

JOINT VENTURES M&E

# Stand Condition Assessment (SCA) Tool case study demonstration – Report 1. Aims and methods to identify case study sites in NSW.

**MDBA JVM&E Program: Improving evaluation and reporting on woody vegetation condition outcomes, at regional and Basin scales**

NSW Department of Industry

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## Acronyms and abbreviations

Acronym or abbreviation	Expanded
API	Aerial Photo Interpretation
Basin Plan	Murray Darling Basin Plan
BWS	Basin Watering Strategy
DIWA	Directory of Important Wetlands in Australia
EEC	Endangered Ecological Community
JVM&E	Joint Venture Monitoring and Evaluation Program
JVSC	Joint Venture Steering Committee
FC NSW	Forestry Corporation NSW
HEVAE	High Ecological Value Aquatic Ecosystem
JVM&E	Joint Venture Monitoring and Evaluation Program
JVSC	Joint Venture Monitoring and Evaluation (JVM&E) Program Steering Committee
LTIM	Long Term Intervention Monitoring (an Australian Commonwealth Government-funded environmental flow monitoring program)
LTWP	Long Term Water Plans
MDBA	Murray-Darling Basin Authority
MER	Monitoring, Evaluation and Reporting
NSW OEH	NSW Office of Environment and Heritage
NSW VIS	NSW Vegetation Information System
PAI	Plant Area Index (used for assessing tree health)
SCA Tool	Stand and Condition Assessment Tool
TLM	The Living Murray Program
VTAG	Vegetation Technical Advisory Group (a sub-committee of the JVSC)
WRP	Water Resource Plan
WRPA	Water Resource plan Area
WSP	Water Sharing Plan

# 1. Introduction

Throughout the Murray-Darling Basin (the Basin) modification of river flows, and the reduction in frequency, duration and timing of flooding, compounded by climate change and deteriorating groundwater, has created unfavourable conditions for all life-history stages of the dominant floodplain woody vegetation species; river red gum (*Eucalyptus camaldulensis*), black box (*Eucalyptus largiflorens*) and coolibah (*Eucalyptus coolabah*). For example, in the Murray River floodplain, this had led to widespread dieback of river red gum forests of 79% by area in 2011 (MacNally et al. 2011).

The Murray-Darling Basin Authority (MDBA) Stand Condition Assessment (SCA) Tool uses remote sensing of tree stand condition and on-ground assessment of adult trees to support the evaluation and reporting on Basin Plan vegetation outcomes. The remotely sensed data collected for the SCA tool provides a measure of canopy health derived from remotely sensed pixel 'greenness' scores. The *Stand Condition model* inputs are statistically correlated with on-ground measures of stand condition, which allows for inferences stand condition at multiple spatial scales, including the Basin-scale (Cunningham et al. 2011).

Outputs of the SCA Tool are currently used for evaluation and reporting (e.g. The Living Murray (TLM) Icon site and 2017 Basin Plan Vegetation Evaluation), but refinements have been identified to improve the modelled outputs and their use in evaluating and reporting on relevant vegetation outcomes across the Basin. In addition, there is a need for improved capacity of the SCA Tool performance in areas with no or very limited on-ground data, and in areas which are different to the mid-Murray where the tool was originally trained (e.g. north and south western NSW), specifically understanding how pixel 'greenness' relates to stand condition in those areas.

The MDBA *Basin Watering Strategy* (BWS) (MDBA 2014) outlines the expected outcomes for forests and woodlands in the NSW Basin that states are required to meet with environmental water:

- to maintain the current (2013) extent of forest and woodland vegetation
- no decline in the condition (2014) of river red gum, black box and coolibah across the Basin
- by 2024, improved condition of river red gum in the Lachlan, Murrumbidgee, Lower Darling, and Murray

The MDBA's Joint Steering Committee for Monitoring and Evaluation (JVSC), Vegetation Technical Advisory Group (VTAG) developed a project '*Improving evaluation and reporting on woody vegetation outcomes, at regional and basin scales*', under the Murray-Darling Basin (MDB) Joint Venture Monitoring and Evaluation (JVM&E) Program. This project seeks to

- Improve the knowledge base and refine tools to enable consistent and accurate condition assessments of River Red Gum, Black Box and Coolabah-dominated forests and woodlands across the Murray-Darling Basin; and in turn,
- Improve evaluation and reporting on woody vegetation condition outcomes at a range of spatial scales across the Basin (e.g. State priority assets, catchments, States, and Basin-wide).

## 2. Aims and scope

As part of this project the NSW Department of Industry-Water (DOIW) was required to undertake the following activities:

- Identify and test priority State-based case study sites to apply the SCA Tool to improve the understanding and accuracy of outputs, and target on-ground surveys on woody vegetation condition. This case study will examine the performance of the SCA tool in regions with little on ground data to answer the key questions:

(1) What is the on-ground condition of woody vegetation?

and

(2) How does this compare with that predicted by the SCA tool?

By the undertaking the following tasks:

- (1) Undertake case study design and site selection in New South Wales to investigate the performance of the SCA Tool, including cross-referencing SCA Tool outputs with State site-data and expert knowledge; and
- (2) Carry out woody vegetation condition field surveys for at least ten sites (budget dependant) across the MDB in New South Wales to identify and describe woody vegetation attributes and undertake stand condition assessments for case study site validation and gap analyses, where required
- (3) Provide the Stand Condition assessment data to the MDBA and any relevant data to the NSW Department of Industry Spatial Database, as per the data protocols and metadata requirements specified.

This report outlines the case study design and site selection (task 1) undertaken in New South Wales.

## 3. Methods for case study design and site selection in New South Wales

### 3.1. Existing NSW data and survey site inventory

The DOIW undertook an inventory of all available studies and datasets that contained tree stand condition data that had been collected under separate programs and for varying purposes. The studies are described in the following sections.

#### 3.1.1. Stand and Condition Tool and the Living Murray Program survey sites

The SCA Tool originally related only to river red gum and black box stands across The Living Murray (TLM) 'Icon Sites' on the Murray River. It was developed using a combination of field data (175 reference sites) and Landsat satellite imagery (Cunningham, et al., 2009a; 2009 b). A follow-up study was undertaken in 2010 (Cunningham et al., 2011). A subsequent modelling investigation was undertaken in 2013 (Cunningham et al. 2014). Additional field observations acquired across the Basin in 2014, 2015 and late 2016 / early 2017 (Newell et al. 2017).

#### 3.1.2. NSW OEH Healthy Inland Wetlands and Environmental Water Program

Location of survey sites and survey data were sourced from the vegetation response monitoring component of the NSW OEH Healthy Inland Wetlands and Environmental Water Program (NSW EWMER). The Program includes environmental monitoring, evaluation and reporting (MER) to inform adaptive management of environmental water management and demonstrate and communicate environmental outcomes (NSW OEH 2017). During the period 2010/11 to 2016/17 tree stand condition data was collected from the Macquarie Marshes, Lower Murrumbidgee Floodplain, Narran Nature Reserve and Gwydir Wetlands. The outputs from the Macquarie Marshes is presented in Bowen et al. (2018).

#### 3.1.3. CEWO Long Term Intervention Monitoring, Lachlan sites

Location of survey sites and tree stand condition data were sourced from the Commonwealth Environmental Water Office (CEWO) Long Term Intervention Monitoring Project (LTIM), Lachlan

LTIM Selected area (CEWO 2015a, 2015b; Dyer et al. 2016; Dyer et al. 2018). The LTIM Project aimed to monitor and evaluate the contribution of Commonwealth environmental water delivery in the Murray-Darling Basin over 5 years (June 2014 to June 2019) (CEWO 2013; Gawne et al. 2013).

### 3.1.4. MDBA SCA Tool NSW gap analysis

#### 3.1.4.1. MDBA SCA Model gap analysis

The MDBA provided a list of 300 plot locations in NSW as geographic co-ordinates to the DOIW. To generate these plot locations, a stratification of potential regions across the NSW Basin was developed. The 300 candidate plots were then selected from a raster surface of the stand condition model from regions that consistently performed poorly in terms of statistical variability (i.e. an assessment of the Coefficient of Variance (CoV) around the modelled stand condition values) (White 2018).

The sites with the highest CoV also tended to correlate the least well with the current SCA Tool; thus are the most likely sites to help train the SCA Tool so that it handles the broader range of values likely to be received in future modelling (Matt White, Arthur Rylah Institute, *pers. comm.* to P. Driver). These areas were typically correlated with woodland areas or areas with sparse tree cover and where the understorey formed part of the reflectance signature. They also generally represented communities that were subject to more arid flow regimes. From the candidate areas plots were chosen that were easily accessible to field survey teams (i.e. delimited by distance from the public road network and on appropriate land tenures) (White 2018).

The 300 candidate plots in NSW were ranked in order by location in regions of most variability (number 1) to least variability (number 300), in the stand condition model.

#### 3.1.4.2. Selection of gap analysis plots in NSW

NSW DOIW used spatial overlay analysis in the geographic Information System (ArcGIS 10.1), to select a subset of these candidate plot locations. The candidate plot sites were overlain on the best available vegetation mapping, compared to existing survey plot locations and plots were selected on the following criteria:

- Located in Water Resource Plan (WRP) areas (WRPA) of interest for NSW MER purposes, and where data was lacking
- On public land or land with known, supportive private landholders
- Clustered for ease of access and efficiency of survey
- Plots with greatest uncertainty (i.e. lower number on the list) as they are stands with sparser canopy or lower condition tree stands. These lower ranked sites were more critical for helping refine the SCAT.

Alternative (second priority) plots were nominated in the sampling design to account for access problems. Forty of the 300 candidate gap analysis sites were selected as first priority sites and 32 alternative sites were selected located in the Macquarie, Lachlan, Intersecting Streams/Barwon Darling and Lower Darling WRP areas. See tables in sections 4 and 5.

## 3.2. NSW case study area and sampling plot selection process

Case study areas for the SCA Tool were chosen to assist NSW government better report against the expected outcomes for forests and woodlands in NSW. Under Part 4, Chapter 8 of the Basin Plan, the BWS, Water Resource Plans (WRPs), and Long Term Water Plans (LTWPs) are part of the framework for managing environmental water at the Basin and catchment-scale (NSW DOIW in prep a; MDBA 2012a). Under this framework WRPs align Basin-wide and state-based water resource management in each water resource plan area (WRPA) (NSW DOI 2018). In addition,

LTWPs apply to WRP areas and must contribute to the achievement of the BWS (NSW OEH 2018a).

Case study areas were selected from areas within WRPA identified by DOIW as being of high ecological value in NSW, under the High Ecological Value Aquatic Ecosystem (HEVAE) framework. The HEVAE framework consists of five key criteria (diversity, distinctiveness, naturalness, vital habitat and representativeness) and is used at a range of scales to map and prioritise aquatic assets for water management (Aquatic Ecosystems Task Group 2012; Healey et al. 2018).

Level of risks to assets within water sources are identified and prioritised in DOIWs' Risk Assessment process undertaken as part of developing each WRP in NSW. Part 9, Chapter 10 of the Basin Plan sets out the key requirements for WRP risk assessments (MDBA 2012a; NSW DOIW 2019). Case study areas were selected from water sources identified at Medium and high risk within each WRPA.

Case study areas will provide data for the DOIW to evaluate WSP rules and objectives for water dependent woody vegetation near river channels and on low-lying areas (riparian and/or GDE sites) and, to monitor ecological objectives for medium risk red gum coolibah and black box communities, in line with NSW DOIW's Vegetation Monitoring Evaluation and Reporting program (NSW DOIW in prep b),

In summary the NSW SCA Tool case study areas were selected based on the following criteria:

- To provide a representative sampling of the water dependent woody vegetation (riverine river red gum, coolibah and black box communities), near river channels and on low-lying areas for Basin Plan and WRP MER.
- Located in priority water sources within WRPA identified in DOIWs Risk Assessment process
- Located in water sources within WRPA identified under the HEVAE Framework to align with NSW Basin Plan Matter 8 reporting.
- Located in water sources within WRPA that are likely to be subject to management actions using planned (and also discretionary) environmental water

Within each case study area plots were selected:

- To be clustered for ease of access and efficiency of survey
- To fill data gaps identified in the SCA Tool Gap analysis
- To complement existing sites and increase stratification and replication within the riverine landscape, within river red gum, coolibah and black box communities.

## 4. NSW case study areas – Northern NSW Basin

The case study areas and sampling plots in the NSW Northern Basin WRPA are described. Each plot is assigned to a NSW Plant Community Type (NSW PCT) (NSW OEH 2019a) by overlay analysis in ArcGIS on the best available vegetation community mapping.

### 4.1. Lower Macquarie River and Lower Bogan River

#### 4.1.1. Description of the case study areas

The Lower Macquarie River and Lower Bogan River case study areas are within the Lower Macquarie River unregulated and the Lower Bogan River unregulated water sources (Figure 1). These water sources are defined in the Macquarie–Castlereagh Water Resource Plan (WRP) (NSW Department of Industry 2018a). The Macquarie–Castlereagh LTWP is being developed by the NSW OEH (NSW OEH 2018a). It has been divided into 28 planning units (PUs). The PU boundaries typically align with WRP water source area boundaries in the Macquarie–Castlereagh WRP (NSW DOI, in prep c). Four unregulated PUs where ecological outcomes may be influenced by regulated deliveries are sampled in the Lower Macquarie/ Lower Bogan case study area:

- The Lower Macquarie and Marra Creek PUs can be influenced by regulated deliveries from the Macquarie River,
- The Marthaguy Creek PU can be influenced downstream of the Terrigal Creek junction by deliveries from the regulated Macquarie through the Eastern Marshes, and
- The Lower Bogan PU can be influenced by water deliveries from the regulated Macquarie through the distributary creeks (NSW OEH 2018b).

The Lower Macquarie River unregulated water source has high ecological values as assessed under the HEVAE framework, including the largest area (~ 40,000 ha), of remaining riparian vegetation in the Northern NSW Basin contained within and downstream of the Macquarie Marshes, (the Marshes) (NSW Department of Industry 2018a). The Marshes are commonly divided into the northern marsh and southern marsh and cover an area of approximately 200,000 hectares (NOW 2012a). The MDBA has identified the Marshes as a key environmental asset within the Basin and an important site for the determination of the environmental water requirements (MDBA 2012b; NSW Department of Industry 2018a). The Macquarie Marshes Ramsar site (19,850 ha), is a wetland of International Significance under the International *Convention on Wetlands* (the *Ramsar Convention*) (Department of Environment and Energy 2019a).

River red gum communities have declined in condition and extent in the Marshes since 1991. In 2008, 40 per cent of the 38,428 ha of river red gum communities were in poor condition (i.e. had more than 80 per cent dead canopy), 55 per cent were in intermediate condition or declining in condition and only 1,932 ha or 5 per cent of the total extent of river red gum communities were in good condition (i.e. had less than 10 per cent of the canopy dead) (Bowen & Simpson 2010; DECCW 2010). Levels had not recovered to the 1991 condition in 2013 (Bowen et al. 2017a; 2017b; Bowen et al 2018).

The Lower Macquarie River and associated waterways; Ginghet Creek and Bora Creek, run through the Marshes. The Ginghet and the unregulated Macquarie River emerge from the Marshes to flow into the Barwon River near Brewarrina. Along with the Marshes, delivered flows are targeted to the Macquarie River channel and the Lower Macquarie River downstream of the Marshes, with potential for water to influence the unregulated distributary systems of the Lower Crooked and Marra creeks. The Marra Creek, Lower Macquarie River (unregulated) and Marthaguy Creek all have high ecological values (NSW Department of Industry 2018a).

The lower reaches of the Bogan River flow roughly parallel to the lower Macquarie River, and a series of creeks break away from the Macquarie River to connect with the Bogan River before it flows north-west to meet the Barwon River upstream of Bourke (NSW DOI 2018a). HEVAE assessment of the Lower Bogan unregulated water source identified endangered ecological communities and threatened frog species (NSW DOI 2018).

#### 4.1.2. Stand condition plots in the case study area

The plots were selected from areas supporting riverine river red gum or coolabah woodland and were located in areas of the lower Macquarie and Bogan Rivers where no data had been collected previously. These sites are likely to receive environmental water continuing downstream of the Marshes in the Lower Macquarie and at the end of system in the Lower Bogan River.

##### 4.1.2.1. SCA Tool Gap analysis plots

Eight plots were selected for data collection from the SCA Tool gap analysis candidate plots in the 2018/19 water year (Figure 1, Table 1: SCaT\_Gap). These will be sampled from the 11 (6 first priority and 5 second priority) plots in the Lower Macquarie and 7 plots (2 first priority and 5 second priority) in the Lower Bogan water sources.

##### 4.1.2.2. Existing SCA Tool survey plots

Thirteen existing plots from the Lower Macquarie case study area will provide data from 2017 and will serve to complement the data collected in the 2018/19 year (Figure 1, Table 1: SCaT). These plots were selected as they occurred in riverine river red gum woodland and forest and coolabah woodland. Together with the gap analysis plots these survey plots should provide a representative sampling of the water dependent woody vegetation near river channels and on low-lying areas for Basin Plan and WRP MER.

#### 4.1.3. Existing stand condition mapping and data in the Macquarie Marshes

Mapping of the condition of the vegetation communities of the Macquarie Marshes was undertaken by the NSW Office of Environment and Heritage over three time periods 1991, 2008 and 2013 (Bowen et al. 2014). The spatial extent and canopy condition of vegetation communities in 2008 and 2013 was delineated by manual Aerial Photo Interpretation (API), of high-resolution (30 cm) digital colour aerial photographs captured in July 2008 and ground-truthed by field surveys in May, October and November 2008. The same area was remapped using high-resolution (50 cm) ADS40 digital colour aerial photographs captured in September 2013 and on ground survey data collected in March 2014. Line work of digitised of a vegetation map undertaken in 1991 (Wilson 1992), was reworked and revised by manual API using digital versions of scanned and ortho-rectified black and white aerial photography captured in January 1991, viewed on screen to a resolution of 1:1000 (Bowen et al. 2014). Co-incident georeferenced on ground survey data, stored in the NSW OEH Vegetation Information System (VIS) Flora Module (NSW OEH 2019), was analysed for vegetation type and condition (Bowen et al. 2017a; 2017b).

##### 4.1.3.1. Data analysis

The tree stand condition data from 37 plots in the Macquarie Marshes (Table 2) collected in 2014 using methods (Bowen 2016), that are compatible with the SCA method (Cunningham et al. 2018). This data can be used to derive the tree stand metrics used in the SCA Tool and condition scores generated from this data and compared to condition score outputs generated by the SCA Tool model.

##### 4.1.3.2. Spatial overlay analysis

The vegetation community canopy condition in 1991, 2008 and 2013/14 as mapped by Bowen et al. (2014), can be compared with the spatial mapping generated by the SCA Tool model and a comparison made in a spatial overlay analysis in ArcGIS 10.1 if suitable satellite imagery products are available.

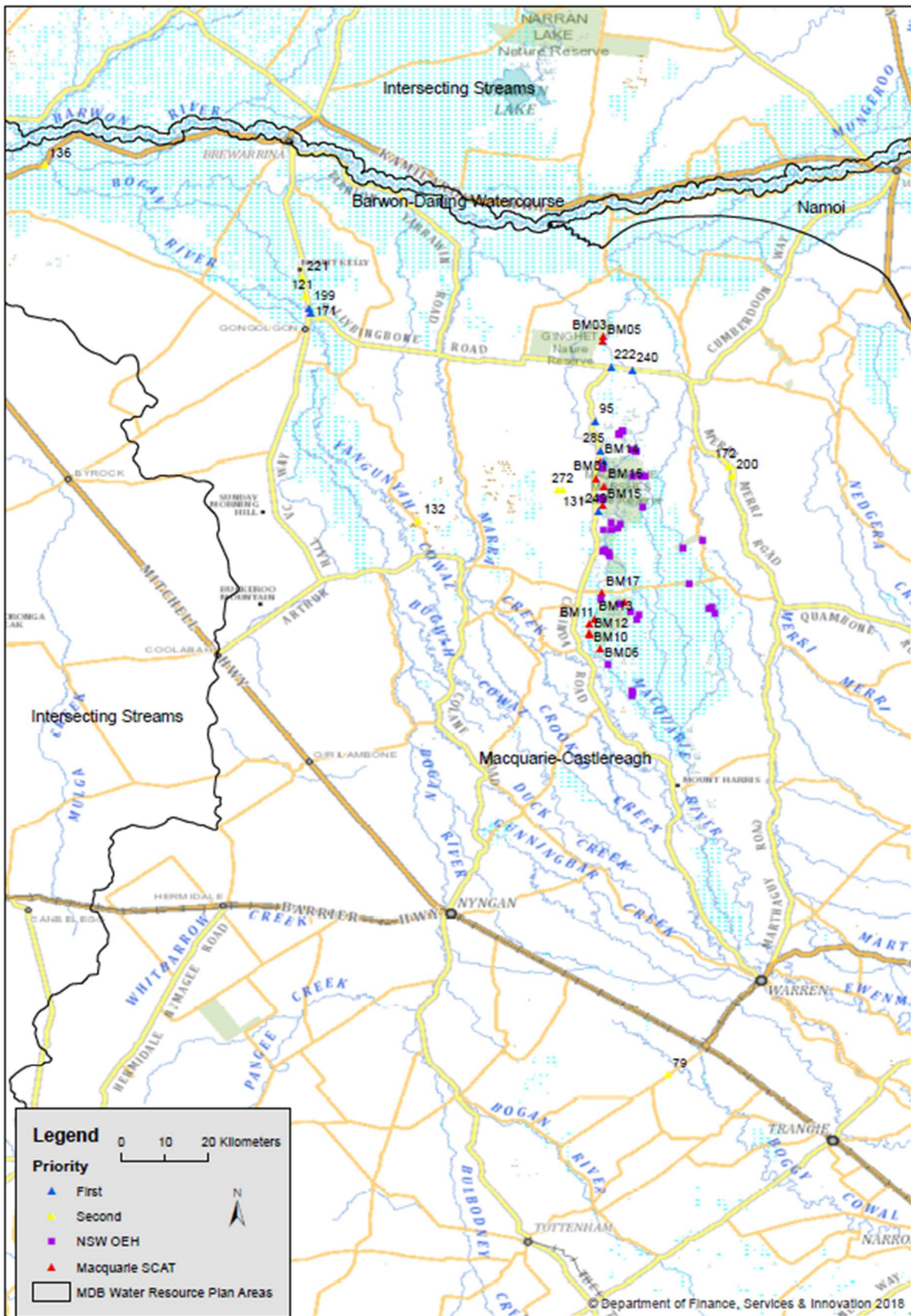


Figure 1 Lower Macquarie / Lower Bogan SCA Tool case study area

**Table 1 Lower Macquarie / Lower Bogan SCA Tool case study sites – SCA Tool**

Site name	Latitude	Longitude	NSW PCT ID	NSW Plant Community Type - Description	Program	Priority	Description	Location
BM04	-30.9164	147.5543	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT	Existing	Southern Macquarie Marshes Nature Reserve	Lower Macquarie
BM16	-30.6758	147.5116	36	River Red Gum tall to very tall open forest / woodland wetland	SCaT	Existing	Macquarie River Southern Nature Reserve	Lower Macquarie
BM03	-30.3668	147.5096	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT	Existing	Ginghet Nature Reserve	Lower Macquarie
BM05	-30.3749	147.5088	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT	Existing	Ginghet Nature Reserve	Lower Macquarie
BM15	-30.7148	147.5087	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT	Existing	Warren-Carinda Rd -W of Southern Nature Reserve	Lower Macquarie
BM17	-30.8976	147.506	36	River Red Gum tall to very tall open forest / woodland wetland	SCaT	Existing	Gibson's Way Macquarie River	Lower Macquarie
BM06	-31.0133	147.504	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT	Existing	Macquarie River Oxley	Lower Macquarie
BM14	-30.6245	147.504	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT	Existing	Macquarie River Southern Nature Reserve	Lower Macquarie
BM01	-30.6601	147.4947	37	Black Box woodland wetland	SCaT	Existing	Northern Macquarie Marshes Nature Reserve	Lower Macquarie
BM13	-30.9524	147.4916	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT	Existing	Macquarie River Southern Nature Reserve	Lower Macquarie
BM11	-30.9633	147.4819	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT	Existing	Macquarie River Southern Nature Reserve	Lower Macquarie
BM12	-30.9854	147.4817	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT	Existing	Macquarie River Southern Nature Reserve	Lower Macquarie
BM10	-30.9807	147.4806	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT	Existing	Macquarie River Bosses Road	Lower Macquarie
LM240	-30.435178	147.569444	40	Coolabah open woodland wetland	SCaT_Gap	First	Macquarie River Carinda Road	Lower Macquarie
LM222	-30.428031	147.526366	36	River Red Gum tall open forest / woodland wetland	SCaT_Gap	First	Macquarie River Carinda Road	Lower Macquarie
LM196	-30.625021	147.509857	40	Coolabah open woodland wetland	SCaT_Gap	First	Ginghet Creek Nth MMNR	Lower Macquarie
LM285	-30.601203	147.503428	36	River Red Gum tall to very tall open forest / wood	SCaT_Gap	First	Ginghet Creek Warren Carinda Rd	Lower Macquarie
LM249Rep	-30.706178	147.49327	36	River Red Gum tall open forest / woodland wetland	SCaT_Gap	First	Macquarie River Warren-Carinda Road	Lower Macquarie
LM95	-30.5398	147.492779	36	River Red Gum tall to very tall open forest / wood	SCaT_Gap	First	Ginghet Creek Warren Carinda Rd	Lower Macquarie
LM200Rep	-30.653874	147.7774	40	Coolabah open woodland wetland	SCaT_Gap	Second	Merri Creek - Merri Merri Rd	Lower Macquarie
LM172	-30.633716	147.769436	40	Coolabah open woodland wetland	SCaT_Gap	Second	Merri Merri Creek - Merri Merri Rd	Lower Macquarie

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Site name	Latitude	Longitude	NSW PCT ID	NSW Plant Community Type - Description	Program	Priority	Description	Location
LM131	-30.6825	147.42652	37	River Red Gum tall open forest / woodland wetland	SCaT_Gap	Second	Floodplain depression of Warren - Carinda Rd west of MM NNR	Lower Macquarie
LM272	-30.682958	147.417623	40	Coolabah open woodland wetland	SCaT_Gap	Second	Floodplain depression of Warren - Carinda Rd west of MM NNR	Lower Macquarie
LM132Rep	-30.822330	147.152123	37	Black Box woodland wetland	SCaT_Gap	Second	Yangunyah Cowal Monkey Bridge Rd	Lower Macquarie
LB171	-30.317247	146.903865	40	Coolabah open woodland wetland	SCaT_Gap	First	Boomi Creek Arthur Hall VC Way	Lower Bogan
LB199	-30.306218	146.90055	40	Coolabah open woodland wetland	SCaT_Gap	First	Boomi Creek Arthur Hall VC Way	Lower Bogan
LB37	-32.479724	147.930836	36	River Red Gum tall open forest / woodland wetland	SCaT_Gap	Second	Bogan River on The McGrane Way	Lower Bogan
LB79Rep	-31.898670	147.646253	40	Coolabah open woodland wetland	SCaT_Gap	Second	Trowan Cowal Nevertiire-Bogan Rd	Lower Bogan
LB121	-30.2815	146.89452	40	Coolabah open woodland wetland	SCaT_Gap	Second	Canal off Boomi Creek	Lower Bogan
LB221	-30.244192	146.887818	40	Coolabah open woodland wetland	SCaT_Gap	Second	Canal off Boomi Creek	Lower Bogan
LB136	-30.010038	146.354241	40	Coolabah open woodland wetland	SCaT_Gap	Second	Bogan River Kamilaroi Highway	Lower Bogan

Rep = Gap Plot relocated to public land

**Table 2 Lower Macquarie existing NSW OEH sites**

Site name	Latitude	Longitude	NSW PCT ID	NSW Plant Community Type - Description	Program	Description	Location
MM 2	568362	6593304	37	Black Box woodland wetland	NSW OEH	Macquarie Marshes -East	Lower Macquarie
MM 23	570805	6576850	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -East	Lower Macquarie
Nov 16	565704	6583537	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -East	Lower Macquarie
Nov 7	570157	6578114	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -East	Lower Macquarie
Nov 8	569521	6577912	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -East	Lower Macquarie
Bluelight A	552053	6618245	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Bluelight B	551976	6618115	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Bluelight C	552059	6618152	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Hunts 1	554663	6608373	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Hunts 2	557077	6608456	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Hunts 3	556301	6608361	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
PoorRRG1	551609	6596193	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
MM 21	550354	6596063	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie

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Site name	Latitude	Longitude	NSW PCT ID	NSW Plant Community Type - Description	Program	Description	Location
MM 22	550421	6596172	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
MM C	549907	6589827	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
MM I	548782	6595877	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Nov 10	555213	6614091	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Nov 11	554444	6614466	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Nov 12	550235	6597896	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Nov 2	548678	6603079	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Nov 9	555376	6614107	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
NthNR 8	556634	6601322	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
NthNR16	548637	6603170	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
RRG 1	552158	6597575	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Ublock 2	549095	6591262	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Ublock 3	549869	6590769	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Ublock 4	549700	6590840	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Ublock 6	548582	6590970	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -North	Lower Macquarie
Barlows Lagoon 1	555248	6575351	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -South	Lower Macquarie
ExpLagoon	551966	6578961	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -South	Lower Macquarie
PoorRRG2	548186	6579912	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -South	Lower Macquarie
Nov 5	549476	6565210	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -South	Lower Macquarie
Oxley 1	554341	6557848	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -South	Lower Macquarie
Oxley 4	554160	6559008	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -South	Lower Macquarie
Oxley 5	554408	6558739	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Macquarie Marshes -South	Lower Macquarie
Barlows Lagoon 2	555248	6575351	40	Coolibah open woodland wetland with chenopod/grassy ground cover	NSW OEH	Macquarie Marshes -South	Lower Macquarie
MM II	554122	6577226	40	Coolibah open woodland wetland with chenopod/grassy ground cover	NSW OEH	Macquarie Marshes -South	Lower Macquarie

## 4.2. NSW Culgoa River and NSW Narran River

### 4.2.1. Description of the case study areas

The Culgoa and Narran River case study areas are in the Culgoa and Narran water sources, within the Intersecting Streams WRPA, near Bourke in north-western NSW. The Culgoa and Narran Rivers are tributaries of the Balonne River, part of the Condamine River system with headwaters in south-eastern Queensland (NOW 2011). The Culgoa River (and Birrie and Bokarra Rivers), enter the Barwon River (NPWS 2000). The Narran River terminates in Narran Lake except in exceptional flood years. The Narran River flows intermittently as a result of heavy rainfall in Queensland and annual flows are highly variable (NOW 2011).

The Culgoa River and Narran River water sources are in the arid zone and have hot dry summers (> 40 °C) and mild dry winters, rainfall averages around 200 mm (NOW 2011). Climate change is predicted to increase temperatures and reduce rainfall resulting in decreases of surface water availability of 8.5 per cent in the Culgoa and Narran River water sources by 2030 (CSIRO 2007a; CSIRO 2007b).

The Culgoa and Narran River water sources support river red gum and river cooba (*Acacia stenophylla*) communities. Coolibah and black box woodlands are common on the plains (NOW 2011). Within the Culgoa River case study area is the Culgoa National Park (35,239 ha). It has the largest continuous tract of coolibah woodland in NSW and supports one of the largest koala populations in northern NSW. It is the only national park in NSW with the Endangered Ecological Community (EEC); Brigalow-gidgee woodland (NPWS 2019). Culgoa National Park is continuous with the Culgoa Floodplain National Park in Queensland (Queensland Department of Environment and Science 2019).

Within the Narran River case study area is the Narran Nature Reserve (26,480 hectares) covering part of the terminal wetland of the Narran River. Part of the reserve (8,447 hectares), is listed as the Narran Lake Nature Reserve Ramsar site and comprises the whole floodplain wetland area (NSW OEH 2019b). The wetlands have large areas of dense lignum (*Duma florulenta*) shrubland and river red gum, Coolibah and cooba woodland (NPWS 2000).

### 4.2.2. Stand condition data in the case study area

#### 4.2.2.1. SCA Tool Gap analysis plots

Eight plots were selected for data collection in the 2018/19 water year from the SCA Tool gap analysis candidate plots. They were selected in areas of the Culgoa River case study area where no data had been collected previously (Table 3: SCaT\_Gap). These will be sampled from 16 (8 first priority and 8 second priority) plots in the Culgoa River water source.

#### 4.2.2.2. Existing SCA Tool survey plots

Eleven 11 existing SCA Tool plots (5 from the Culgoa and 6 from the Narran River) will provide data from 2017 and will serve to complement the data collected in the 2018/19 year (Table 3: SCaT).

### 4.2.3. Existing stand condition data in the Narran Nature Reserve

#### 4.2.3.1. Data analysis

Tree stand condition data from 16 plots in the Narran Nature Reserve (Table 4) were collected in 2017 using methods (Bowen 2016) that are compatible with the SCA method (Cunningham et al. 2018). This data can be used to derive the tree stand metrics used in the SCA Tool and condition scores generated from this data and compared to condition score outputs generated by the SCA Tool model.



**Table 3 Culgoa River and Narran River SCA Tool case study sites – SCA Tool**

Site name	Latitude	Longitude	NSW PCT ID	NSW Plant Community Type - Description	Program	Priority	Description	Location
IS114	-29.0735	147.0365	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT_Gap	First	Culgoa NR	Culgoa River
CM01	-29.3286	147.0648	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT	Existing	Birrie River Goodooga-Langboyd Rd	Culgoa River
CM03	-29.2863	147.3815	39	Coolibah - River Cooba - Lignum woodland wetland	SCaT	Existing	Bokhara River Goodooga Rd	Bokara River
CM04	-29.2888	146.8849	36	River Red Gum tall to very tall open forest / woodland wetland	SCaT	Existing	Culgoa River West Culgoa Rd SW of Weemoringle	Culgoa River
CM05	-29.5756	146.6076	36	River Red Gum tall to very tall open forest / woodland wetland	SCaT	Existing	Culgoa River West Culgoa Rd SW of Weemoringle	Culgoa River
CM06	-29.402	146.6842	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT	Existing	Culgoa River West Culgoa Rd SW of Weemoringle	Culgoa River
CM07	-29.4004	146.7168	37	Black Box woodland wetland	SCaT	Existing	Culgoa River West Culgoa Rd SW of Weemoringle	Culgoa River
CM13	-29.3063	147.7615	39	Coolibah - River Cooba - Lignum woodland wetland	SCaT	Existing	Narran River off Castlereagh Hwy	Narran River
CM14	-29.5878	147.4167	39	Coolibah - River Cooba - Lignum woodland wetland	SCaT	Existing	Narran River Kilarney-Amarod Rd	Narran River
CM15	-29.4476	147.5234	39	Coolibah - River Cooba - Lignum woodland wetland	SCaT	Existing	Narran River Wilby Rd	Narran River
CM16	-29.6694	147.3988	37	Black Box woodland wetland	SCaT	Existing	Narran River Narran Nature Reserve Narran Lake Rd	Narran River
CM23	-29.6929	147.3709	37	Black Box woodland wetland	SCaT	Existing	Narran River - Narran Nature Reserve Narran Lake Rd	Narran River
IS115	-29.0745	147.0365	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT_Gap	First	Culgoa NR	Culgoa River
IS169	-29.69367	146.6399	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT_Gap	First	Culgoa River Twin Rivers Road	Culgoa River
IS168	-29.97993	146.0109	39	Coolibah - River Cooba - Lignum woodland wetland	SCaT_Gap	Second	Darling River West Culgoa Rd	Culgoa River
IS184	-29.69096	146.6465	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT_Gap	First	Culgoa River Twin Rivers Road	Culgoa River
IS185	-29.71802	146.676	39	Coolibah - River Cooba - Lignum woodland wetland	SCaT_Gap	First	Culgoa River Twin Rivers Road	Culgoa River
IS186	-29.71791	146.679	39	Coolibah - River Cooba - Lignum woodland wetland	SCaT_Gap	First	Culgoa River Twin Rivers Road	Culgoa River
IS52	-29.1225	147.0175	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT_Gap	First	Culgoa River off West Culgoa Rd	Culgoa River

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Site name	Latitude	Longitude	NSW PCT ID	NSW Plant Community Type - Description	Program	Priority	Description	Location
IS38	-29.1225	147.0165	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT_Gap	Second	Culgoa River off West Culgoa Rd	Culgoa River
IS183	-29.92012	146.1762	37	Black Box woodland wetland	SCaT_Gap	Second	Warraweena Lagoon West Culgoa Rd	Culgoa River
IS218	-29.89849	146.0182	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT_Gap	Second	Whiskey Creek Mitchell Hwy near Bunndy Road	Culgoa River
IS219	-29.86433	146.0212	39	Coolibah - River Cooba - Lignum woodland wetland	SCaT_Gap	Second	Whiskey Creek Mitchell Hwy near Bunndy Road	Culgoa River
IS220	-29.91769	146.9131	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT_Gap	Second	Cato Creek -Kamilaroi Hwy	Culgoa River
IS238	-29.97161	146.0213	39	Coolibah - River Cooba - Lignum woodland wetland	SCaT_Gap	Second	Darling River West Culgoa Rd	Culgoa River
IS250 Rep	-29.1618	147.004	39	Coolibah - River Cooba - Lignum woodland wetland	SCaT_Gap	Second	Culgoa River off West Culgoa Rd	Culgoa River
IS26	-29.12554	147.0128	40	Coolibah open woodland wetland with chenopod/grassy ground cover	SCaT_Gap	First	Culgoa River off West Culgoa Rd	Culgoa River

Rep = Gap Plot relocated to public land

**Table 4 Culgoa River and Narran River SCA Tool case study sites – existing NSW OEH sites**

Site name	Latitude	Longitude	NSW PCT ID	NSW Plant Community Type - Description	Program	Description	Location
NarRRG 4	-29.7213	147.463	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Back Lake	Narran River
NarRRG7	-29.7151	147.4606	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Back Lake	Narran River
NarRRG 5	-29.7133	147.456	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Back Lake	Narran River
NarRRG 3	-29.7128	147.4504	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Lignum Swamp East	Narran River
NarCool 4	-29.7093	147.4319	40	Coolibah open woodland wetland with chenopod/grassy ground cover	NSW OEH	Lignum Swamp West	Narran River
NarCool 3	-29.7311	147.4109	39	Coolibah - River Cooba - Lignum woodland wetland	NSW OEH	Trewah Trail	Narran River
None	-29.7192	147.4109	39	Coolibah - River Cooba - Lignum woodland wetland	NSW OEH	Trewah Trail	Narran River
NarCool 2	-29.7206	147.4079	39	Coolibah - River Cooba - Lignum woodland wetland	NSW OEH	Trewah Trail	Narran River
Bundahcool8	-29.7518	147.386	39	Coolibah - River Cooba - Lignum woodland wetland	NSW OEH	Bundah Tilbbeys Trail	Narran River
Bundahcool7	-29.7517	147.385	39	Coolibah - River Cooba - Lignum woodland wetland	NSW OEH	Bundah Tilbbeys Trail	Narran River
NarCool 1	-29.6709	147.3717	40	Coolibah open woodland wetland with chenopod/grassy ground cover	NSW OEH	Big Ben Trail Narran River	Narran River

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Site name	Latitude	Longitude	NSW PCT ID	NSW Plant Community Type - Description	Program	Description	Location
Bundacool5	-29.7314	147.3696	39	Coolibah - River Cooba - Lignum woodland wetland	NSW OEH	Bundah Tilbbeys Trail	Narran River
Bundahcool6	-29.7299	147.3688	39	Coolibah - River Cooba - Lignum woodland wetland	NSW OEH	Bundah Tilbbeys Trail	Narran River
NarRRG6	-29.6734	147.367	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Big Ben Trail Narran River	Narran River
NarRRG 2	-29.6735	147.3653	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Big Ben Trail Narran River	Narran River
NarRRG 1	-29.672	147.3632	36	River Red Gum tall to very tall open forest / woodland wetland	NSW OEH	Big Ben Trail Narran River	Narran River

## 5. NSW case study areas – Southern NSW Basin

The case study areas and sampling plots in the NSW Southern Basin WRPAs are described. Each plot is assigned to a NSW Plant Community Type (NSW PCT) (NSW OEH 2019a) by overlay analysis in ArcGIS on the best available vegetation community mapping (NSW OEH 2019b).

### 5.1. Lower Lachlan

#### 5.1.1. Description of the case study area

The Lower Lachlan case study area is the extensive floodplain environment of the western part of the catchment of the Lachlan WSPA (NSW Department of Industry 2018b). The Lachlan River is a usually a terminal system with little water flowing past the Great Cumbung Swamp at the end of the river (Driver et al. 2010, CEWO 2012). Over time, regulation of flow in the Lachlan River has decreased the amount of water reaching the wetlands, detrimentally affecting flood-dependent vegetation such as river red gums (Armstrong et al. 2009, Higgison et al. 2019).

The Lower Lachlan SCA Tool case study area (Figure 3), includes three hydrologic indicator sites that are determined to be crucial environmental assets of the Basin; the Great Cumbung Swamp, Booligal Wetlands and the Lachlan Swamp (MDBA 2012c; MDBA 2012d; MDBA 2012e). They are listed in the Directory of Important Wetlands in Australia (Department of Environment and Energy 2019b). They support at least six flow-dependent frog species (Amos 2017; Dyer et al. 2016; Amos et al. 2014). The aquatic ecological community in the natural drainage system of the lower Lachlan River is also listed as an endangered ecological community (EEC) in NSW (NSW DPI 2006).

The Booligal Wetlands (~15,000 hectares), include the floodplains of the Merrimajeel and Muggabah Creeks, distributaries of an anabranch of the Lachlan River. Watercourses are lined by black box and lignum swamps, and provide extensive habitat for waterbird breeding (NSW OEH 2018b). They support some of the most extensive areas of lignum in NSW, and when flooded, support breeding colonies of up to 120,000 pairs of ibis (Magrath 1992; Australian Heritage Commission 1998; Chowdhury & Driver 2007). The Booligal Wetlands are consistent with the Lachlan LTWP PUs; PU12: Merrowie Creek, PU13: Merrimajeel Creek and PU15: Muggabah Creek (NSW OEH 2018c).

Lachlan Swamp (30,000 hectares), extends from Lachlan Valley Nature Reserve downstream past Oxley to just above the commencement of the Great Cumbung Swamp. It contains black box and lignum swamps. This is consistent with the LTWP PU14: Lower Lachlan watercourse (NSW OEH 2018c).

The Great Cumbung Swamp (16,000 hectares), is the terminal drainage swamp of the Lachlan River and the surrounding floodplain, and is an extensive complex of wetlands near the confluence of the Lachlan and Murrumbidgee Rivers. The Great Cumbung swamp contains large areas of reed beds (~ 4,000 ha), surrounded by river red gum woodlands, lignum swamps, shallow marshes and lakes. Together with the adjoining Lowbidgee wetlands, the swamp supports one of the largest areas of river red gum in southern NSW that interact with surface water and alluvial groundwater (Driver et al. 2004; Barbour et al. 2011; NSW Department of Industry 2018b). It is also important as waterbird breeding habitat (Chessman et al. 2003; Department of Environment and Energy 2019b). This is consistent with the LTWP PU16: Western Lachlan watercourse (NSW OEH 2018b).

#### 5.1.2. Stand condition data in the case study area

##### 5.1.2.1. SCA Tool Gap analysis plots

Eight plots were selected for data collection in the 2018/19 water year from the SCA Tool gap analysis candidate plots in the Lower Lachlan case study area, where no data had been collected previously (Table 7: SCaT\_Gap). These will be sampled from 4 (selected from 4 first priority and 2 second priority) plots in the Booligal Wetlands, 2 plots (selected from 2 first priority and 4 second priority) plots in the Lachlan Swamp and 2 (first priority) plots in the Great Cumbung Swamp.

#### 5.1.2.2. Existing SCA Tool survey plots

Twelve existing SCA Tool plots (10 from the Mid Lachlan and 2 from the Booligal Wetlands) will provide data from 2017 and will serve to complement the data collected in the 2018/19 year (Table 7: SCaT).

#### 5.1.3. Existing stand condition data from the Lachlan LTIM

##### 5.1.3.1. Data analysis

The tree stand condition data from 25 plots (8 from the Booligal Wetlands, 14 from Lachlan Swamp and 3 from the Great Cumbung Swamp) (Table 8) collected in under the Lachlan LTIM from 2014 to 2017 using methods (Bowen 2016), that are compatible with the SCA method (Cunningham et al. 2018). This data can be used to derive the tree stand metrics used in the SCA Tool and condition scores generated from this data and compared to condition score outputs generated by the SCA Tool model.

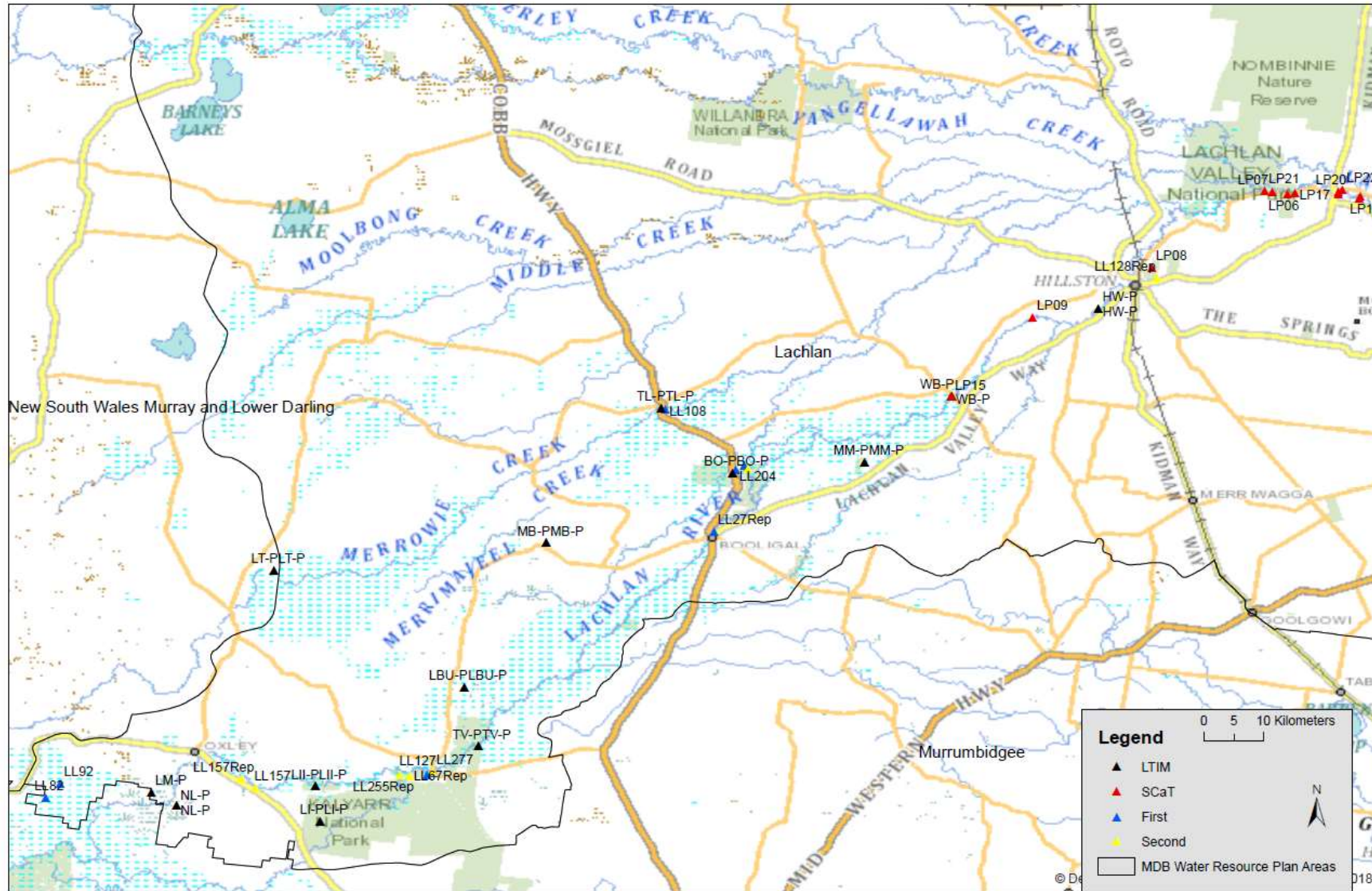


Figure 3 Lower Lachlan SCA Tool case study areas

**Table 5 Lower Lachlan SCA Tool case study plots – SCA Tool**

Site name	Latitude	Longitude	NSW PCT ID	NSW Plant Community Type - Description	Program	Priority	Description	Location
LP16	-33.3496	145.8739	10	River Red Gum - Black Box woodland wetland	SCaT	existing	E of Lachlan Valley NP W of Lake Cargelligo	Mid Lachlan
LP04	-33.3525	145.8723	10	River Red Gum - Black Box woodland wetland	SCaT	existing	E of Lachlan Valley NP W of Lake Cargelligo	Mid Lachlan
LP22	-33.339	145.8469	13	Black Box - Lignum woodland wetland	SCaT	existing	Lachlan Valley NP W of Lake Cargelligo	Mid Lachlan
LP10	-33.3455	145.8407	13	Black Box - Lignum woodland wetland	SCaT	existing	E of Lachlan Valley NP W of Lake Cargelligo	Mid Lachlan
LP20	-33.3424	145.8407	10	River Red Gum - Black Box woodland wetland	SCaT	existing	E of Lachlan Valley NP W of Lake Cargelligo	Mid Lachlan
LP17	-33.344	145.7746	10	River Red Gum - Black Box woodland wetland	SCaT	existing	E of Lachlan Valley NP W of Lake Cargelligo	Mid Lachlan
LP06	-33.3455	145.7632	13	Black Box - Lignum woodland wetland	SCaT	existing	Lachlan Valley NP W of Lake Cargelligo	Mid Lachlan
LP07	-33.3425	145.7402	13	Black Box - Lignum woodland wetland	SCaT	existing	E of Lachlan Valley NP W of Lake Cargelligo	Mid Lachlan
LP21	-33.3406	145.7284	10	River Red Gum - Black Box woodland wetland	SCaT	existing	Lachlan Valley NP W of Lake Cargelligo	Mid Lachlan
LP08	-33.4577	145.5567	15	Black Box open woodland wetland with chenopod understorey	SCaT	existing	Lachlan Valley Regional P E of Hillston	Mid Lachlan
LP09	-33.533	145.3754	13	Black Box - Lignum woodland wetland	SCaT	existing	Merungle Road W of Hillston	Booligal Wetlands
LP15	-33.6543	145.2506	11	River Red Gum - Lignum very tall open forest/woodland wetland	SCaT	existing	Crows nest Road w of Hillston	Booligal Wetlands
LL167Rep	-33.759	144.936	13	Black Box - Lignum woodland wetland	SCaT_GAP	First	Muggabah Creek Lachlan Valley SCA	Booligal Wetlands
LL204	-33.7655	144.92252	13	Black Box - Lignum woodland wetland	SCaT_GAP	First	Muggabah Creek	Booligal Wetlands
LL27Rep	-33.859	144.888	13	Black Box - Lignum woodland wetland	SCaT_GAP	First	Lachlan River Cobb hwy at Booligal	Booligal Wetlands
LL108	-33.673628	144.81589	11	River Red Gum - Lignum very tall open forest/woodland wetland	SCaT_GAP	First	Merowie Creek Cobb Hwy	Booligal Wetlands
LL128Rep	-33.473	145.563	13	Black Box - Lignum woodland wetland	SCaT_GAP	Second	Lachlan Valley Regional Park	Booligal Wetlands
LL190Rep	-33.235	144.941	13	Black Box - Lignum woodland wetland	SCaT_GAP	Second	Muggabah Creek Lachlan Valley SCA	Booligal Wetlands
LL33Rep	-34.225	144.466	13	Black Box - Lignum woodland wetland	SCaT_GAP	First	Lachlan River Kalyarr NP	Lachlan Swamp
LL127	-34.2265	144.46252	13	Black Box - Lignum woodland wetland	SCaT_GAP	First	Lachlan River The Langerin Road	Lachlan Swamp
LL157Rep	-34.235	144.466	13	Black Box - Lignum woodland wetland	SCaT_GAP	Second	Lachlan River Oxley Road	Lachlan Swamp
LL277	-34.2255	144.46152	13	Black Box - Lignum woodland wetland	SCaT_GAP	Second	Lachlan River The Langerin Road	Lachlan Swamp
LL67Rep	-34.231	144.427	13	Black Box - Lignum woodland wetland	SCaT_GAP	Second	Lachlan River Kalyarr NP	Lachlan Swamp
LL255Rep	-34.23	144.411	13	Black Box - Lignum woodland wetland	SCaT_GAP	Second	Lachlan River Kalyarr NP	Lachlan Swamp
LL92	-34.2435	143.89452	15	Black Box open woodland wetland with chenopod understorey	SCaT_GAP	First	Cockaoo Creek near Cumbung off Oxley Rd	Cumbung Swamp
LL82	-34.2645	143.87252	15	Black Box open woodland wetland with chenopod understorey	SCaT_GAP	First	Cockaoo Creek near Cumbung off Oxley Rd	Cumbung Swamp

Rep = Gap Plot relocated to public land

**Table 6 Lower Lachlan SCA Tool case study plots – Lachlan LTIM**

Site name	Latitude	Longitude	NSW PCT ID	NSW Plant Community Type - Description	Program	Priority	Description	Location
HW-P	-33.5208	145.4751	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Hazelwood	Booligal Wetlands
HW-P	-33.5208	145.4751	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Hazelwood	Booligal Wetlands
WB-P	-33.6541	145.2519	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Merrimajeel Creek Lachlan Valley Way	Booligal Wetlands
WB-P	-33.6541	145.2519	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Merrimajeel Creek Lachlan Valley Way	Booligal Wetlands
MM-P	-33.7539	145.1196	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Moon Moon Swamp	Booligal Wetlands
MM-P	-33.7539	145.1196	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Moon Moon Swamp	Booligal Wetlands
BO-P	-33.7707	144.9183	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Booligal Cobb Hwy	Booligal Wetlands
BO-P	-33.7707	144.9183	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Booligal Cobb Hwy	Booligal Wetlands
TL-P	-33.6719	144.8099	13	Black Box - Lignum woodland wetland	LTIM	existing	Tom's Lake	Lachlan Swamp
TL-P	-33.6719	144.8099	13	Black Box - Lignum woodland wetland	LTIM	existing	Tom's Lake	Lachlan Swamp
MB-P	-33.8767	144.6349	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Murrumbidgal Swamp	Lachlan Swamp
MB-P	-33.8767	144.6349	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Murrumbidgal Swamp	Lachlan Swamp
TV-P	-34.1863	144.5308	13	Black Box - Lignum woodland wetland	LTIM	existing	The Ville	Lachlan Swamp
TV-P	-34.1863	144.5308	13	Black Box - Lignum woodland wetland	LTIM	existing	The Ville	Lachlan Swamp
LBU-P	-34.0966	144.5098	11	River Red Gum - Lignum very tall open forest or woodland wetland	LTIM	existing	Lake Bullogal	Lachlan Swamp
LBU-P	-34.0966	144.5098	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Lake Bullogal	Lachlan Swamp
LI-P	-34.3007	144.2902	13	Black Box - Lignum woodland wetland	LTIM	existing	Lake Ita	Lachlan Swamp
LI-P	-34.3007	144.2902	13	Black Box - Lignum woodland wetland	LTIM	existing	Lake Ita	Lachlan Swamp
LII-P	-34.2469	144.2829	13	Black Box - Lignum woodland wetland	LTIM	existing	Lake Ita Inlet	Lachlan Swamp
LII-P	-34.2469	144.2829	13	Black Box - Lignum woodland wetland	LTIM	existing	Lake Ita Inlet	Lachlan Swamp
LT-P	-33.9194	144.2202	13	Black Box - Lignum woodland wetland	LTIM	existing	Lake Tarwong	Lachlan Swamp

**Stand Condition Assessment (SCA) Tool case study demonstration – Report 1. Aims and methods to identify case study sites in NSW.**

Site name	Latitude	Longitude	NSW PCT ID	NSW Plant Community Type - Description	Program	Priority	Description	Location
LT-P	-33.9194	144.2202	13	Black Box - Lignum woodland wetland	LTIM	existing	Lake Tarwong	Lachlan Swamp
NL-P	-34.2752	144.0715	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Nooran Lake	Cumbung Swamp
NL-P	-34.2752	144.0715	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Nooran Lake	Cumbung Swamp
LM-P	-34.2571	144.0332	11	River Red Gum - Lignum very tall open forest/woodland wetland	LTIM	existing	Lake Marool	Cumbung Swamp

## 5.2. Lower Darling and Lower Barwon-Darling Watercourse

### 5.2.1. Description of the case study area

The Barwon-Darling Watercourse case study area is within the Lower Barwon–Darling WRPA where it is sandwiched within the Lower Darling WRPA and the Intersecting Stream WRPA (Figure 4). Downstream of where the lower end of the Barwon River meets the Culgoa River, the river channel becomes the Darling River. The Barwon–Darling WRPA extends downstream to the Menindee Lakes and provides a connection to the southern Basin through the lower Darling River and provides habitat during dry periods. The most common vegetation community are riverine woodlands dominated by river red gum (NOW 2012b).

The Lower Darling case study area is within the Lower Darling WRPA (Figure 4). The lower Darling River flows from the Menindee Lakes to its junction with the River Murray at Wentworth. The catchment is located on the semi-arid plains of far south-western New South Wales, where most of the landscape has an elevation of less than 100 m, and rainfall less than 300 mm (NOW 2012c). The Menindee Lakes provide important habitat for waterbirds including threatened species like freckled duck, and migratory waders. The Menindee Lakes are listed in the Directory of Important Wetlands in Australia (DIWA) (Department of Environment and Energy 2019b; MDBA 2019).

Below the Menindee Lakes, the Darling River has two channels; its main channel, the lower Darling River, and its ancestral channel, the Great Darling Anabranh. The Great Darling Anabranh and its associated lakes provide refuge for wildlife during drought and are an important ecological asset in the Basin listed in the DIWA. Vegetation in the lower Darling consists largely of river red gum woodland in the riparian zone and immediate floodplain, and extensive areas of black box woodland with lignum and nitre goosefoot in the greater floodplain. Kinchega National Park near Menindee includes 62 km of Darling River frontage and is one of only two large conservation areas of river red gum woodland along the Darling River (MDBA 2019).

### 5.2.2. Stand condition data in the case study area

#### 5.2.2.1. SCA Tool Gap analysis plots

Twelve plots were selected for data collection in the 2018/19 water year from the SCA Tool gap analysis candidate plots in the Lower Darling case study area (12 first priority and 8 second priority in the ) along the Darling Lower Darling River where no data had been collected previously (Table 7: SCaT\_Gap).

#### 5.2.2.2. Existing SCA Tool survey plots

Eight existing SCA Tool / TLM plots (2 from the Barwon-Darling watercourse, 2 from the Darling at Menindee and 4 from the Western end of the Lower Darling at Wentworth) will provide data from 2017 and will serve to complement the data collected in the 2018/19 year (Table 7: SCaT).

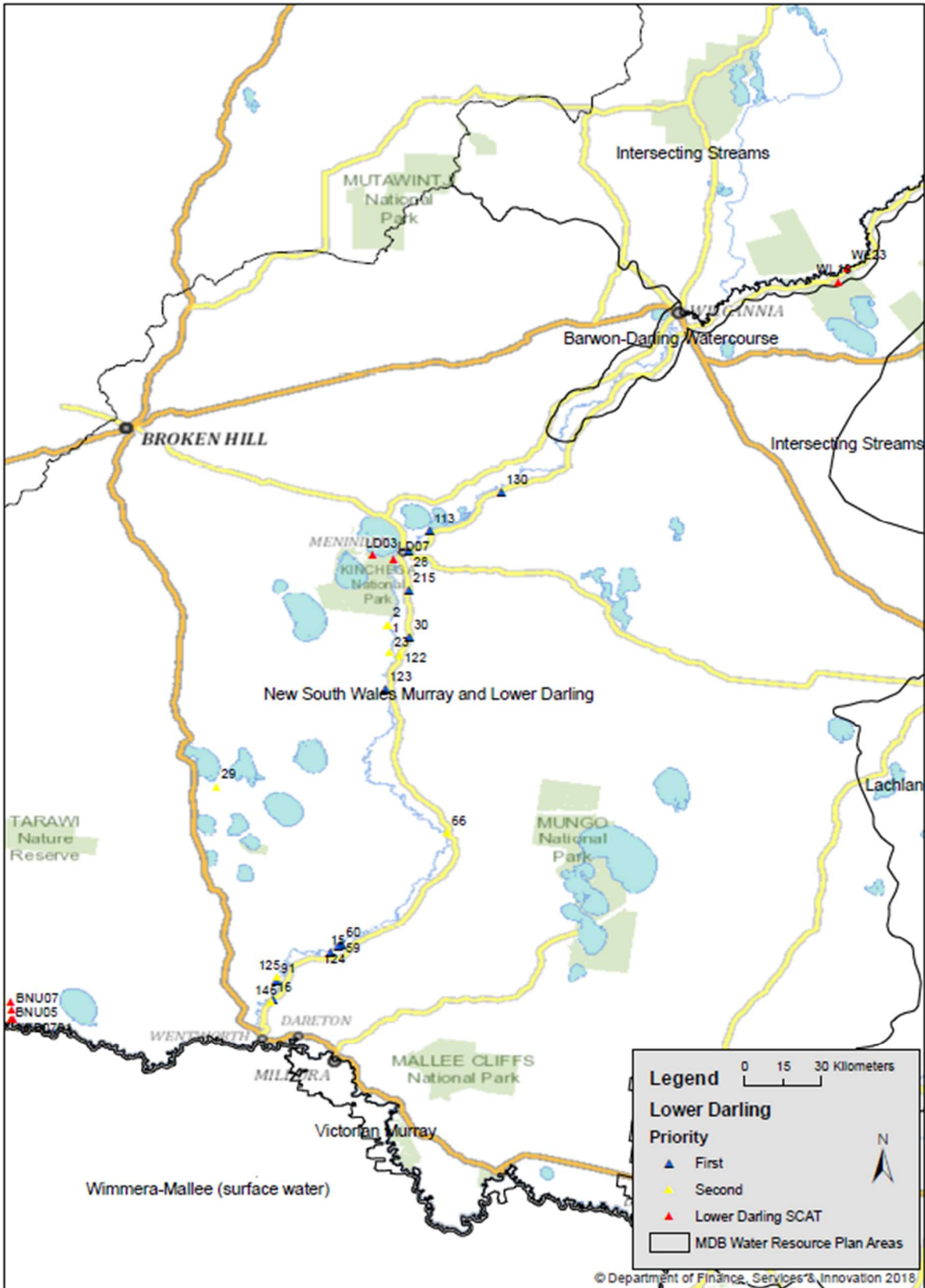


Figure 4 Lower Darling/Barwon-Darling Watercourse SCA Tool case study areas

**Table 7 Lower Darling/Barwon-Darling Watercourse SCA Tool case study plots – SCA Tool and TLM sites**

Site name	Latitude	Longitude	NSW PCT ID	NSW Plant Community Type - Description	Program	Priority	Description	Location
WL23	-31.3968	143.9722	36	River Red Gum tall to very tall open forest / woodland wetland	SCaT	Existing	Talywalka Creek East Tilpa Road	Barwon-Darling watercourse
WL19	-31.4455	143.9386	39	Coolibah - River Cooba - Lignum woodland wetland	SCaT	Existing	Menindee lake Papepapineilla Creek	Barwon-Darling watercourse
LD07	-32.4187	142.3793	13	Black Box - Lignum woodland wetland	SCaT	Existing	Menindee Lake Woolshed Drive	Darling River near Menindee
LD03	-32.4053	142.3064	13	Black Box - Lignum woodland wetland	SCaT	Existing	Menindee Lake	Darling River near Menindee
KKA0301	-34.0317	141.0452	11	River Red Gum - Lignum very tall open forest or woodland wetland	TLM	Existing	Salt creek Old Wentworth Road	Murray River W of Wentworth
BNU07	-33.9971	141.0404	11	River Red Gum - Lignum very tall open forest or woodland wetland	TLM	Existing	Salt creek Old Wentworth Road	Murray River W of Wentworth
KKB0701	-34.0334	141.0393	11	River Red Gum - Lignum very tall open forest or woodland wetland	TLM	Existing	Salt Creek Bannock Hill	Murray River W of Wentworth
BNU05	-33.9704	141.0364	11	River Red Gum - Lignum very tall open forest or woodland wetland	TLM	Existing	Salt creek Old Wentworth Road	Murray River W of Wentworth
LD29Rep	-33.4171	141.8357	11	River Red Gum - Lignum very tall open forest or wo	SCaT_Gap	Second	Great Darling Anabranh - Old Broken Mill Rd near Popio Lake	Darling Anabranh
LD130	-32.1829	142.7583	13	Black Box - Lignum woodland wetland	SCaT_Gap	First	Darling River - near Lake Wetherell - Wilcannia-Menindee Rd	Darling River near Kinchega NP
LD113Rep	-32.3717	142.47837	13	Black Box - Lignum woodland wetland	SCaT_Gap	First	Darling River - near Lake Wetherell	Darling River near Kinchega NP
LD28	-32.3900	142.4334	13	Black Box - Lignum woodland wetland	SCaT_Gap	First	Darling River - Menindee - Wilcannia - Menindee Rd	Darling River near Kinchega NP
LD215Rep	-32.5266	142.4333	13	Black Box - Lignum woodland wetland	SCaT_Gap	First	Charlie Stones Ck - Pooncarie Rd near Yampoola Bore	Darling River near Kinchega NP
LD30	-32.6921	142.4356	13	Black Box - Lignum woodland wetland	SCaT_Gap	First	Yampoola Creek - Pooncarie Rd near eight Mile Bore	Darling River near Kinchega NP
LD123	-32.8745	142.35052	13	Black Box - Lignum woodland wetland	SCaT_Gap	First	Darling River - Old Pooncarie Rd near Bobs Yards Bore	Darling River near Kinchega NP
LD122Rep	-32.7382	142.407	15	Black Box open woodland wetland with chenopod understorey	SCaT_Gap	Second	Darling River - Pooncarie Rd near Murley Cooley Point	Darling River near Kinchega NP
LD01	-32.6485	142.35852	39	Coolibah - River Cooba - Lignum woodland wetland	SCaT_Gap	Second	Darling River -near Pinnelco Bore	Darling River near Kinchega NP
LD02	-32.6485	142.36352	39	Coolibah - River Cooba - Lignum woodland wetland	SCaT_Gap	Second	Darling River -near Pinnelco Bore	Darling River near Kinchega NP

Site name	Latitude	Longitude	NSW PCT ID	NSW Plant Community Type - Description	Program	Priority	Description	Location
LD23	-32.7445	142.36752	15	Black Box open woodland wetland with chenopod understorey	SCaT_Gap	Second	Darling River - Old Pooncarie Rd near Murley Cooley Point	Darling River near Kinchega NP
LD124	-33.7775	142.18552	13	Black Box - Lignum woodland wetland	SCaT_Gap	First	Darling River - Nangulla Point on Pooncarie Rd	Darling River near Wentworth
LD15Rep	-33.8025	142.1297	13	Black Box - Lignum woodland wetland	SCaT_Gap	First	Darling River - Nangulla Point on Pooncarie Rd	Darling River near Wentworth
LD16Rep	-33.9654	141.9500	13	Black Box - Lignum woodland wetland	SCaT_Gap	First	Darling River - on Pooncarie Rd near Flecters Lake Rd	Darling River near Wentworth
LD59	-33.7725	142.19552	13	Black Box - Lignum woodland wetland	SCaT_Gap	First	Darling River - Nangulla Point on Pooncarie Rd	Darling River near Wentworth
LD60	-33.7725	142.19752	13	Black Box - Lignum woodland wetland	SCaT_Gap	First	Darling River - Nangulla Point on Pooncarie Rd	Darling River near Wentworth
LD91	-33.8975	141.96752	11	River Red Gum - Lignum very tall open forest or woodland wetland	SCaT_Gap	First	Darling River near junction with Tingui Creek	Darling River near Wentworth
LD125	-33.8855	141.97252	11	River Red Gum - Lignum very tall open forest or woodland wetland	SCaT_Gap	Second	Darling River near junction with Tingui Creek	Darling River near Wentworth
LD146Rep	-33.9705	141.953	11	River Red Gum - Lignum very tall open forest or woodland wetland	SCaT_Gap	Second	Darling River - on Pooncarie Rd near Flecters Lake Rd	Darling River near Wentworth
LD66	-33.3775	142.56852	13	Black Box - Lignum woodland wetland	SCaT_Gap	Second	Darling River - Pooncarie Rd near Ivanhoe Rd	Darling River near Ivanhoe

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