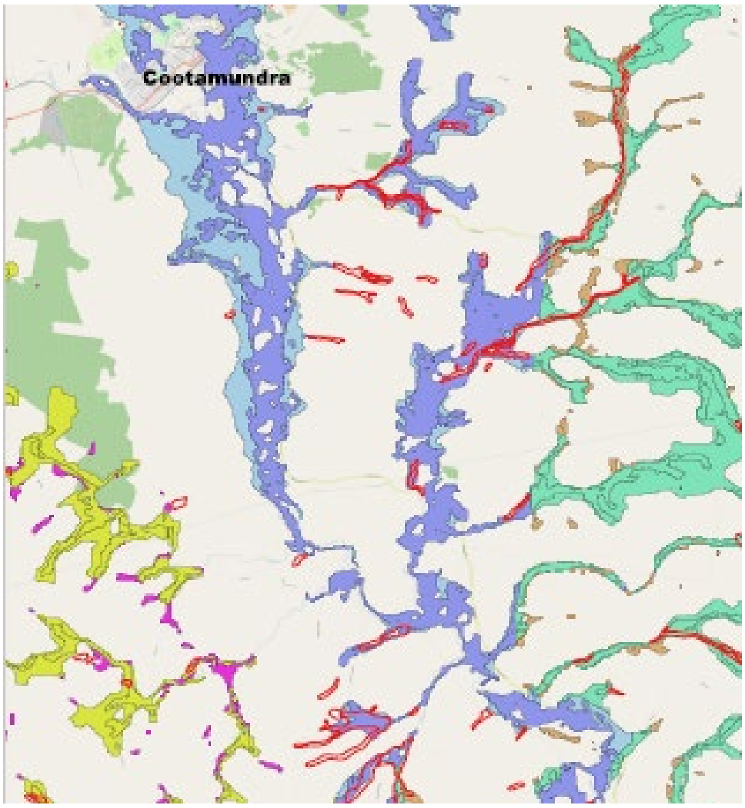

Figure 51: PCSR project modelling and conceptualisation for Muttama Catchment compared against actual salt outbreak mapping (red)

The successful pilot was able to relate Statewide Salinity Hazard to determine the landscape element that is the source of salt at an EC gauging station (Figure 52). Following the success of the pilot, the approach has been expanded to the full catchments of the Lachlan and the Macquarie.

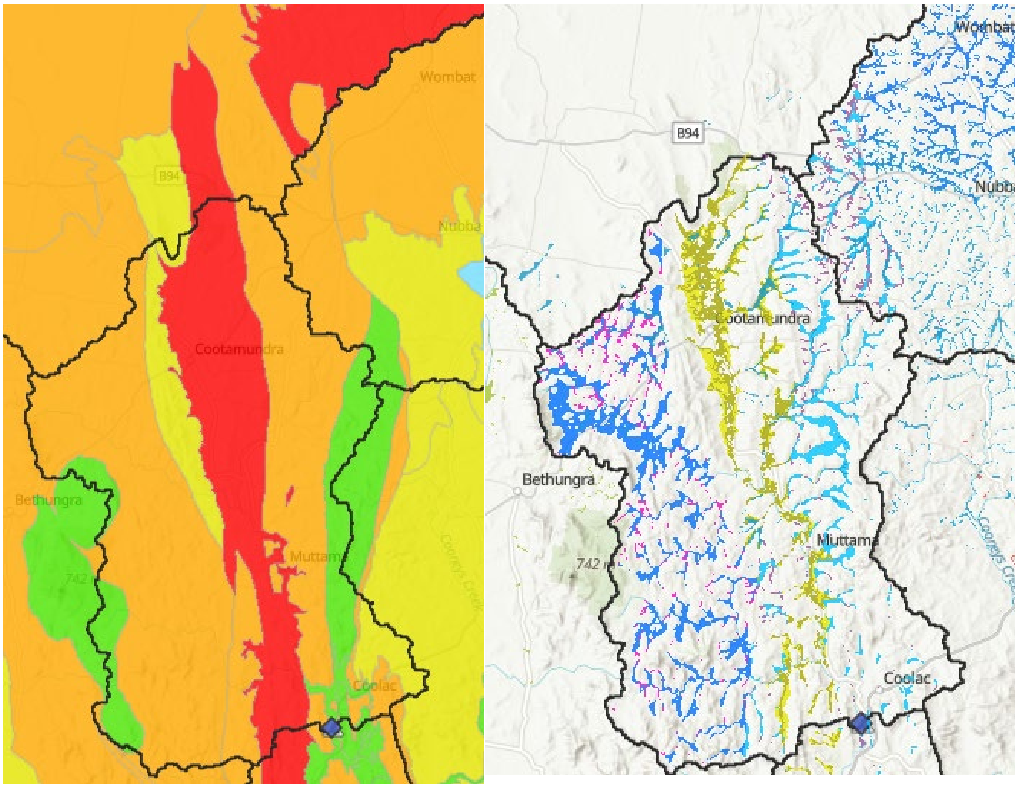

Figure 52: Comparative maps of salinity hazard and source of salinity in the Muttama catchment.

EC trend analysis

In the past, the review of salinity targets has been achieved using numerical salinity modelling with large resource base. As a first step prior to commissioning salinity modelling, NSW has been trialling an initial test step to determine if there has been a changing trend in EC at gauging stations in areas where there is likely to be impact. The trial was targeted in the Murrumbidgee as it was likely a trend would be detected from highly saline catchments following wet conditions.

The objective is to identify the catchments that have a changing risk profile (when compared to previous analysis) and would trigger a more detailed investigation or investment in re-modelling.

EC trend analysis was a major component of the 2009 Salinity Audit indicating streams with a rising, stable, or declining EC trend over time. The work was repeated in 2017[8] for the period 1970 -2013 using similar statistical methods for EC as well as temperature and turbidity.

A pilot was conducted to check if the methodology developed by Frank Harvey (DECC, 2009) could be replicated. Activity was piloted in two major EC contributors to the Murrumbidgee, namely the Jugiong and Muttama sub catchments (Figure 53).

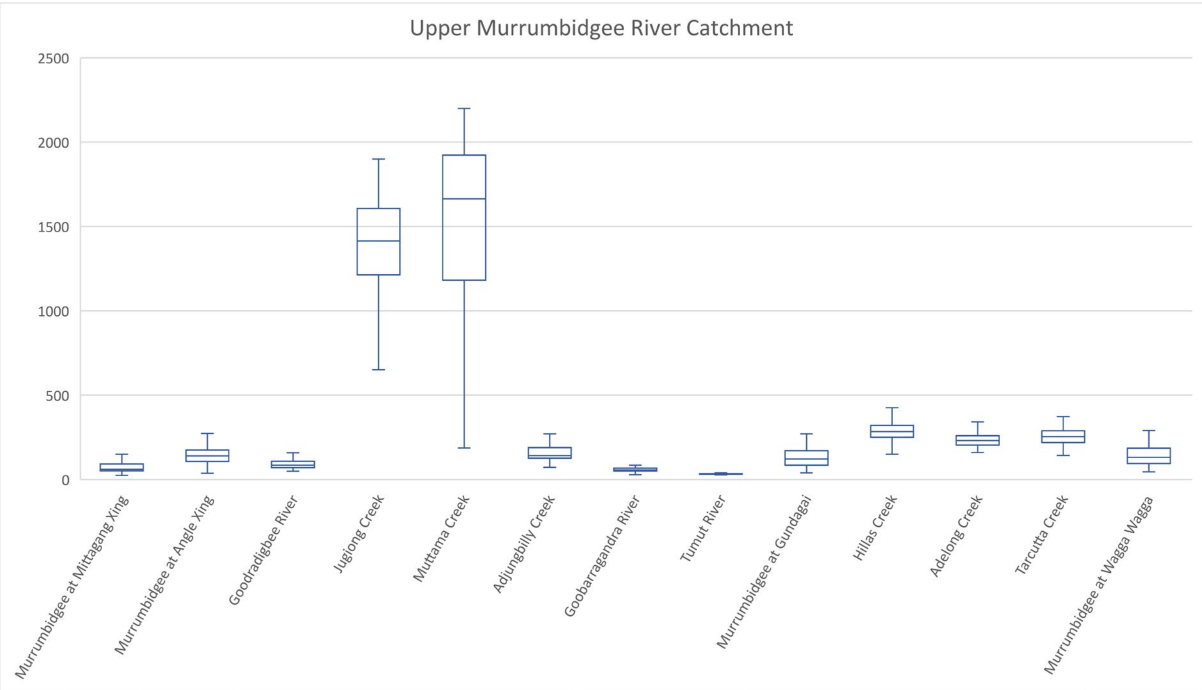

Figure 53: Boxplots of 2010 to 2020 electrical conductivity data for routine water quality monitoring sites in the Upper Murrumbidgee catchment highlighting EC contributions from Jugiong and Muttama Creek.

The results generally replicated the 2017 report outputs well, with close agreement of the modelled results. Both the Python and R models replicated the original Splus model, for the original code provided. The graphics below demonstrate the close match between original Splus (LHS) and Python/ R output (RHS) for Jugiong Creek catchment.

[8] 2017 Evaluation of water quality data and historical trends in New South Wales rivers, Australia: 1970-2013

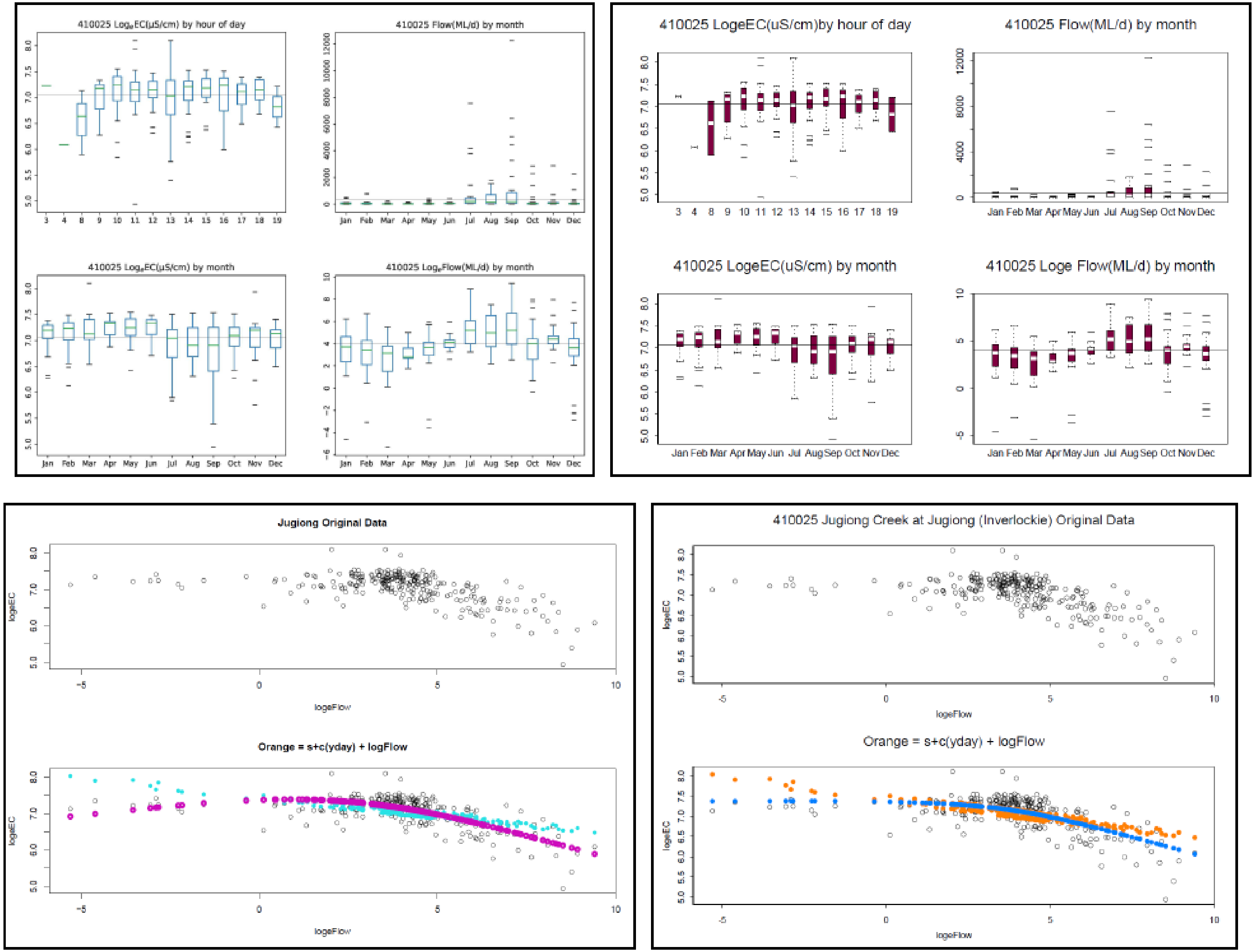

Figure 54: Comparison of modelled EC from original Splus to new Python/R for Jugiong Creek

A way forward to utilise time series data for catchment EC trend across NSW where salinity sub-catchment EC gauges exist has been realised and a work program is being developed to work progressively through the High and Very High-Risk sub-catchments and river basins in the NSW Murray Darling Basin. The trend analysis will be used for the Profiling Catchment Salinity Risk (PCSR) project to better inform EOVT and risks to shared water resources.

The time series data offers new opportunities to review trends with potential to improve understanding. There has been a desire to use the time series data in the past for trend analysis. Also aware of relatively short period of data (both sampled and continuous) compared to climatic cycles/trends. Applied methodology would include comparison of the statistical model (in open-source code) at various sites at similar timesteps.

- Spatial analysis shows links where the salt comes from within a catchment and catchment dynamics.
- Some rivers will need a combination of grab sample data as there are few EC continuous sites.
- Prioritise catchments connected to the Murray River. Continue initially with the Murrumbidgee, then progress to the Darling.

Urban salinity advice

There is a slow and steady demand for urban salinity information to assist in planning. A project was initiated to provide information to meet this demand through the development of *Urban Salinity Planning, Development and Management Guidelines* (Scone NSW Pilot) which was undertaken in the reporting period.

The purpose of this document is to minimise the current and future impacts of urban salinity by utilisation of a planning development management guideline that informs:

- planning process of development informed by landscape management approach to urban salinity and principles of ecologically sustainable development
- investigation procedures and data interpretation that result in information allowing for management and planning decisions that are sound, effective and scientifically justified
- urban salinity identification, management and education so that responsible environmental and land use planning occurs.

In a continuing working partnership with Upper Hunter Shire Council, salinity considerations are being incorporated into Local Environmental Plans, Development Control Plans, Development Application information requirements and Salinity Management Plans. Urban HGL development has been a component of information for the pilot.

High risk development areas in Dubbo, Forbes and Sydney's North West and South West Growth Sectors have continued to use HGL products provided to assist with planning and development. During the reporting period:

- the (Aerotropolis) Badgerys Creek Airport Development used the HGL framework for guiding development and planning
- Dubbo Regional Council – Regional Sporting Hub design and layout
- DPE Planning actively sought HGL information for regional planning frameworks in conjunction with DPE Environment and Heritage and Water groups
- Parkes Hockey Field salinity investigation and management plan implementation has been ongoing, as well as the Dubbo Regional Sports Hub/ Dubbo Cycle Park development dealing with high levels of salinity in Dubbo
- Gunnedah High School Urban salinity

- Wagga Wagga Regional Council has revisited the major Lloyd Subdivision in Stage 2 development approvals.

Upper Darling AEM survey

In April to June 2021, negotiations were undertaken with Geoscience Australia regarding provision of AEM data to several DPE Water priorities in the Upper Darling River System. The priority areas include areas that would benefit from increased understanding of salinity processes such as:

- Upper Darling Salt Interception Scheme – close line spacing survey around disposal basin and pumping areas
- River Corridor – detection of structures to groundwater flow, and near river salt store with survey lines close to river.

Outputs from the AEM data has been used to inform the review of Upper Darling Salt Interception Scheme and recommendations for further monitoring sites and improve understanding near river salinity processes.

A report by Sarah Buckerfield[9] highlighted the following:

Communities and ecosystems along the Darling River face critical water shortages and water quality issues including high salinity and algal blooms due to a reliance on declining surface water flows, which are impacted by extraction and drought, exacerbated by increases in temperature driven by climate change.

The Darling River, characterised by highly variable flows, is the primary water source for the region and our understanding of the spatial extent and character of lower salinity groundwater within the surrounding Darling Alluvium, which could provide an alternative water source, is limited. Scientific understanding of the highly variable groundwater-surface water system dynamics of the Darling River is also an integral part of the evidence base required to manage the water resources of the wider Murray-Darling Basin, which has experienced critical water shortages for domestic and agricultural consumptive use and serious ecological decline due to reduced flows.

Other relevant groundwater systems in the study area include aquifers of the underlying Eromanga and Surat Basins in the north, aquifers of the Murray Basin in the south, and fractured rock aquifers of the Darling Basin in the south-central area. Understanding of connectivity between these systems and the groundwater systems within the Darling Alluvium, and surface water of the Darling River, is also limited.

Initial findings of a desktop analysis that combines previous research with new analysis on water level, hydrochemistry, and Airborne Electromagnetic depth sections suggests that basement geometry and hydro stratigraphy within the Darling Alluvium are key structural controls on surface-groundwater connectivity, and the occurrence of a saline groundwater system within the lower part of the alluvium impacts the quality of surface water and shallow alluvial groundwater resources.

Further data acquisition and integrated analysis are planned to test these relationships as part of the Upper Darling Floodplain project.

[9] Upper Darling Floodplain groundwater resource assessment S. Buckerfield[1], A. McPherson[1], K. P. Tan[1], P. Kilgour[1], and S. Buchanan[1] 1 Geoscience Australia

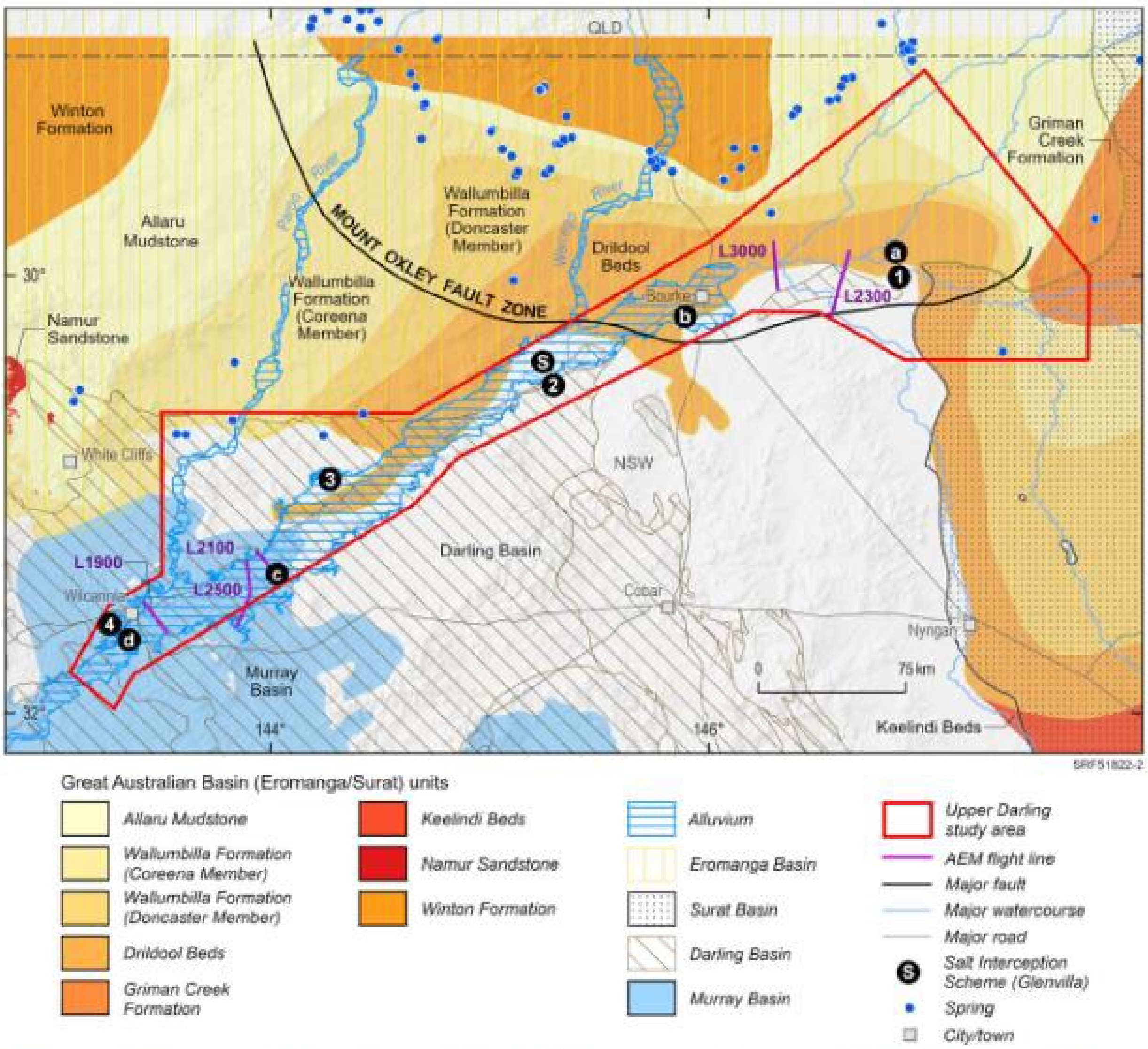

Figure 2 Relevant groundwater systems in the study area: Darling Alluvium and alluvium associated with Paroo and Warrego river tributaries (blue hatching), the Great Artesian Basin, the Darling Basin, and the Murray Basin. The salt interception scheme is marked (S), the locations of four groundwater bores relevant to subsequent sections marked (a), (b), (c), and (d) and locations of four surface water gauges marked (1),(2),(3), and (4).

Figure 55: Footprint of the Upper Darling AEM survey

Mallee AEM survey proposal

In the previous comprehensive reporting period, NSW undertook a preliminary design for an AEM survey within the NSW Mallee as a proposal for NSW to consider funding and implementing. This was an opportunity to conduct a survey in NSW at the same time as a proposed survey by the Mallee CMA to gain cost efficiencies.

The overarching objective of the proposed AEM survey is to reduce the level of uncertainty associated with imperfect knowledge of the distribution of salt and geological controls in the NSW Murray region landscape. The AEM survey will link directly to NSW programs for salinity management, irrigation planning and environmental watering.

The derived products will assist NSW in conducting salinity impact assessments (including the assessment of salinity impact to areas of high conservation and cultural heritage status) and associated modelling to support BSM obligations, mitigating and offsetting salinity impacts to land, guiding irrigation zoning activities and other regulatory mechanisms to guide irrigation activities away from high impact areas, the design and implementation of SIS operations and environmental watering activities, and in the refinement of the river operations (e.g. weir pool manipulation) to support floodplain management.

The project was not successful in securing funding and will not proceed.

6. Community engagement and communication

DPE Water continued to provide salinity technical support to a range of partner groups in the form of:

- formal salinity training and support to landholders, Landcare groups, Local Land Services (LLS), Agency, University, Local Government, Industry groups and schools
- HGL training and specific expert soils/ salinity advice to LLS and Landcare Co-ordinators
- support to planning systems of Agency and Local Government regarding urban and rural salinity.
- support to Landcare groups and networks including participation in delivery of training, field days and education programs targeted at grazing, salinity and soils management
- support to Regional and Local Landcare natural resource management programs jointly undertaken by LLS and Landcare
- project involvement in delivery of LLS projects, departmental projects, Biodiversity Conservation Trust projects, NSW Soil Knowledge Network projects, ANU projects and Geoscience Australia.

Community engagement activities are varied and wide-ranging dealing with several partner groups in training and support. Salinity management advice and field days have increased, now that COVID-19 restrictions have ceased. In 2021/2022, some 160 people were engaged in direct training events in a range of capacity building activities across LLS, Landcare staff and agencies (Figure 56).

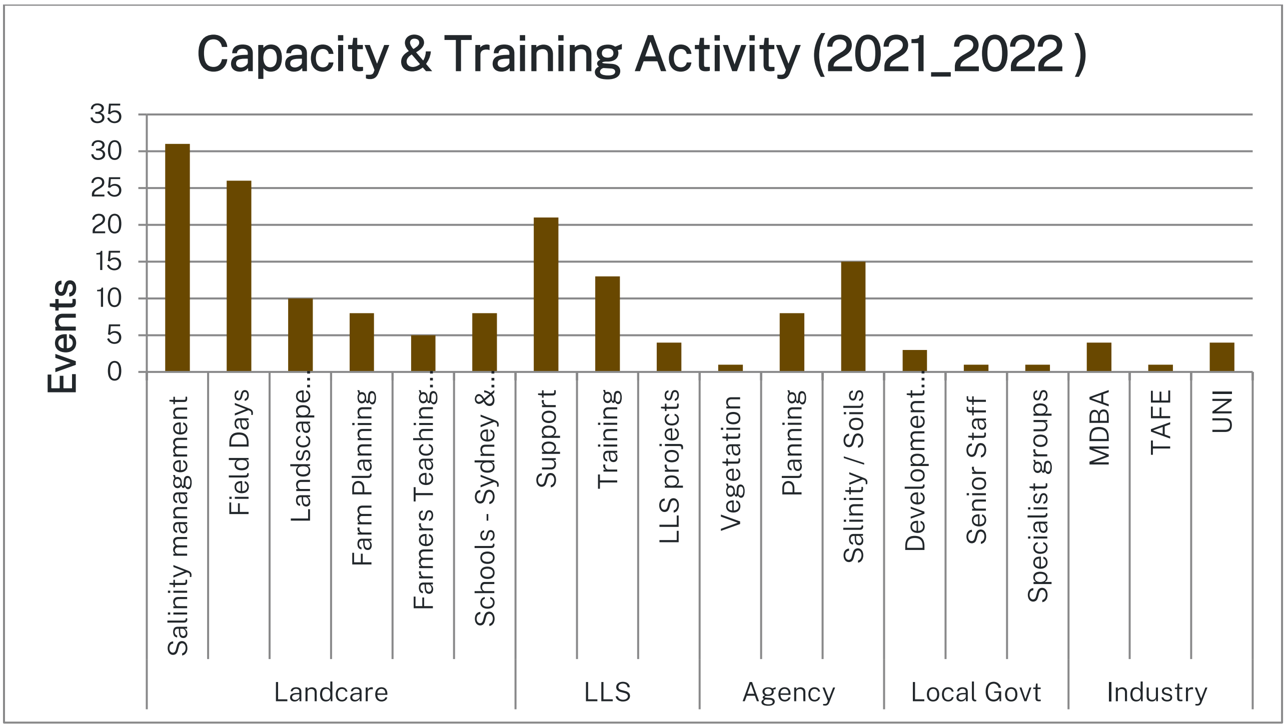

Figure 56: Salinity capacity building summary – 2021-2022.

In 2021/22 and 2022/23, there was a shift to salinity management events, field days and training. This reflects the increased salinity seen in landscape. There has also been a shift to soils and salinity projects, and a decline in urban salinity activity.

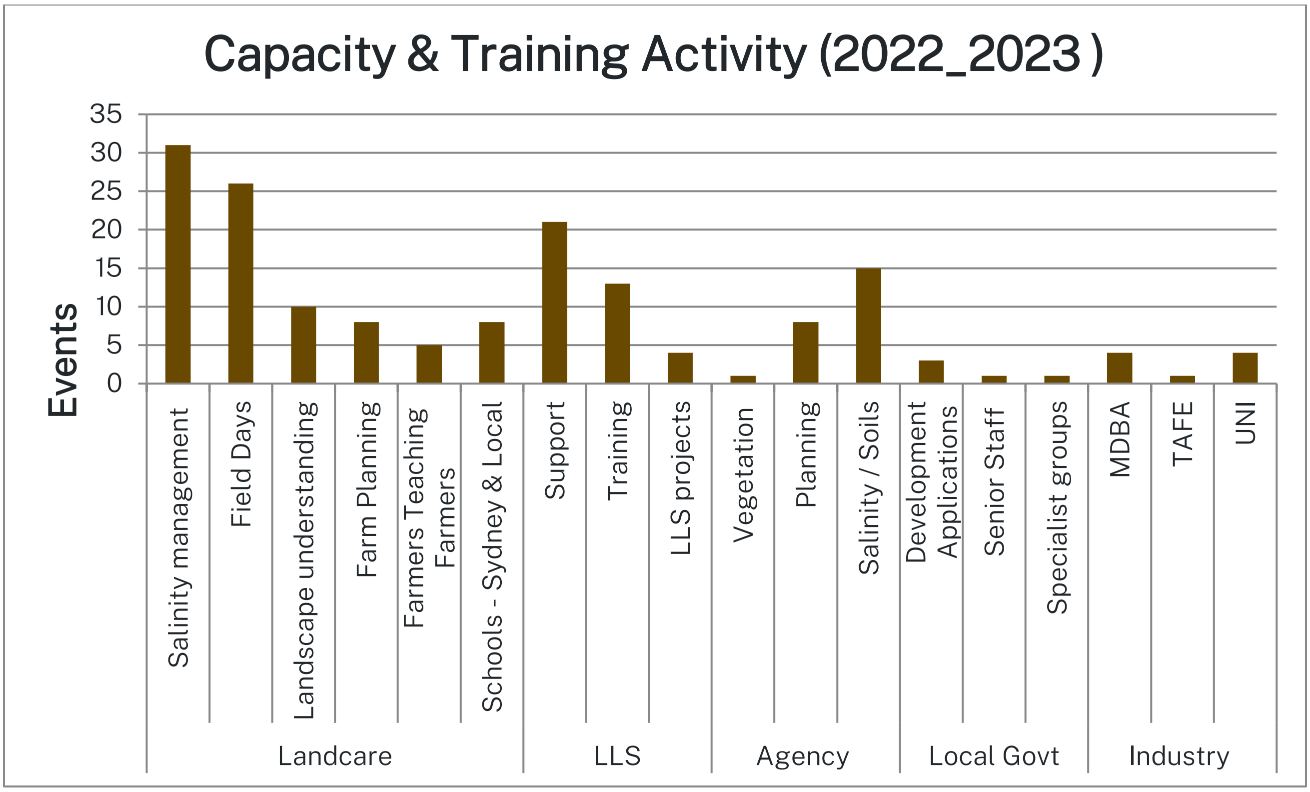

Figure 57: Salinity capacity building summary – 2022-23

The type of communication activities varied to allow engagement across a wide front supporting the knowledge and implementation of salinity management across NSW.

Partnering with Landcare organisations

Landcare water quality program

A program to spatially capture EC data from streams, creeks and rivers using Landcare staff to sample many waterways across local Landcare districts. This has enabled greater understanding of the variability of EC and flow conditions across a wide area of current study for HGL and PCSR work. The activity was a great data source, has rekindled salinity interest in Landcare groups and provided a platform for Basin Salinity Staff to brief committee members and train local staff. As part of the program, Landcare staff re-engaged with famers who have done successful salinity work, and provide advice to engage to an emerging salinity problem area under the following themes:

- knowledge creation filling data gaps in surface water quality information in key saline landscapes
- capacity building – build the skills of local Landcare staff and volunteers
- build local partnerships – work with Landcare staff and volunteers on projects which benefit local scale salinity management and state scale salinity management.

We have been working with a range of groups in the southern/central areas to achieve project outcomes including Mid Lachlan Landcare, Yass and District Landcare, Little River Landcare, Murrumbidgee Landcare Inc and Harden-Murrumbah Landcare.

Soils and salinity project

A partnership project with Little River Landcare group and the Soils Knowledge Network has conducted soils and salinity activity across the Central West of NSW (Figure 57). A hugely successful soil sampling, testing, pit workshops and "what the numbers mean" workshops have been conducted across the Little River catchment and in some adjoining Landcare Groups such as Coonamble/ Mid Macquarie/ Watershed (Mudgee and Rylstone) and Central Tablelands.

Over 1200 samples were taken, tested and entered into the departmental SALIS database, involving some 150 landholders and 15 workshops.

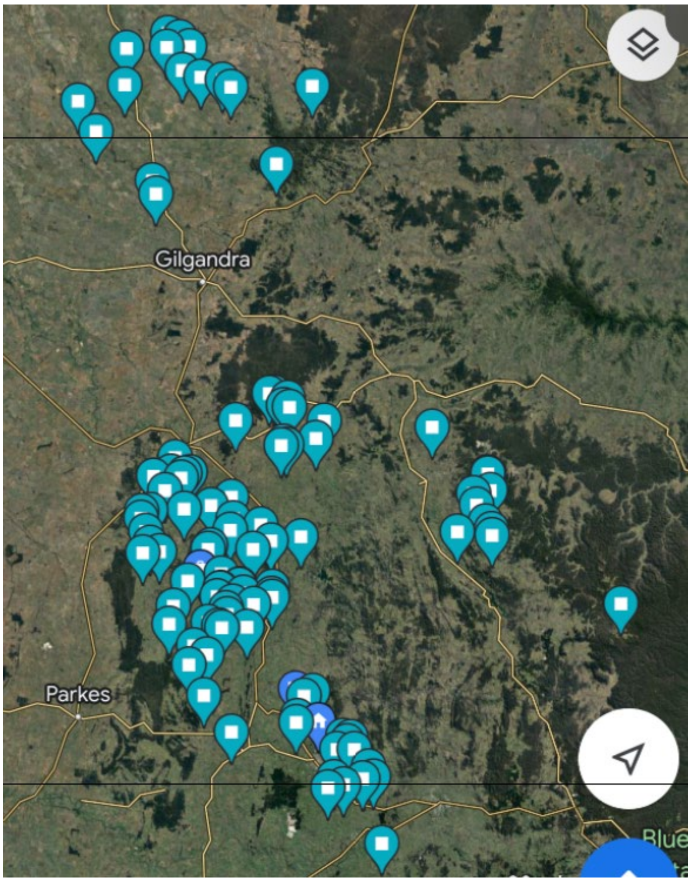

Figure 58: Graphic of Extent of Soil and Salinity Project sampling over 2022-23 in Central West NSW

Webpage development

DPE EHG salinity webpages remain the main repository for salinity resources, with Soils Knowledge Network and Landcare Groups adding localised data to their websites. Creation of NSW Basin salinity management webpage has been flagged for 2023/2024.

eSPADE - salinity information delivery platform

Delivery of HGL information to eSPADE online platform has very significant outcomes with very high use by a wide range of stakeholders (including LLS, Landcare groups, consultants, agencies, universities and individual landholders). It has also become an invaluable salinity training resource - in the field and the university classroom.

Linkage to soil landscape information within the platform is extremely useful in understanding the management of a landscape. HGL templates are available on the platform and the accompanying reports are now available on SEED.nsw.gov.au (Sharing and Enabling Environmental Data in NSW).

Work was undertaken in 2023 to speed up the editing and access to completed HGL data.

Videos and fact sheets

A specialist video production group was retained to produce several videos, which will lead to a wide range of products including long and short videos, social media materials, fact sheets and articles for newsletters and digital platforms. The series is called "Salinity Success Stories" and captures landholder's endeavours in having productive and sustainable outcomes from salinity management.

Initially three videos were developed to showcase successful salinity management over time:

- Landholder Case Study – Don Bruce, Cumnock NSW
- Landholder Case Study- John Ive, Murrumbateman NSW
- Hydrogeological Landscapes (HGL).

In a partnership with Central West LLS a series of 'Salinity Success Stories' have been initiated with the first focusing on 'Salinity and Soils Management' utilising the very successful soil management improvement program of Richard Langley 'Homestead View', Greenthorpe NSW. This was recently expanded to include a property at Woodstock, near Cowra NSW.

Training

In the reporting period, the types of expert salinity training included:

- HGL Frameworks for LLS and Landcare groups. High demand for 1–3 day courses are targeted at local scale, sub-catchment and regional scales
- farm planning training with a focus on soil/salinity for community groups and industry groups
- training of LLS staff – up-skilling new staff, particularly in minor district locations.
- 'Farmers teaching farmers' programs have been supported and continue to be an effective interface with the community.

A major focus was to improve the awareness and understanding of salinity management works to Landcare networks and community groups who have an interest in salinity. These groups typically cluster around catchments with significant salinity issues and have also received salinity investment in the past. Training and support were delivered to a number of Landcare networks, listed below:

Boorowa Landcare	Holbrook Landcare
Mid Lachlan Landcare	West Hume Landcare
Weddin Landcare	Central Tablelands Regional Landcare Network
Little River Landcare	Central West Regional Landcare Network
Central Tablelands Landcare	Coonamble Landcare
Condobolin Landcare	Mid Macquarie Landcare
Watershed Landcare	Murrumbidgee Landcare Inc
Upper Lachlan Landcare	Yass District Landcare
Harden Murrumbah Landcare Group	

Online training

Online information sessions were delivered successfully to LLS and agency staff, after the COVID-19 period triggered a shift in delivery method:

- internally to staff in the Soils Assessment section of DPE EHG
- South East, Central Tablelands, Murray and Central West LLS staff
- Geoscience Australia staff

A shift to online training for LLS staff and Landcare co-ordinators was achieved with structured sessions over several days, and a field visit to imbed and localise training. This has proven to be well received and effective. The Landcare Groups listed above were involved in online training.

Train the Trainer/Mentoring program

Training is an integral part of HGL program to imbed HGL knowledge in the typical business of partners. A 'Train the Trainer' approach has been undertaken and feedback from partners has indicated that in some areas people are confident in communicating HGL information themselves. Partners have indicated that the training is of high value and is integral to project success.

Participant feedback from capacity building activities conducted in the HGL program has continued to show that HGLs provide:

- a framework for people to understand more about the landscapes they work in
- the opportunity for land management generalists to consider the salinity implications of their decisions.

There has been an increasing expansion of "Train the Trainer" approach into understanding soils and salinity as a mechanism to engage a wider training group (Landcare and LLS staff). A study of salinity processes at the landscape level and soils at specific sites have been undertaken at field days in Little River, Coonamble, Mid Macquarie, Watershed and Central Tablelands in conjunction with Landcare, Soils Knowledge Network and LLS staff to provide detailed salinity/soils information.

Figure 59: Andrew Wooldridge conducting soils/salinity training at Canowindra (June 2020)

A targeted new mentoring program has been designed to up skill LLS staff, so that they can become confident salinity practitioners and provide sound salinity and HGL advice within their respective LLS area. This has successfully been introduced to Condobolin and Dubbo with 1:1 individual support to projects, extension and salinity/natural resource management programs.

Liaison with other networks

The Soils Knowledge Network is a group of retired soil scientists/soil conservationists who are committed to the preservation of soils knowledge. Their website houses videos and training materials, as well as current activity to store important soils information on the national TROVE database.

DPE has an active working relationship with the Soils Knowledge Network to develop and deliver soils and salinity training packages and arrangements for a salinity page to be set up on the SKN website to retain salinity information that is rapidly being lost through updating of websites and databases.

Education

Partnerships with Landcare Networks have led to education programs, with salinity staff providing expert input to program designed and run by Landcare groups, using part time skills of local teachers.

The proximity to and relationship with ANU/University of Canberra, has led to some course components and field trip study units being undertaken in the Lachlan catchment.

7. Priorities for future work

Future priorities in NSW are focused on maintaining existing resources and capacity to successfully implement and contribute to BSM2030 key tasks and objectives before the mid-term review. Securing resources for the program beyond 2026 remains a key priority. Other key initiatives are listed in Table 11 below showing progress on actions:

Table 11: NSW key BSM initiatives and progress to date

Activity	Progress
New Irrigation Development policy framework including: • the review of current policy and legislation, and interagency roles and responsibilities • evaluation of current and potential risks and mitigation strategies • evaluation of interstate policy arrangements including the application and applicability of Salinity Impact Zones • documenting and communicating the 'revised' New Irrigation Development Guidelines • establishing a database that captures new irrigation development and associated salinity impacts • evaluation of current salinity assessment tools (SIMRAT) and development of new tools (if required).	Review of legislation, policy, responsibilities and procedures completed as part of issues identification process with interagency working group. Preferred option for implementation has been identified with targeted stakeholder consultation and policy finalisation planned for 2024. Potential benefits in aligning with development of the Sunraysia groundwater model and testing of new internal procedure to assess infrastructure projects. Hydrogeologists trialling the use of salinity zoning approach for new irrigation development applications and comparing results with SIMRAT.
Completion of current Register reviews: • Mallee LoH - Dryland clearing and pre-88 irrigation • Murray LWMP • Upper Darling SIS.	Upper Darling SIS was completed in 2021. LWMP review are underway and a priority to complete by 2024.
Assist and support the (MDBA led) Sunraysia (EM2) model refinement project and register reviews for: • NSW Reduced Irrigation Salinity Impact (RISI): Stage 1 and 2 • -improved Buronga SIS and Improved Buronga and Mildura-Merbein SIS • Mallee Cliffs SIS.	Complete
Finalise the scheme performance reviews of the Buronga and Mallee Cliffs SIS	Complete

Activity	Progress
Finalise Billabong Creek SIS Proof of Concept project and determine if this is a new accountable action	Proof of concept project is complete. Preliminary assessment of salinity effect will be completed by 2024
Commence NSW Sunraysia Irrigation Development (1997-2006) Register review post-Sunraysia model refinement project	Review will be completed with assessment for provisional register action 'Sunraysia Irrigation Development (2007-2018) by mid-2025
Completing the transition from IQQM model to the eWater Source framework for all NSW river system models	Need for Source salt load modelling to be evaluated by catchment. Alternate analysis methods being investigated based on salinity risk
Re-assessing the salinity contribution from the upland catchments in the NSW tributaries such as the NSW Upland Catchment Audit	Profiling Catchment Salinity Risk project implemented focussing on strategic sub catchment priorities
Integration of salinity information, including HGL data and reports, onto publicly accessible on-line platforms i.e., eSPADE portal	Continued use of eSPADE for HGL data, upload of salinity resources to Soil Knowledge Network website
Community engagement and communication activities	Continue to provide on-line and in person engagement opportunities, and salinity training to range of stakeholders. Communication products being developed in collaboration with LLS.
Continue to implement and deliver Murray-Darling Basin Plan initiatives.	Input into the development of • Peer review and publication of final Salinity Technical Reports to be completed Review into Salt export objective and Burtundy target supported
Salinity impact assessments of SDLAM progressed and/or completed, including the assessment of other environmental water initiatives (as required)	Lock 8/9 preliminary salinity assessment completed. Preliminary assessment of 3 other SDLAM projects being finalised. Continue to work with MDBA, DPE Water and DPE EHG project leads on remaining projects and progressing assessments as required.
Continue to deliver water for the environment with due regard for salinity impacts (/benefits) particularly in known salt-affected regions such as the Edward-Wakool River systems.	No notifiable or river restart events in the reporting period. First use of Water Quality Allowance in Lachlan catchment to address local salinity risk.
AEM data capture	AEM data acquisition and interpretation for Upper Darling complete. Proposed AEM data acquisition for the Lower Murray will not proceed.

Activity	Progress
Continued input into the development of NSW strategic plans and priorities.	Continued input to state and regional water strategies, options analysis and implementation plans.

In addition, NSW will continue working with other Basin States and the MDBA on key priorities such as:

- review and improvement of BSM Procedures
- assist with the transition from BigMod to Source River Murray model
- implement the SIS Responsive Management Trial
- bringing environmental water actions (such as SDLAM) into the Salinity Accountability Framework
- assist with the review of elevated salinity events
- develop and assist with BSM2030 knowledge priority projects
- implementation of BSM Roadmap and preparation for the BSM2030 mid-term review.

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