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# Operation Environmental Management Plan – Hunter River Pump Station Augmentation

Bayswater Power Station

Date: 10 July 2015

## Table of Contents

1.	Introduction.....	4
1.1.	<b>AGL Macquarie .....</b>	<b>4</b>
1.2.	<b>Project Description .....</b>	<b>4</b>
1.2.1.	Operation Activities.....	4
1.3.	<b>OEMP Context .....</b>	<b>7</b>
1.4.	<b>OEMP Objectives .....</b>	<b>7</b>
2.	Environmental Management.....	8
2.1.	<b>Environmental Management Structure and Responsibility .....</b>	<b>8</b>
2.1.1.	Roles and Responsibilities .....	8
2.2.	<b>Approval and Licensing Requirements .....</b>	<b>12</b>
2.2.1.	Approval Requirements .....	12
2.2.2.	Licensing Requirements .....	12
2.3.	<b>Reporting .....</b>	<b>13</b>
2.4.	<b>Environmental Training .....</b>	<b>15</b>
2.5.	<b>Emergency Contacts and Response .....</b>	<b>15</b>
2.6.	<b>Complaints Record .....</b>	<b>16</b>
3.	Implementation.....	16
3.1.	<b>Environmental Management Activities and Controls .....</b>	<b>16</b>
3.2.	<b>Environmental Management Plans .....</b>	<b>16</b>
3.3.	<b>Environmental Management.....</b>	<b>16</b>
4.	Monitor and Review OEMP .....	21
4.1.	<b>Environmental Monitoring .....</b>	<b>21</b>
4.2.	<b>Environmental Auditing.....</b>	<b>21</b>
4.3.	<b>Corrective Actions .....</b>	<b>21</b>
4.4.	<b>OEMP Review .....</b>	<b>22</b>
5.	References .....	23



## Document Revision History

Date	Version	Author	Comment
19/3/2009	1.0	Heidi Waters	Original Document
19/12/2013	2.0	Matt Parkinson	Incorporated changes required from Independent Environmental Audit
27/4/2015	3.0	Matt Parkinson	Review and transfer to AGL format, inclusion of DPE comments



# 1. Introduction

## 1.1. AGL Macquarie

AGL Macquarie produces approximately 12% of the electricity needed by consumers in eastern Australia.

AGL Macquarie's assets include the 2640 MW Bayswater Power Station, the 2000 MW Liddell Power Station, the 50 MW Hunter Valley Gas Turbines and the Liddell Solar Thermal Project. AGL Macquarie is the former NSW Government power producer Macquarie Generation, which AGL acquired in September 2014.

On average Bayswater Power Station produces approximately 15 000 GWh of electricity and Liddell Power Station 8000 GWh of electricity per year.

## 1.2. Project Description

Macquarie Generation (now AGL Macquarie) was granted consent on 23 May 2007 by the Minister for Planning under the Environmental Planning and Assessment Act 1979. Condition 6.3 of the Project Approval requires the preparation of an Operational Environmental Management Plan (OEMP).

The Hunter River Pump Station Augmentation site lies within the land holding of Bayswater Power Station, approximately 20 km south of Muswellbrook and two kilometres north of Jerrys Plains, in the Singleton Local Government Area (Figure 1).

The Hunter River Pump Station Augmentation involves a new pumping station, pipeline and power supply. The additional pumping capacity and new pipeline will be used to transfer water directly to Plashett Dam for storage until required.

The project enables AGL Macquarie to extract its water entitlements during higher river flows.

### 1.2.1. Operation Activities

The main components of the project include:

- A new pumping station capable of extracting up to 800ML/day.
- Dual underground delivery pipelines and associated surge mitigation equipment to transfer the water from the new pumping station to the discharge outlet at Plashett Dam, across a distance of approximately 2.8 km.
- A water discharge structure at Plashett Dam.
- Power supply works, including an additional substation, switchroom and upgrading of a portion of the existing 33kV Line no. 732.
- Access works including roads to access the pumping station and the pipelines.

The new pumping station is to be used in conjunction with the existing pumping station to supply AGL Macquarie's water requirements in accordance with its operational needs and Water License Package conditions.

Operation of the overall water supply system is illustrated schematically in Figure 2.

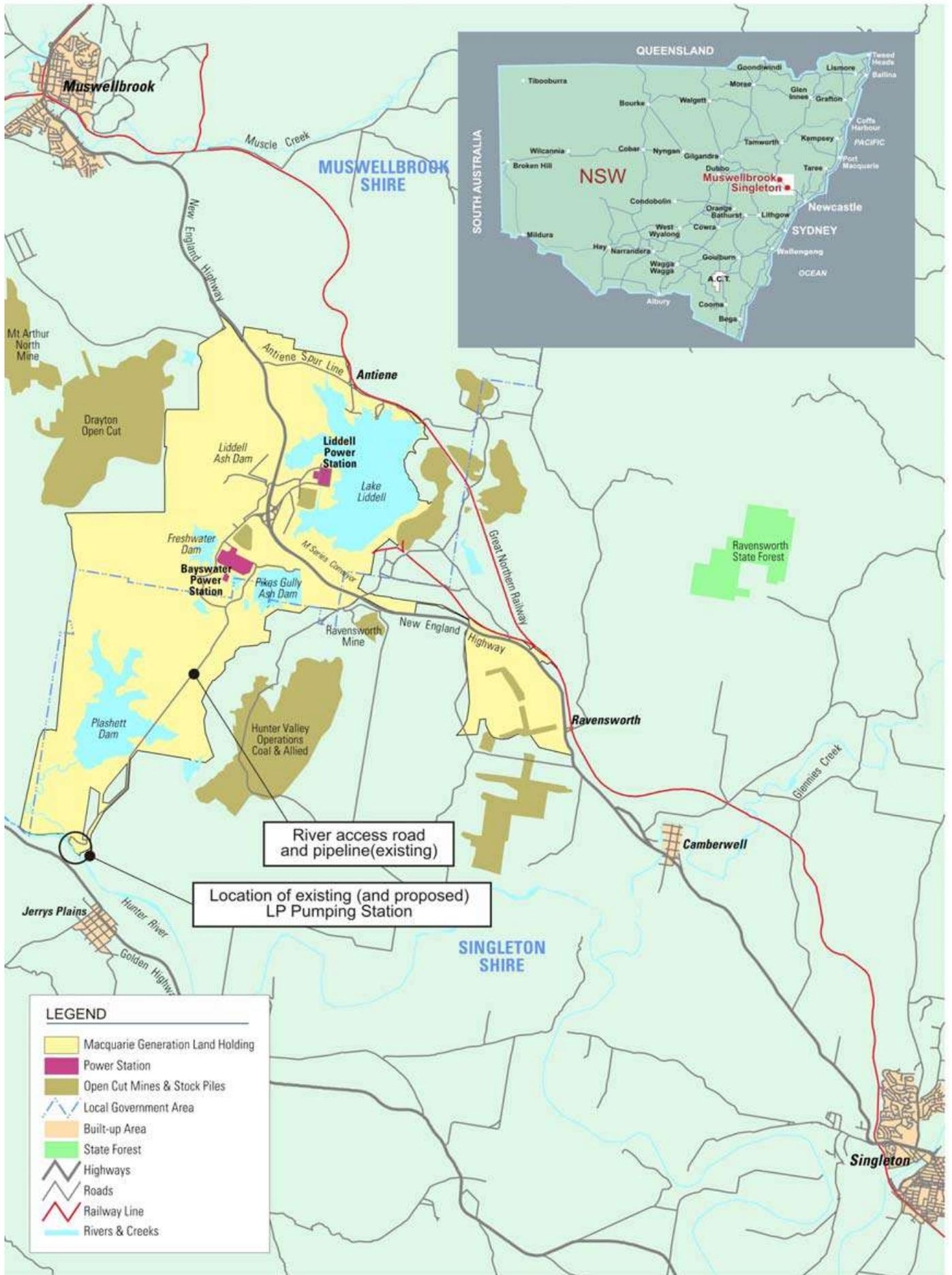
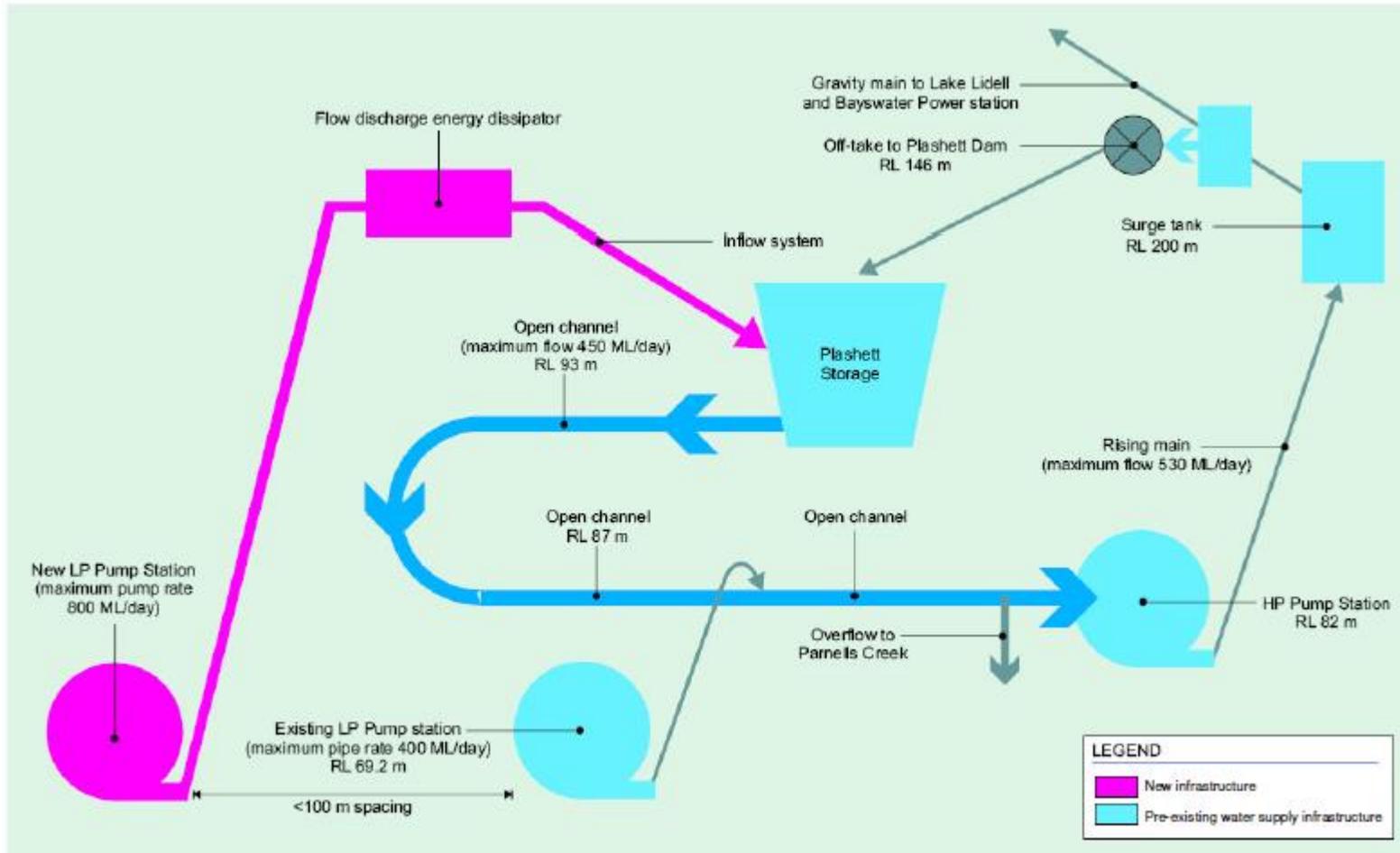


Figure 1: Site Location



**Figure 1: Augmented Pumping System Arrangement Schematic Diagram**



Specific operational procedures for the project are described in AGL Macquarie documents including:

- Power Station Standing Instruction (PSSI): Ops 18.
- Daily Operating Instructions.
- Plant Notes.

### 1.3. OEMP Context

The project is carried out generally in accordance with:

- a) Major Projects Application 06-0259.
- b) Macquarie Generation Hunter River Pump Station Augmentation, Environmental Assessment prepared by Connell Wagner Pty Ltd and dated 16 January 2007.
- c) The Project Approval conditions of the Minister for Planning granted under part 3A of the EP& A Act (**Appendix A**).

Condition 6.3 of the Project Approval prescribes

*Prior to the commencement of operation, the Proponent shall develop an Operation Environmental Management Plan to detail an environmental management framework, practices and procedures to be followed during operation of the project and existing plant. The Plan shall be consistent with the Guideline for the Preparation of Environmental*

*Management Plans (DIPNR 2004) and shall be formed in consultation with DECC and DWE.*

*The Plan shall include, but not necessarily be limited to:*

- a) *identification of all statutory and other obligations that the Proponent is required to fulfil in relation to operation of the project including all approvals, licences, approvals and consultations;*
- b) *a description of roles and responsibilities for all relevant employees involved in the operation of the project;*
- c) *overall environmental policies and principles to be applied to the operation of the project;*
- d) *standards and performance measures applying to the project, and a means by which environmental performance can be periodically reviewed and improved, where appropriate;*
- e) *management policies to ensure that environmental performance goals are met and to comply with conditions of this approval;*
- f) *the additional plans listed under condition 6.4 of this approval (Ecology Management Plan); and*
- g) *the environmental monitoring requirements listed under condition 3.1 (Environmental Auditing).*

### 1.4. OEMP Objectives

The overall objective of the OEMP is to ensure that the operational works achieve the environmental performance specified in the Environmental Assessment, and that required by the consent conditions.



## 2. Environmental Management

### 2.1. Environmental Management Structure and Responsibility

Every employee of AGL Macquarie is responsible for environmental performance. All staff are made aware of their general environmental responsibilities through the site induction process. Specific environmental responsibilities are defined within each position description. The organisational structure of relevant AGL Macquarie employees involved in the operation of this project is provided in Figures 3 to 5. The External Plant Manager has ultimate accountability for the operation of the project.

#### 2.1.1. Roles and Responsibilities

##### Head of Engineering

- Ensure that appropriate resources are made available for the implementation of this OEMP.

##### External Plant Manager

- Ensure that water related management controls identified in this plan are implemented.
- Liaise with the Environment Manager (or delegate) to ensure appropriate corrective and preventative actions are developed and implemented in accordance with this plan.

##### Water and Chemistry Team Leader

- Liaise with the Environment Manager (or delegate) to ensure appropriate corrective and preventative actions are developed and implemented in accordance with this plan.
- Liaise with NSW Office of Water regarding the water license.

##### Water and Chemistry Engineer

- Ensure that all appropriate management measures are implement and maintained onsite.
- Where potential or actual breaches have been identified, implement the appropriate corrective and preventative actions to fulfil the requirements of this OEMP.

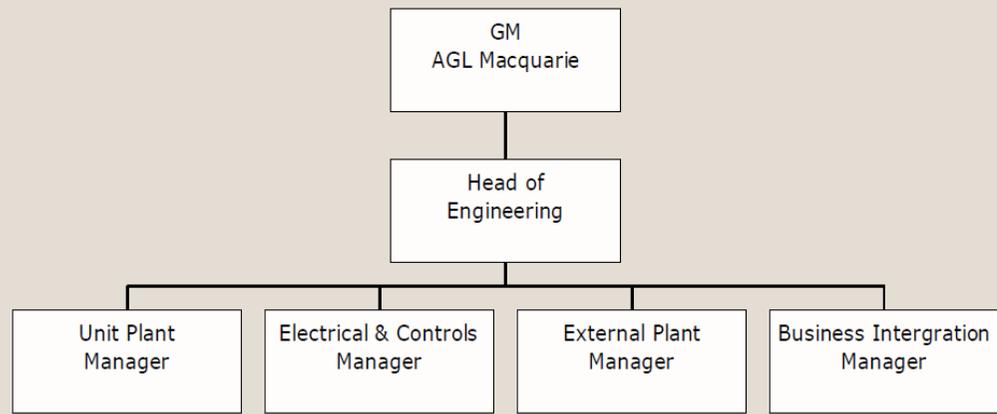
##### Environment Manager/Officers

- Undertake inspection to determine if management controls have been implemented.
- In the event of an identified potential or actual breach, manage the incident, liaise with the relevant stakeholders and assist in the development of appropriate corrective and preventative actions to fulfil the requirements of this plan.
- Provide assistance and technical advice to External Plant Manager and their team.



# Engineering

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1 April 2015

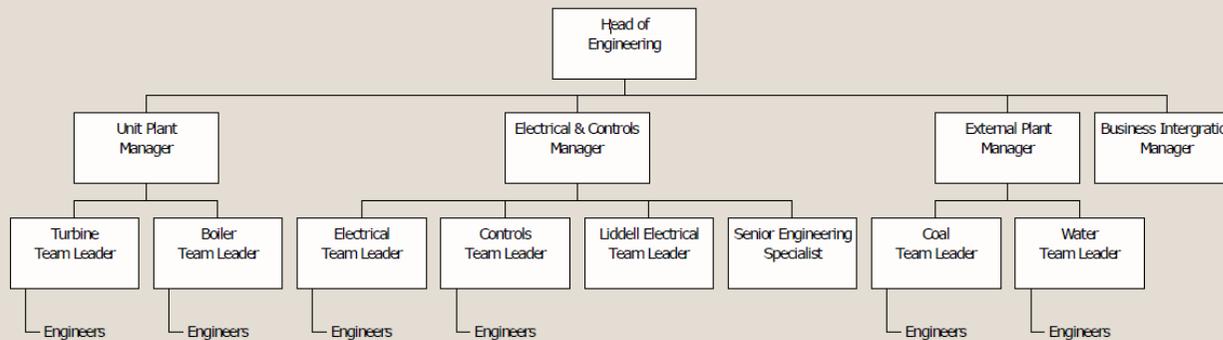


**Figure 2: Organisational Structure**



# Engineering

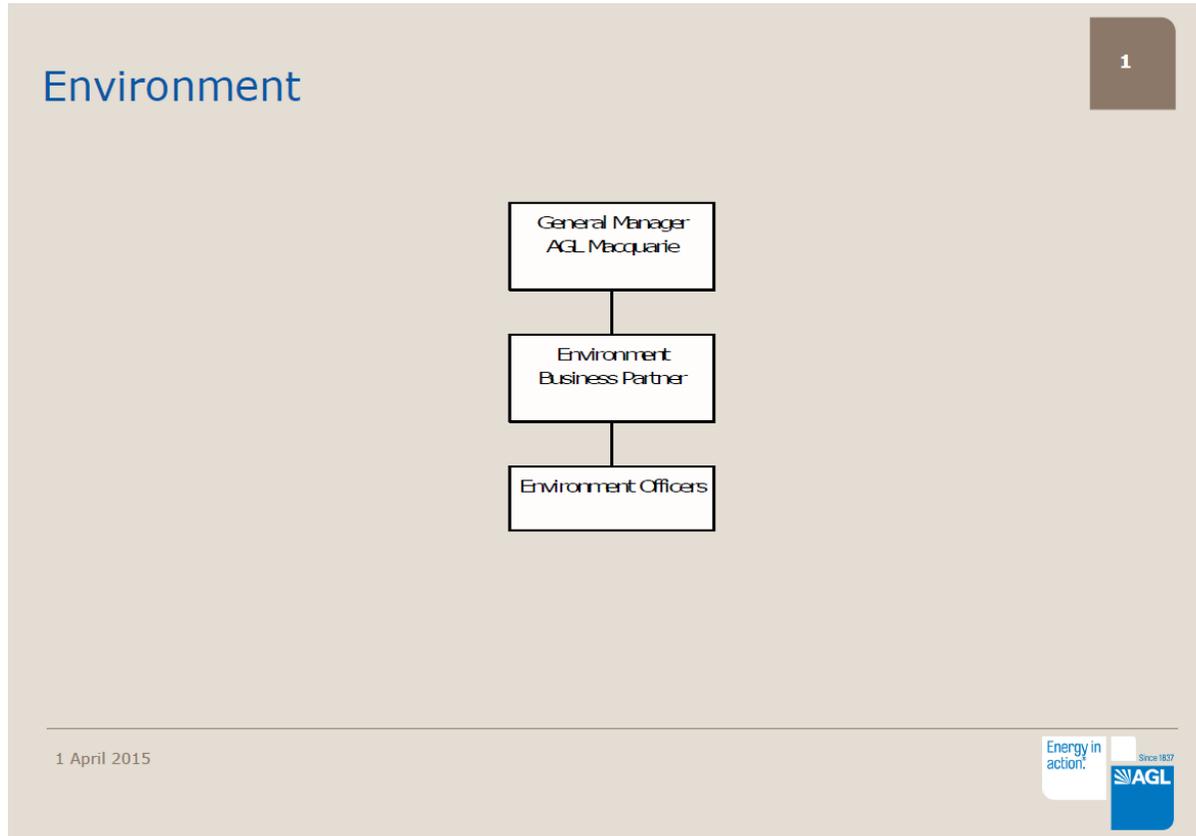
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1 March 2015



**Figure 4: Organisational Structure**



**Figure 5: Organisational Structure**

- Manage complaints and provide advice to enable a consistent outcome and approach to be achieved.
- Liaise with the EPA, DPE and other relevant authorities as required.

## 2.2. Approval and Licensing Requirements

### 2.2.1. Approval Requirements

This project was assessed as a major project under 3A of the EP & A Act by the Minister for Planning, and planning approval was granted on 23 May 2007 (**Appendix A**). A summary of categories of consent conditions of the planning approval and relevant section of the OEMP.

**Table 1: Summary of Project Approval Conditions**

Project Approval Condition	Where Addressed
6.3 Prior to commencement of operation, the Proponent shall develop and Operation Environmental Management Plan to detail an environmental management framework, practices and procedures to be followed during operation of the project and existing plant. The Plan shall be consistent with <i>Guideline for the Preparation of Environmental Management Plans (DIPNR 2004)</i> and shall be formed in consultation with DECC and DWE. The Plan shall include but not be limited to:	This OEMP
a) Identification of all statutory and other obligations that the Proponent is required to fulfil in relation to operation of the project, including approvals, licenses, approvals and consultations;	Section 2, Table 2
b) A description of the roles and responsibilities for all relevant employees involved in the operation of the project;	Section 2.1
c) Overall environmental policies and principles to be applied to the operation of the project;	Table 2
d) Standards and performance measures to be applied to the project, and a means by which environmental performance can be periodically reviewed and improved, where appropriate;	Section 3 & 4
Management of policies to ensure that environmental performance goals are met and comply with the conditions of this approval;	Section 3 & 4
f) The additional plans listed under condition 6.4 of this approval; and	Appendix B
g) The environmental monitoring requirements outlined under condition 3.1.	Section 4

### 2.2.2. Licensing Requirements

The relevant legislative regulations, permits and licenses that pertain to the project are outlined in Table 2. AGL Macquarie must comply with all requirements. AGL Macquarie’s Environment Manager or delegate will maintain a copy of all relevant environmental approvals.

**Table 2: Summary of Legislative Requirements**

Legislation	Section(s)	Triggers	Permits /Licenses	Responsibility
<i>Environmental Planning and Assessment Act 1979</i>	75B(1)(a)	Clause 24 of schedule 1 to State Environmental Planning Policy (Major Projects) 2005	Project Approval Conditions (Appendix A)	AGL Macquarie
<i>Protection of the Environment Operations Act 1997</i>	S 120 Part 5.4 Part 5.5 Part 5.6	Water Pollution Air Pollution (dust) Noise Waste	Environmental Protection License - 779	AGL Macquarie
<i>Threatened Species Conservation Act 1995</i>		River Flat Eucalypt Forest	Flora and Fauna Management Plan and Ecology Management Plan as per DoP approval	AGL Macquarie
Water Management Act 2000 and Water Management Licence (WML)		Water Extraction There is a requirement for the new facility to be a registered Water Management Work in the WML	Water Extraction Licence (Major utility high security and general security) Supplementary water access licence	AGL Macquarie

### 2.3. Reporting

AGL Macquarie has a number of environmental reporting requirements specified by its consent conditions of the planning approval, Water Management Licences and other approvals and internal practices. A summary of the ongoing reporting requirements is provided in Table 3.

**Table 3: Key Environmental Reporting Requirements**

Key Reporting Requirements	To Whom	Time Period	Condition/Licence Number
Prepare and submit an Annual Water Licence Report	Manager, Corporate Licence Development (NOW)	Within 90 days of the commencement of each new financial year	WML Approval 20CA203313
Annual Monitoring and Compliance Report	Manager, Corporate Licence Development (NOW)	Within 60 days of the commencement of each new financial year	WML 20WM000021 Conditions 5.11 and 5.12 WML Approval 20CA203313 Part B Conditions 21 and 22
Non-compliance incident report for any reportable event (including accidental or intentional departure from any of the conditions of the WML)	Manager, Corporate Licence Development (NOW)	As soon as practicable after it becomes known to AGL Macquarie or to one of its employees or agents	WML 20WM000021 Condition 5.13
Report failure of device/s used for measuring the volume of water taken	Minister (NOW)	Within seven days of failure of device/s	WML Approval 20CA203313 Schedule 3A Condition 5
EPL Annual Return	EPA	Not later than 60 days after the end of each reporting period or in the case of a transferring licence not later than 60 days after the date of transfer was granted (the 'due date')	EPL 779 Condition R1
Report of any incident with actual or potential significant off-site impacts on people or the biophysical environment	EPA	Immediate notification on becoming aware of incident occurring Full written details within seven days of the date on which the incident occurred	EPL 779 Condition R2.1 and R2.2

<p>The Proponent shall notify the Director-General of any incident with actual or potential significant off-site impacts on people or the biophysical environment. The Proponent shall provide full written details of the incident within 7 days to the Director-General.</p>	<p>DPE</p>	<p>Within 12 hours of becoming aware</p>	<p>DA 06_0259 Condition 7.1 and 7.2</p>
<p>Report in the event that any spill or release of water from any of the water management works exceeds 15 000 cells/ml (or such other relevant criteria specified in the Regional Algal Contingency Plan) of blue green algae</p>	<p>Hunter Algal Coordinating Committee Secretariat</p>	<p>As soon as practicable after it becomes known to AGLM or to one of its employees or agents</p>	<p>WML 20WM000021 Condition 5.15</p>

## 2.4. Environmental Training

Environmental training procedures are outlined in Section 4.4.2 of the Bayswater Power Station Environmental Management Manual Part 1 Environmental Management System Procedures. Records of environmental training for personnel are recorded in the AGL Macquarie training register. Contractors are required to maintain records to demonstrate compliance to the procedure.

## 2.5. Emergency Contacts and Response

Emergency contacts and response procedures are outlined in Bayswater Power Station Standing Instruction (PSSI): HSE01 (Macgen Portal > Bayswater > BW

Community (home page) > Power Station Standing Instructions > Health and Safety > HSE 01 Emergency Services Plan). Key elements include:

- on-site emergency responses
- responsibilities of relevant personnel
- equipment and training in its use



- notification and reporting procedures.

## 2.6. Complaints Record

AGL Macquarie will record the details of any complaints or issues raised by the community. According to the obligations set out by the Department of Planning and Environment project approval, the following information will be recorded:

- Date and time of the complaint.
- The means by which the complaint was made.
- Personal details of the complainant, or if none were collected, a note to that effect.
- The nature of the complaint.
- Actions taken to address the complaint, including investigation and any follow up.
- If no action was taken, an explanation as to why no action was taken.

All complaints will be managed in accordance with Section 4.4.3 of the Bayswater Power Station Environmental Management Manual Part 1 Environmental Management System Procedures. All complaint records for the project will be kept for a minimum of 4 years.

# 3. Implementation

## 3.1. Environmental Management Activities and Controls

This section identifies the environmental aspects and impacts associated with the various operational elements of the project. Table 4 outlines the potential impacts associated with the project, the targets and control measures required for each aspect, and the personnel responsible for implementing these control measures.

## 3.2. Environmental Management Plans

An Ecology Management Plan has been prepared in accordance with Condition 6.4 of the Project Approval (Appendix B).

## 3.3. Environmental Management

AGL Macquarie forms, reports and registers relevant to this project include:

- Bayswater Power Station Monthly Environmental Inspection Checklist
- Environmental Incident Report (Work Safe Online)
- Shift Managers logs
- Compliance Database.

**Table 4: Environmental Aspects and Impacts**

Aspect	Impact	Target	Control	Person(s)
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			Measures	Responsible
<b>Water Extraction – Pumping Station</b>				
Blockage of extraction drain from accumulation of debris or vegetation	Stoppage of pumping or damage to equipment	No unplanned stoppages or damage to equipment to occur	Inspect extraction drain for presence of debris or vegetation prior to each pumping event	Water & Chemistry Professional Officer
Entrapment of aquatic fauna in extraction drains	Injury or fatality to Platypus and other aquatic fauna. Stoppage of pumping or damage to equipment	No injuries to aquatic fauna to occur No unplanned stoppages or damage to equipment	Inspect water surrounding extraction drain for presence of aquatic fauna prior to each pumping event.	Water & Chemistry Professional Officer
Noise	Disturbance to nearby residents	No noise complaints received (no close sensitive receivers)	Routine maintenance and regular inspection of equipment	Water & Chemistry Professional Officer Team Leader Water & Chemistry
Lighting	Disturbance to nearby residents	No complaints received. There is limited visibility of the project.	Routine inspection of lighting arcs	Environment Officer
Failure of equipment and instrumentation	Leakage of fuel or lubricants	No leakage of fuel or lubricants	Implementation of operation procedures. Regular maintenance of equipment. Reporting as per license requirements.	Water & Chemistry Professional Officer Team Leader Water & Chemistry
Erosion around the intake.	Bank instability and increased sedimentation	No significant erosion to occur due to water extraction	Monitoring of bank stability	Water & Chemistry Professional Officer Team Leader

				Water & Chemistry
Obstruction of fishway from vegetation or debris	Decline in local populations of fish species	No obstruction of fishway	Undertake a survey (including photographs) of fishway.  Monitoring and removal of vegetation or debris that may obstruct the fishway as required.	Environment Officer  Team Leader – Station Services
<b>Water Delivery Pipelines</b>				
Disturbed land along pipeline route	Disturbance to flora and fauna. Erosion and sedimentation  Subsidence of land.	Pipeline route rehabilitated as per Ecology Management Plan and maintained as per the Vegetation Management Plan	Pipeline route inspected for signs of erosion as per the Ecology Management Plan.	Environment Officer
Pipeline failure	Leakage/drainage of water into river, or surrounding soil and native vegetation. Disturbance to flora and fauna. Erosion	No pipeline failures	Drainage and monitoring. Appropriate maintenance and operating procedures.	Team Leader Water and Chemistry
Surge Tower	Leakage/drainage of water into, river or surrounding soil and native vegetation. Disturbance to flora and fauna. Erosion (rilling).	No leakage or overflow	Drainage and monitoring. Appropriate maintenance and operating procedures.	Team Leader Water and Chemistry
Relief valve	Leakage/drainage of water into river, or surrounding soil and native	Operate within specifications	Drainage, monitoring and inspection. Appropriate maintenance	Team Leader Water and Chemistry

	vegetation. Disturbance to flora and fauna. Erosion		and operating procedures.	
<b>Water Discharge Outlet</b>				
Open spillway	Injury or fatality to fauna. Injury or fatality to people gaining unauthorised access To the spillway.	No injuries to occur	Fences to be installed around spillway. Signposting of the area to restrict access. Maintenance of fences and signage.	Team Leader Water and Chemistry Team Leader Station Services
Water energy dissipation	Scouring or undermining of dam embankment at Plashett Dam	No erosion of dam embankment to occur due to discharges.	Energy dissipater to be installed and maintained. Monitoring of discharges to Plashett Dam	Team Leader Water and Chemistry
Erosion around the outlet.	Bank instability and increased sedimentation	No erosion or bank instability	Monitor bank stability. Maintain appropriate erosion and sedimentati on controls.	Team Leader Water and Chemistry Team Leader Station Services
<b>Substation</b>				
Transformer oil on site	Leakage or spill of oil	No leakage or spillage of oil	No drums to be stored at the site during operation and maintenance. Transformer bundling built to standard and maintained. Regular inspections.	Team Leader - Electrical
Sulphur hexafluoride on site	Leakage or spill of sulphur hexafluoride	No leakage or spill	Installation of fully enclosed circuit breaker. Monitor pressure	Team Leader - Electrical

			gauge to identify any leakage.	
Batteries (containing acid) on site	Acid leakage or spill	No leakage or spill	Routine inspection of equipment. No storage of old batteries on site.	Team Leader - Electrical
Transmission lines	Fire from electrical short. Foam from fire extinguishers entering switchyard and river.	No electrical fire to occur	Utilise existing drains to contain firefighting foam. Detailed incident response procedures prepared.	Team Leader – Electrical Leader Station Services
<b>Access Roads</b>				
Vehicular access	Injury or fatality to fauna	No injuries to fauna to occur.	Speed limited to 60km/hr. Signposts to restrict access and identify speed limit. Take injured animals to an animal rescue organisation.	Leader Station Services Environment officer
Unsealed roads	Impact to air quality through generation of dust.	No significant impacts to air quality. No complaints received.	Speed limited to 60km/h. Maintain road base.	Leader Station Services
Increased run-off to access roads.	Poor drainage causing damage to surrounding soil and vegetation.	No erosion or damage due to runoff.	Appropriate drainage systems established for all access roads. Regular inspections.	Team Leader Station Services
<b>Maintenance</b>				
Spraying of weeds with herbicides	Injury or fatality to non-target flora and fauna. Leakage of spills to surrounding land or river.	No injuries or spills.	Use appropriate herbicide application method to suit environmental conditions. Store	Team Leader Station Services Environment Officer

			herbicides in accordance with Pesticides Act.	
Chemical treatment (containing boron) of transmission lines to protect against termites	Injury or fatality to native flora and fauna. Leakage or spills to surrounding land or river.	No injuries or spills	Utilise specialist contractors	Team Leader Electrical
Site housekeeping	Accumulation of debris in river or on site.	Waste to be disposed of appropriately. Clean and tidy workplace.	Provision of rubbish bins at appropriate locations. Monitoring of waste in river and on site. Regular inspections.	Team leader – Water and Chemistry

## 4. Monitor and Review OEMP

### 4.1. Environmental Monitoring

An Ecology Management Plan has been developed in accordance with Condition 6.4 of the Project Approval. This Plan includes:

- A monitoring program over two years to assess the functionality of the fishway consecutively for two years following commissioning and operation of the project, focusing on the impact of the project on the fishway during breeding season.
- A rehabilitation monitoring program focusing on the health of rehabilitation areas to ensure that the occurrence of weeds and pests in areas within and adjacent to the project are controlled.

### 4.2. Environmental Auditing

Section 4.5.5 of the Bayswater Power Station Environmental Management Manual Part 1 Environmental Management System Producers outlines the auditing required at Bayswater Power Station. In summary, audits required under the procedure are:

- External Environmental Audit (biennial)
- Internal EMS Audit

In addition an independent environmental audit for the project was undertaken in 2013, the findings of that audit have been included in this OEMP where applicable.

### 4.3. Corrective Actions



The findings, conclusions and recommendations developed through the monitoring and auditing processes are reported to the Leadership Team. In addition, corrective actions and preventative actions are identified and implemented to minimise environmental impacts through the following:

- Monthly Reporting
- Compliance Database

#### **4.4. OEMP Review**

In addition, the OEMP will be a continually revised document, to incorporate changes achieved through:

- staff training
- environmental audits
- implementation of corrective actions
- the inclusion of new initiatives in environmental management
- revision of PSSIs, Daily Operating Instructions and Plant Notes
- regulatory changes.



## 5. References

Connell Wagner. 2007a. Macquarie Generation Hunter River Pump Station Augmentation Environmental Assessment. Connell Wagner Pty Ltd, Neutral Bay.

Connell Wagner. 2007b. Outline Construction Environmental Management Plan Hunter River Pump Station Augmentation Macquarie Generation. Connell Wagner Pty Ltd, Neutral Bay.

ENSR. 2009. Ecology Management Plan – Bayswater Power Pumping Station Upgrade to Increase Water Extraction Capacity. ENSR Australia Pty Ltd, Singleton.

ERM. 2008. Hunter River Pump Station Augmentation Flora and Fauna Management and Rehabilitation Plan. Environmental Resources Management Australia, Thornton.

Macquarie Generation. 2008. Bayswater Power Station Standing Instruction (PSSI): OPS18 River Pumping Operation, CW Make Up, LSP (Located on the Macgen Portal , Bayswater, BW Community (home page), Power Station Standing Instructions, Operations , OPS 18 River Pumping Operation, CW Make Up, LSP).

Macquarie Generation. 2007. Bayswater Power Station Environmental Management Manual Part 1 Environmental Management System Procedures. (Located at Macgen Portal, Environment, Bayswater, Bayswater Environment Manual).

Macquarie Generation. 2006. Bayswater Power Station Standing Instruction (PSSI): HSE01 Emergency Services Plan (Located on the Macgen Portal , Bayswater, BW Community (home page), Power Station Standing Instructions, Health and Safety, HSE 01 Emergency Services Plan).



**Appendix A**  
**Project Approval 06-0259**

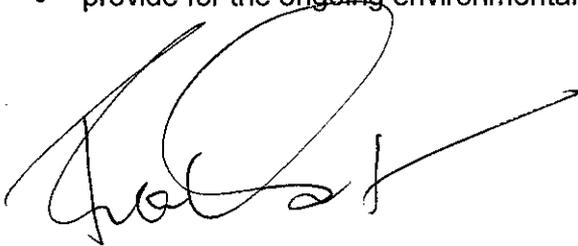
# Project Approval

## Section 75J of the *Environmental Planning and Assessment Act 1979*

I, the Minister for Planning, approve the project referred to in Schedule 1, subject to the conditions in Schedule 2.

These conditions are required to:

- prevent, minimise, and/or offset adverse environmental impacts;
- set standards and performance measures for acceptable environmental performance;
- require regular monitoring and reporting; and
- provide for the ongoing environmental management of the project.



Frank Sartor MP  
Minister for Planning

Sydney

23 May

2007

File No: S07/00079

### SCHEDULE 1

**Application No:** 06\_0259

**Proponent:** Macquarie Generation

**Approval Authority:** Minister for Planning

**Land:** Lot 91 DP 234544, Lot 1 DP 616024, Lot 110 DP 625973, Hunter River and adjacent land to Plashett Dam, Singleton local government area

**Project:** Bayswater Power Station Water Pumping Station Upgrade to increase Water Extraction Capacity

**Major Project:** The proposal is declared a Major Project under section 75B(1)(a) of the *Environmental Planning and Assessment Act 1979*, because it is a development of a kind described in clause 24 of Schedule 1 to *State Environmental Planning Policy (Major Projects) 2005*.

## KEY TO CONDITIONS

<b>1. ADMINISTRATIVE CONDITIONS</b>	<b>4</b>
Terms of Approval	4
Limits of Approval	4
Statutory Requirements	4
<b>2. SPECIFIC ENVIRONMENTAL CONDITIONS</b>	<b>4</b>
Air Quality Impacts	4
Flora and Fauna Management	4
Water Management	5
Waste Generation and Management	5
Hazards and Risk	5
Aboriginal Cultural Heritage	5
<b>3. ENVIRONMENTAL MONITORING AND AUDITING</b>	<b>6</b>
Environmental Auditing	6
<b>4. COMPLIANCE MONITORING AND TRACKING</b>	<b>6</b>
Compliance Tracking Program	6
<b>5. COMMUNITY INFORMATION, CONSULTATION AND INVOLVEMENT</b>	<b>6</b>
Complaints Procedure	6
<b>6. ENVIRONMENTAL MANAGEMENT</b>	<b>7</b>
Environmental Representative	7
Construction Environmental Management Plan	7
Operation Environmental Management Plan	8
Ecology Management Plan	8
<b>7. ENVIRONMENTAL REPORTING</b>	<b>9</b>
Incident Reporting	9

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## SCHEDULE 2

<b>Act, the</b>	<i>Environmental Planning and Assessment Act, 1979</i>
<b>Conditions of Approval</b>	The Minister's conditions of approval for the project.
<b>Council</b>	Singleton Shire Council
<b>DECC</b>	Department of Environment and Climate Change
<b>Department, the</b>	Department of Planning
<b>Director-General, the</b>	Director-General of the Department of Planning (or delegate)
<b>Director-General's Approval</b>	<p>A written approval from the Director-General (or delegate).</p> <p>Where the Director-General's Approval is required under a condition the Director-General will endeavour to provide a response within one month of receiving an approval request. The Director-General may ask for additional information if the approval request is considered incomplete. When further information is requested the time taken for the Proponent to respond in writing will be added to the one month period.</p>
<b>Director-General's Report</b>	The report provided to the Minister by the Director-General of the Department under section 75I of the EP&A Act.
<b>DWE</b>	Department of Water and Energy
<b>Dust</b>	any solid material that may become suspended in air or deposited
<b>EA</b>	<i>Macquarie Generation Hunter River Pump Station Augmentation Environmental Assessment</i> (prepared by Connell Wagner Pty Ltd and dated 16 January 2007).
<b>EPA</b>	Environment Protection Authority as part of the Department of Environment and Climate Change
<b>EPL</b>	Environment Protection Licence issued under the <i>Protection of the Environment Operations Act, 1997</i>
<b>Minister, the</b>	Minister for Planning.
<b>Proponent</b>	Macquarie Generation
<b>Publicly Available</b>	Available for inspection by a member of the general public (for example available on an internet site or at a display centre).
<b>Site</b>	Land to which Major Projects Application 06_0259 applies.

## **1. ADMINISTRATIVE CONDITIONS**

### **Terms of Approval**

- 1.1 The Proponent shall carry out the project generally in accordance with the:
  - a) Major Projects Application 06\_0259;
  - b) *Macquarie Generation Hunter River Pump Station Augmentation, Environmental Assessment*, prepared by Connell Wagner Pty Ltd and dated 16 January 2007;
  - c) the conditions of this consent.
- 1.2 If there is any inconsistency between the above, the conditions of this approval shall prevail to the extent of the inconsistency.
- 1.3 The Proponent shall comply with any reasonable requirement(s) of the Director-General arising from the Department's assessment of:
  - a) any reports, plans or correspondence that are submitted in accordance with this approval; and
  - b) the implementation of any actions or measures contained in these reports, plans or correspondence

### **Limits of Approval**

- 1.4 This approval shall lapse five years after the date on which it is granted, unless the works subject of this approval are physically and substantially commenced on or before that time.
- 1.5 The pumping station component of the project shall consist of up to 20 submersible pumps with a total extraction capacity of 800 ML/day.
- 1.6 The Proponent shall only extract water from the Hunter River in accordance with the Water Management Licence.

### **Statutory Requirements**

- 1.7 The Proponent shall ensure that all licences, permits and approvals are obtained and maintained as required throughout the life of the project. No condition of this consent removes the obligation for the Proponent to obtain, renew or comply with such licences, permits or approvals. The Proponent shall ensure that a copy of this consent and all relevant environmental approvals are available on the site at all times during the project.

## **2. SPECIFIC ENVIRONMENTAL CONDITIONS**

### **Air Quality Impacts**

- 2.1 The Proponent shall construct the project in a manner that minimises dust emissions from the site, including wind-blown and traffic-generated dust. All activities on the site shall be undertaken with the objective of preventing visible emissions of dust from the site. Should such visible dust emissions occur at any time, the Proponent shall identify and implement all practicable dust mitigation measures, including cessation of relevant works, as appropriate, such that emissions of visible dust cease.

### **Flora and Fauna Management**

- 2.2 The pumping station component of the project and associated construction works shall be confined to the heavily disturbed section of the bank immediately upstream of the existing plant. The Proponent shall erect temporary fencing around the River-Flat Eucalypt Forest and adjacent river bank up to the section requiring disturbance as part of construction activities. Orange mesh and reflective markers are to be attached to the fence along its perimeter. The fence is to be maintained for the duration of site clearing, preparation and construction works.
- 2.3 All construction works associated with the pumping station component that may impact on the local platypus population may only commence between the period from mid-March to mid-September inclusive unless it has been demonstrated, in consultation with the DECC

and to the satisfaction of the Director-General, that the temporary removal, care and eventual return of the fauna will not adversely affect the local platypus population.

- 2.4 The Proponent shall not remove any hollow-bearing trees potentially affected by the construction of the pipeline and shall undertake all practicable measures to ensure the retention of existing native trees.

### **Water Management**

- 2.5 Except as may be expressively provided by an Environment Protection Licence for the project, the Proponent shall comply with section 120 of the *Protection of the Environment Operations Act 1997* which prohibits the pollution of waters.
- 2.6 Soil and water management controls shall be employed to minimise soil erosion and the discharge of sediment and other pollutants to lands and/or waters during construction activities, in accordance with Landcom's *Managing Urban Stormwater: Soils and Conservation*.

### **Waste Generation and Management**

- 2.7 All waste materials removed from the site shall only be directed to a waste management facility lawfully permitted to accept the materials.

The Proponent shall maximise the treatment, reuse and/ or recycling on the site of any waste oils, excavated soils, slurries, dusts and sludges associated with project, to minimise the need for treatment or disposal of those materials outside the power station. To remove any doubt, this condition does not allow the use of any of the materials listed above as potential fuel sources.

- 2.8 The Proponent shall not cause, permit or allow any waste generated outside the site to be received at the site for storage, treatment, processing, reprocessing, or disposal on the site, except as expressly permitted by a licence under the *Protection of the Environment Operations Act 1997*, if such a licence is required in relation to that waste.
- 2.9 The Proponent shall ensure that all liquid and/ or non-liquid waste generated and/ or stored on the site is assessed and classified in accordance with *Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes* (DECC, 2004), or any future guideline that may supersede that document.

### **Hazards and Risk**

- 2.10 The Proponent shall demolish all relevant structures strictly in accordance with *Australian Standard 2601-1991: The Demolition of Structures*, as in force at 1 July 1993.
- 2.11 The Proponent shall store and handle all dangerous goods, as defined by the Australian Dangerous Goods Code, strictly in accordance with:
- a) all relevant Australian Standards;
  - b) a minimum bund volume requirement of 110% of the volume of the largest single stored volume within the bund; and
  - c) the EPA's Environment Protection Manual Technical Bulletin *Bundling and Spill Management*.

In the event of an inconsistency between the requirements listed from a) to c) above, the most stringent requirement shall prevail to the extent of the inconsistency.

### **Aboriginal Cultural Heritage**

- 2.12 In the event that an Aboriginal object is identified during construction of the project, the Proponent shall adopt management strategies to ensure that such Aboriginal objects are subjected to partial or nil impact. The Proponent shall ensure that the cultural heritage management strategies are developed in conjunction with the Aboriginal community.

### **3. ENVIRONMENTAL MONITORING AND AUDITING**

#### **Environmental Auditing**

- 3.1 Twelve months after the commencement of operation of the project, or within such period as otherwise agreed by the Director-General, the Proponent shall commission an independent person or team to undertake an Environmental Audit of the project. The independent person or team shall be approved by the Director-General prior to the commencement of the Audit shall be submitted for the approval of the Director-General no later than one month after the completion of the Audit. The Audit shall:
- a) be carried out in accordance with *ISO 14010 - Guidelines and General Principles for Environmental Auditing* and *ISO 14011 - Procedures for Environmental Auditing*;
  - b) assess compliance with the requirements of this approval, and other licences and approvals that apply to the project;
  - c) assess the environmental performance of the project against the predictions made and conclusions drawn in the documents referred to under condition 1.1 of this approval; and
  - d) review the effectiveness of the environmental management of the project, including any environmental impact mitigation works; and
  - e) review the effectiveness of the Ecology Management Plan referred to under condition 6.4.

The Director-General may require the Proponent to undertake works to address the findings or recommendations presented in the Environmental Audit Report. Any such works shall be completed within such time as the Director-General may agree. The Environmental Audit Report shall be made available for public inspection on request.

### **4. COMPLIANCE MONITORING AND TRACKING**

#### **Compliance Tracking Program**

- 4.1 The Proponent shall develop and implement a **Compliance Tracking Program** to track compliance with the requirements of this approval. The Program shall include, but not necessarily limited to:
- a) provisions for periodic review of the compliance status of the project against the requirements of this approval;
  - b) provisions for periodic reporting of compliance status to the Director-General;
  - c) a program for independent environmental auditing at least annually, or as otherwise agreed by the Director-General, in accordance with *ISO 19011:2002 - Guidelines for Quality and/ or Environmental Management Systems Auditing*; and
  - d) mechanisms for rectifying any non-compliance identified during environmental auditing or review of compliance.

### **5. COMMUNITY INFORMATION, CONSULTATION AND INVOLVEMENT**

- 5.1 Subject to confidentiality, the Proponent shall make all documents required under this approval available for public inspection on request.

#### **Complaints Procedure**

- 5.2 Prior to the commencement of construction of the project, the Proponent shall ensure that the following are available for community complaints for the life of the project (including construction and operation):
- a) a telephone number on which complaints about construction and operational activities at the site may be registered;
  - b) a postal address to which written complaints may be sent; and
  - c) an email address to which electronic complaints may be transmitted.

The telephone number, the postal address and the email address shall be displayed on the Proponent's website and on a sign near the site, in a position that is clearly visible to the public from the river, and which clearly indicates the purposes of the sign.

- 5.3 The Proponent shall record details of all complaints received through the means listed under condition 5.2 of this approval in an up-to-date Complaints Register. The Register shall record, but not necessarily be limited to:
- a) the date and time, where relevant, of the complaint;
  - b) the means by which the complaint was made (telephone, mail or email);
  - c) any personal details of the complainant that were provided, or if no details were provided, a note to that effect;
  - d) the nature of the complaint;
  - e) any action(s) taken by the Proponent in relation to the complaint, including any follow-up contact with the complainant; and
  - f) if no action was taken by the Proponent in relation to the complaint, the reason(s) why no action was taken.

The Complaints Register shall be made available for inspection by the Director-General upon request.

## 6. ENVIRONMENTAL MANAGEMENT

### Environmental Representative

- 6.1 Prior to the commencement of construction of the project, the Proponent shall nominate a suitably qualified and experienced Environmental Representative(s) for the approval of the Director General. The Proponent shall employ the Environmental Representative(s) on a full-time basis, or as otherwise agreed by the Director General, during the construction of the project. The Environmental Representative shall be:
- a) the primary contact point in relation to the environmental performance of the project;
  - b) responsible for ensuring that all Management Plans and commitments made by the Proponent under this approval are implemented;
  - c) responsible for considering and advising on matters specified in the conditions of this approval, and all other licences and approvals related to the construction impacts of the project; and
  - d) given the authority and independence to require reasonable steps be taken to avoid or minimise unintended or adverse environmental impacts, and failing the effectiveness of such steps, to direct that relevant actions be ceased immediately should an adverse impact on the environment be likely to occur.

### Construction Environmental Management Plan

- 6.2 Prior to the commencement of construction of the project, the Proponent shall prepare and implement a **Construction Environmental Management Plan** to outline environmental management practices and procedures to be followed during the construction of the project. The Plan shall be prepared in accordance with *Guideline for the Preparation of Environmental Management Plans* (DIPNR 2004) and shall include, but not necessarily be limited to:
- a) an **Erosion and Sedimentation Management Plan** to detail measures to minimise erosion during site preparation, construction and demolition works associated with the project. The Plan shall include, but not necessarily be limited to:
    - i) results of investigations into soils associated with the site, in particular the stability of the soil and its susceptibility to erosion;
    - ii) details of erosion, sediment and pollution control measures and practices to be implemented during construction of the project, with specific measures outlined for minimising bank sedimentation and erosion;
    - iii) demonstration that erosion and sediment control measures will conform with, or exceed, the relevant requirements of the Regional Erosion and Sediment Control Policy and Code of Practice adopted by Council;
    - iv) design specifications for diversionary works, banks and sediment basins;
    - v) an erosion monitoring program during construction and demolition works associated with the project; and

- vi) measures to address erosion, should it occur, and to rehabilitate/ stabilise disturbed areas of the site.
- b) a **Flora and Fauna Management Plan** to detail measures to minimise impacts on flora and fauna during site preparation, construction and demolition works associated with the project. The Plan shall be consistent with section 5 of the EA and shall be formed in consultation with the DECC. The Plan shall include, but not necessarily be limited to:
  - i) detailed maps clearly indicating the relative locations of construction areas and sensitive flora and fauna habitat areas;
  - ii) comprehensive procedures and work methodologies to minimise adverse impacts on flora and fauna habitat with specific attention given to platypus habitat and River-Flat Eucalyptus Forest;
  - iii) specific measures, such as fencing to ensure that the removal of hollow bearing trees are avoided; and
  - iv) a description of methods for ensuring the retention and separation of topsoil from other soils for the purposes of site rehabilitation.
- c) a **Chemical Management Plan** to detail measures to prevent any oil or chemical spills associated with the construction of the project from contaminating the river. The Plan shall be in accordance with the EPA's Environment Protection Manual Technical Bulletin *Bunding and Spill Management*.

### Operation Environmental Management Plan

- 6.3 Prior to the commencement of operation, the Proponent shall develop an **Operation Environmental Management Plan** to detail an environmental management framework, practices and procedures to be followed during operation of the project and existing plant. The Plan shall be consistent with *Guideline for the Preparation of Environmental Management Plans* (DIPNR 2004) and shall be formed in consultation with DECC and DWE. The Plan shall include, but not necessarily be limited to:
- a) identification of all statutory and other obligations that the Proponent is required to fulfil in relation to operation of the project, including all approvals, licences, approvals and consultations;
  - b) a description of the roles and responsibilities for all relevant employees involved in the operation of the project;
  - c) overall environmental policies and principles to be applied to the operation of the project;
  - d) standards and performance measures to be applied to the project, and a means by which environmental performance can be periodically reviewed and improved, where appropriate;
  - e) management policies to ensure that environmental performance goals are met and to comply with the conditions of this approval;
  - f) the additional plans listed under condition 6.4 of this approval; and
  - g) the environmental monitoring requirements outlined under condition 3.1.

### Ecology Management Plan

- 6.4 Prior to the commencement of construction the Proponent shall, in consultation with the DECC, prepare and implement a **Ecology Management Plan** which will outline measures and a monitoring regime to ensure that the long term impacts of the project on flora and fauna are effectively managed. The Plan shall be submitted to the Director-General for approval and shall include, but not necessarily be limited to:
- a) a system framework that allows management practices and monitoring regimes to be regularly reviewed and adapted as appropriate, such that any adverse impacts are avoided or rectified;
  - b) a long-term management plan detailing a monitoring regime and specific measures that will be undertaken to conserve the local platypus population and the River-Flat Eucalypt Forest;
  - c) a monitoring program to regularly assess the functionality of the fishway before and after the operation of the project with specific attention given to the impact of the project on the fishway during breeding season;

- d) a detailed rehabilitation schedule describing areas to be rehabilitated, rehabilitation methods and maintenance regimes; and
- e) a program to monitor the health of rehabilitation areas and to ensure that the occurrence of weeds and pests in areas adjacent to the project are controlled.

The Plan shall be submitted for the approval of the Director-General no later than one month prior to the commencement of operation of the project, or within such period otherwise agreed by the Director-General. Operation shall not commence until written approval has been received from the Director-General.

## **7. ENVIRONMENTAL REPORTING**

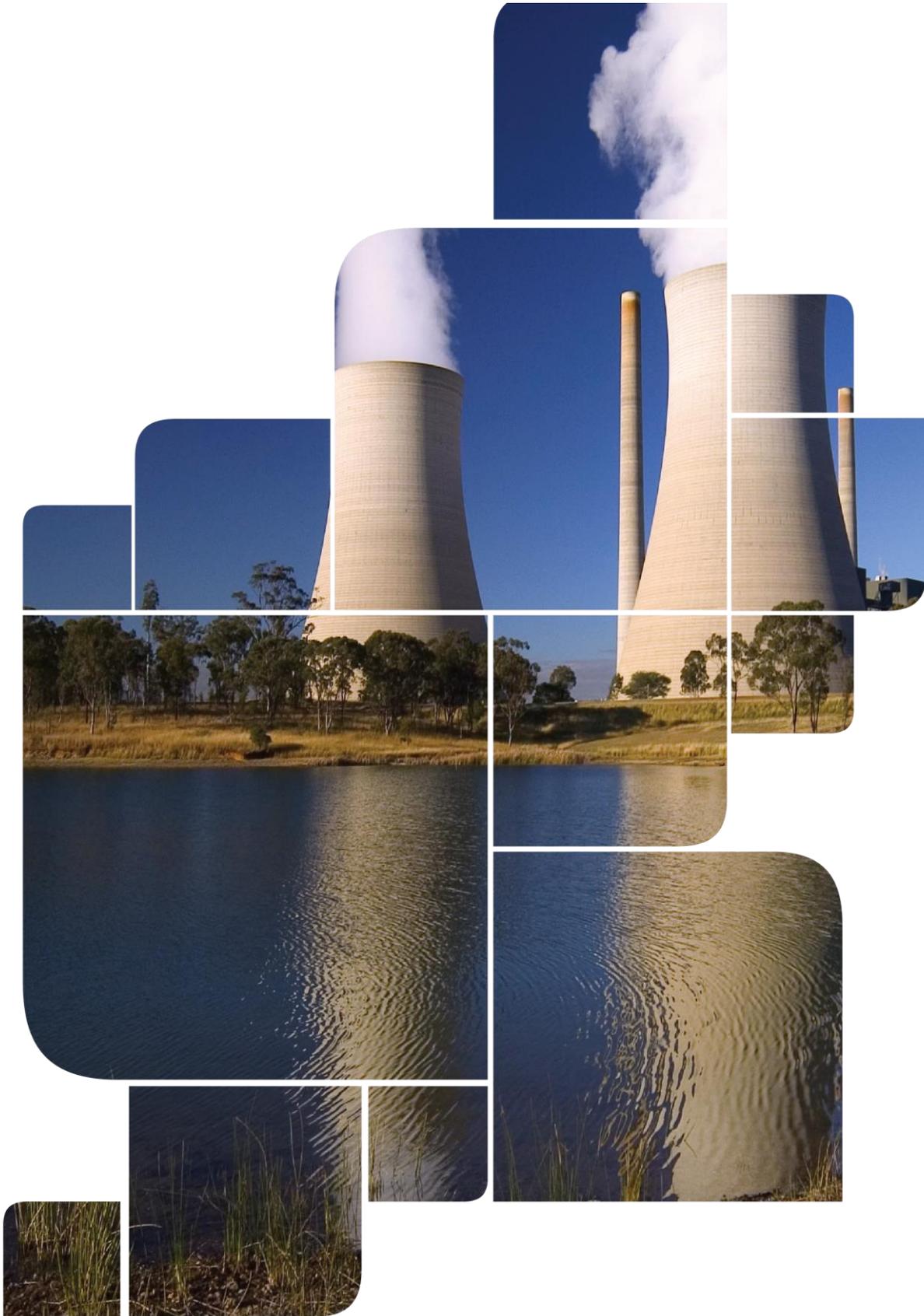
### **Incident Reporting**

- 7.1 The Proponent shall notify the Director-General of any incident with actual or potential significant off-site impacts on people or the biophysical environment within 12 hours of becoming aware of the incident. The Proponent shall provide full written details of the incident to the Director-General within seven days of the date on which the incident occurred.
  - 7.2 The Proponent shall meet the requirements of the Director-General to address the cause or impact of any incident, as it relates to this approval, reported in accordance with condition 7.1 of this approval, within such period as the Director-General may require.
-



## **Appendix B**

### **Ecology Management Plan**



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# Bayswater Power Station Upgrade to Increase Water Extraction Capacity

Ecology Management Plan

Date: 10 July 2015

## Table of Contents

1.	Introduction.....	5
1.1.	<b>AGL Macquarie .....</b>	<b>5</b>
1.2.	<b>Project Overview.....</b>	<b>5</b>
1.3.	<b>Purpose.....</b>	<b>5</b>
1.4.	<b>Scope .....</b>	<b>5</b>
1.5.	<b>Consultation.....</b>	<b>7</b>
2.	Flora and Fauna Management .....	9
2.1.	<b>Platypus .....</b>	<b>9</b>
2.1.1.	Description .....	9
2.1.2.	Habitat.....	9
2.1.3.	Local Distribution.....	9
2.1.4.	Conservation Status.....	10
2.1.5.	Management.....	10
2.1.6.	Monitoring .....	11
2.2.	<b>River Flat Eucalypt Forest .....</b>	<b>11</b>
2.2.1.	Description .....	11
2.2.2.	Local Distribution.....	11
2.2.3.	Conservation Status.....	11
2.2.4.	Management .....	12
2.2.5.	Monitoring .....	13
3.	Fishway Monitoring .....	14
3.1.	<b>Introduction.....</b>	<b>14</b>
3.2.	<b>Management .....</b>	<b>14</b>
3.3.	<b>Monitoring Program .....</b>	<b>15</b>
3.4.	<b>Methods .....</b>	<b>16</b>
3.4.1.	Passive Sampling Techniques .....	16
3.4.2.	Calculating Sampling Effort .....	17



3.4.3.	Active Sampling Techniques .....	17
3.4.4.	Euthanasia of Specimens .....	18
4.	Rehabilitation .....	18
<b>4.1.</b>	<b>Rehabilitation Schedule .....</b>	<b>19</b>
5.	Reporting and Review .....	21
6.	References and Bibliography .....	22



## Document Revision History

Date	Version	Author	Comment
27/4/2009	1.0	Heidi Waters (AECOM)	Original Document
17/12/2013	2.0	Matt Parkinson	Updated to include the findings from the Independent Environmental Audit
27/4/2015	3.0	Matt Parkinson	Review and transfer to AGL format and inclusion of DPE comments.



# 1. Introduction

## 1.1. AGL Macquarie

AGL Macquarie produces approximately 12% of the electricity needed by consumers in eastern Australia.

AGL Macquarie's assets include the 2640 MW Bayswater Power Station, the 2000 MW Liddell Power Station, the 50 MW Hunter Valley Gas Turbines and the Liddell Solar Thermal Project. AGL Macquarie is the former NSW Government power producer Macquarie Generation, which AGL acquired in September 2014.

On average Bayswater Power Station produces approximately 15 000 GWh of electricity and Liddell Power Station 8000 GWh of electricity per year.

## 1.2. Project Overview

The site lies within the land holding of the Bayswater Power Station, approximately 20km south of Muswellbrook and two kilometres north of Jerrys Plains (**Figure 1**).

The augmentation works involve an additional pumping station, pipelines to transfer the water approximately 2.8 kilometres to Plashett Dam, a water discharge structure, associated power supply works, site restoration and any other related construction activity undertaken pertaining to the project.

The new pumping station is positioned immediately upstream of the existing pumping station on the northern bank of the Hunter River (**Figure 2**).

## 1.3. Purpose

The Ecology Management Plan (EMP) provides a system framework that allows for regular review and adaptation of management practices and monitoring regimes to ensure that the long term impacts of the project on flora and fauna are effectively managed at the site.

## 1.4. Scope

This EMP has been prepared in accordance with the consent conditions, relevant legislation and guidelines, and is also consistent with the environmental impact assessment which was undertaken prior to the granting of consent for the project.

Condition 6.4 of Project Approval No. 06-0259 for the Bayswater Power Pumping Station Upgrade to Increase Water Extraction Capacity prescribes:

*Prior to the commencement of construction the Proponent shall, in consultation with the DECC, prepare and implement an Ecology Management Plan which will outline measures and a monitoring regime to ensure that the long term impacts of the project*

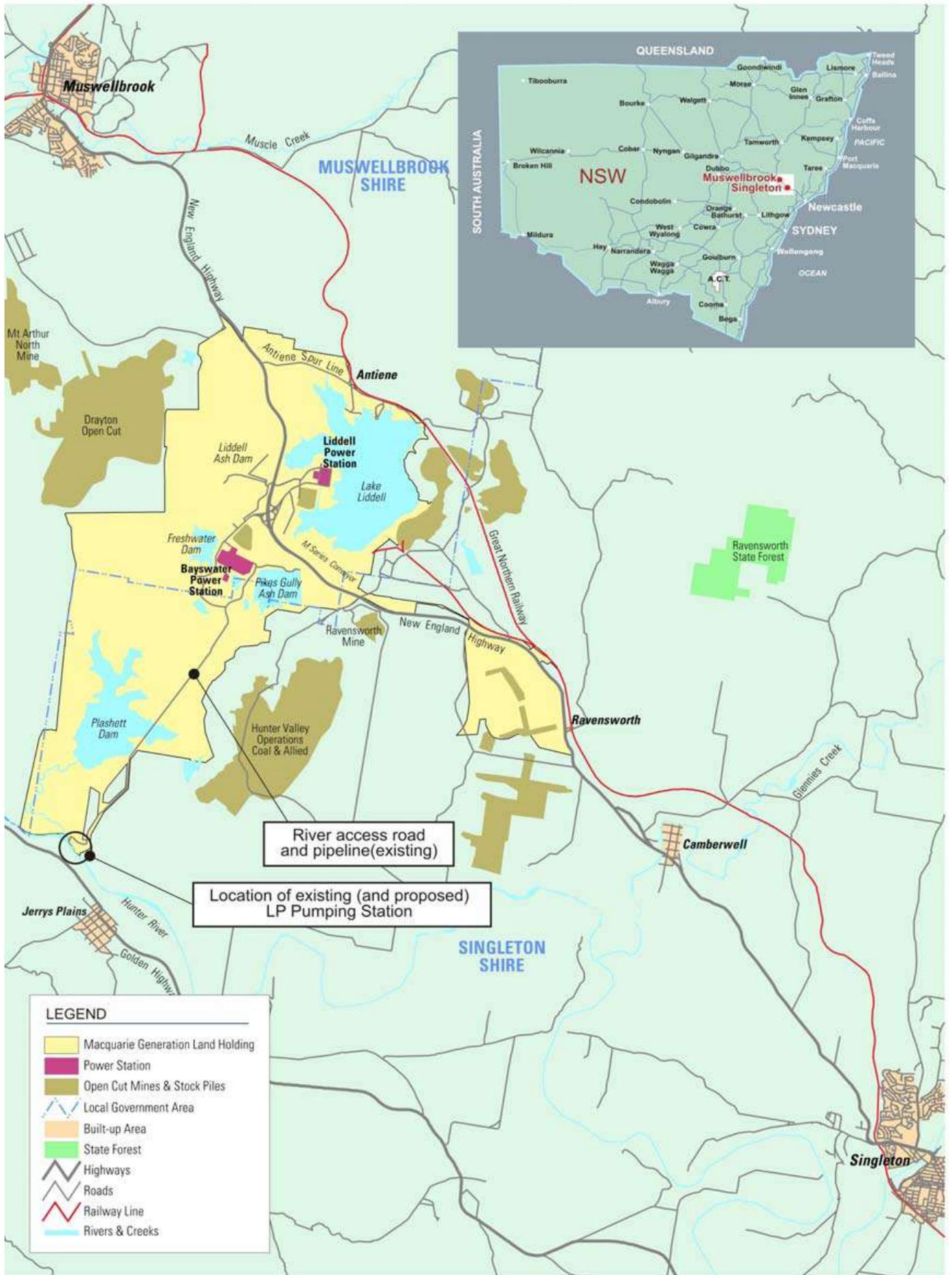


Figure 1: Site Location

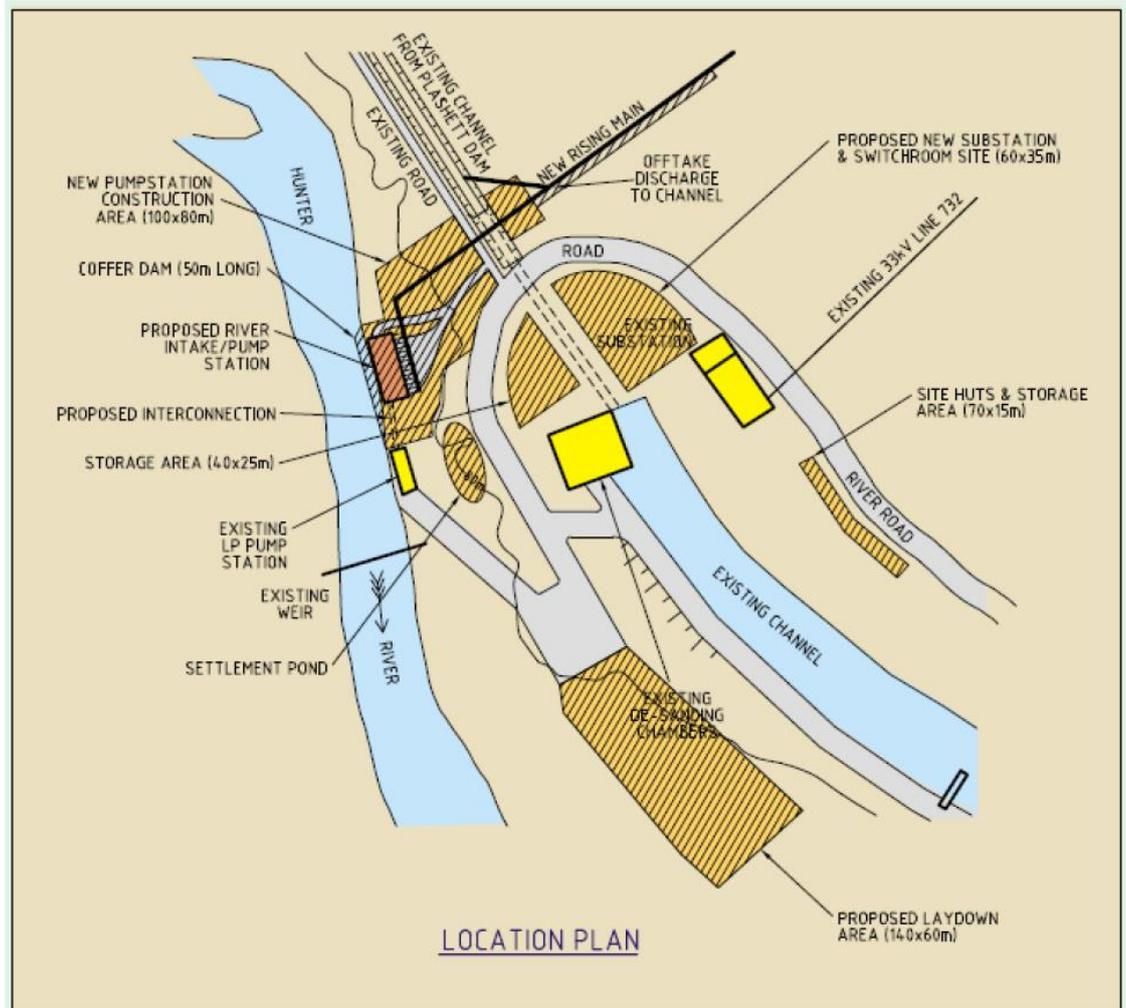


*on flora and fauna are effectively managed. The Plan shall be submitted to the Director-General for approval and shall include, but not necessarily be limited to:*

- a) A system framework that allows for regular review and adaptation of management practices and monitoring regimes, such that any adverse impacts are avoided or rectified;*
- b) A long term management plan detailing a monitoring regime and specific measures that will be undertaken to conserve the local platypus populations and the River Flat Eucalypt Forest;*
- c) A monitoring program to regularly assess the functionality of the fishway before and after the operation of the project with specific attention given to the impact of the project on the fishway during the breeding season;*
- d) A detailed rehabilitation schedule describing areas to be rehabilitated, rehabilitation methods and maintenance regimes; and*
- e) A program to monitor the health of rehabilitation areas and to ensure that the occurrence of weeds and pests in areas adjacent to the project are controlled.*

## **1.5. Consultation**

As required by Condition 6.4 of Project Approval No. 06-0259, the Department of Environment and Climate Change (DECC), now referred to as Department of Planning and Environment (DPE) were formally consulted during the preparation of the EMP. A teleconference was held with DECC officers on 11 November 2008. Additional consultation (email and telephone) was undertaken during November 2008. The DECC position focussed on the need to address the conservation and management of the local platypus population and the River Flat Eucalypt Forest Endangered Ecological Community (EEC).



**Figure 1: Pump Station Layout**

## 2. Flora and Fauna Management

This section details the long term management plan for measures and monitoring for the conservation of local platypus populations and the River Flat Eucalypt Forest EEC (Consent Condition 6.4 (b)).

### 2.1. Platypus

#### 2.1.1. Description

The platypus is only one of two monotremes, or egg-laying mammals, that live in Australia. They have a streamlined fur-covered body, webbed feet and a smooth, leathery bill. Adult males and females can differ greatly in size and weight. The average male platypus is about 50 cm long (head to tail) while females measure about 43 cm.

#### 2.1.2. Habitat

Platypuses are naturally burrowing creatures and have particular requirements as to what sort of substrate they will use to construct their burrows. They prefer undercut and relatively steep earthen riverbanks that rise over 1m. Their preference is for banks which are well consolidated by roots and overhung by vegetation. Platypuses also strongly prefer any overhanging vegetation or consolidating roots to be from native plants (Redland City Council, undated). Platypus also favour those waterways that have aquatic vegetation, logs and debris, and a series of shallow pools less than 5m deep that are joined by cobble riffle areas.

Platypus site selection and development is strongly linked to benthic invertebrate food organism availability which in turn is strongly linked to various stream requirements which include:

- Dissolved oxygen above 5mg/L
- pH close to 7
- salinity below 1000mg/L (1500  $\mu$ S/cm)
- turbidity that fluctuates <10%
- water temperature that does not vary more than 2°C
- total nitrogen between 0.001 and 0.01 mg/L and
- total phosphorous between 0.1 – 0.75mg/L

#### 2.1.3. Local Distribution

Platypus have been recorded in the Muswellbrook-Singleton section of the Hunter River since at least the early 1980s but are most likely not present in high numbers. Platypus have been recorded occurring in the Bayswater Hunter River Pump Station weir pool from 1984 to 2006 (Connell Wagner 2007).

#### 2.1.4. Conservation Status

Like most other native Australian animals, platypuses are protected under the NSW National Parks and Wildlife Act 1974 (NPA Act). The platypus is not listed on the NSW Threatened Species Conservation Act 1997 (TSC Act) or the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

#### 2.1.5. Management

**Table 1** identifies the threats and management recommendations (both short and long term) of these threats to the local platypus population at the site.

**Table 1: Platypus Threats and Management**

Threats	Management Recommendations
Riparian vegetation removal	Buffer zones of healthy vegetation should be maintained along the bank of the Hunter River. Riparian and smaller vegetation strips are to be protected and developed in the vicinity of drainage lines to filter sediment and nutrients and protect fauna and for human health. Riparian revegetation should be researched and wide enough to support a self-sustaining plant community including native understorey species originally found in the habitat. Fire Asset Protection Zones (APZ) should be maintained outside of the core riparian area.
Water quality	Water quality management and ongoing water quality improvement for drainage line and catchment areas during disturbance and rehabilitation.
Bank stability - erosion	Ensure areas of bare soil are revegetated as soon as practical (i.e. during weed management activities). Maintain sediment and erosion control measures along the riverbank and pipeline corridor. Monitoring and maintenance is to be undertaken.
Pollution and litter	Education programs are to be included in training regarding litter and its effects, waste reduction and recycling.
Predation	Monitor and control pest animal populations.



### **2.1.6. Monitoring**

Grant (2013) recommends that monitoring using Closed Circuit Television (CCTV) could be used to monitor whether platypus are continuing to use the pumping pool for foraging and/or remote camera monitoring at burrow entrances could be beneficial. Grant (2013) believes that the original recommendations in the EMP by AECOM are onerous and unwise given the risk of platypus mortality with the methods suggested. AGL Macquarie will consult further with the Platypus Consultant in 2015 to determine whether this monitoring would yield beneficial results.

## **2.2. River Flat Eucalypt Forest**

### **2.2.1. Description**

River Flat Eucalypt Forest stands are found on flats, terraces and drainage lines of coastal river flood plains and are composed of a tall open eucalypt forest to woodland (up to 40m or more high), a mid-story of small trees, an under-storey of shrubs and a mix of ground cover endemic to river flat and flood plain areas (DPE). The species content of River Flat Eucalypt Forests varies broadly with the most common and abundant canopy species north of Sydney being:

- Eucalyptus tereticornis (forest red gum)
- Eucalyptus ampliflora (cabbage gum)
- Angophora floribunda (rough-bark apple)
- Angophora subvelutina (broad-leaved apple)
- Eucalyptus saligna (Sydney Blue gum) and
- Eucalyptus grandis (flood gum)

River Flat Eucalypt Forests are distinguishable by their dominance of a single or mixed eucalypt canopy, low abundance of Casuarina and Melaleuca species, low abundance of *Eucalyptus robusta* and prominent ground cover of soft-leaved forbs and grasses (Department of Environment and Conservation (NSW) 2005).

### **2.2.2. Local Distribution**

River Flat Eucalypt Forest communities have been recorded near Singleton, Maitland and Cessnock and could once be found throughout the floodplains and river flats of the Hunter. It is likely that less than 30% of the River Flat Eucalypt Forest remains of its original distribution (DECC 2008).

### **2.2.3. Conservation Status**

The River Flat Eucalypt Forest is listed under the Threatened Species Conservation Act 1995 (NSW) as an EEC. As a listed EEC, River Flat Eucalypt Forest has significant conservation value and some activities may require a license, consent or approval. Further information on the River Flat Eucalypt Forest is available from the Office of Environment and Heritage (OEH) threatened species website <http://www.environment.nsw.gov.au/threatenedSpeciesApp/>.

#### 2.2.4. Management

**Table 2** identifies the threats and management recommendations (both short and long term) of these threats to the River Flat Eucalypt Forest at the Site.

**Table 2: River Flat Eucalypt Forest Threats and Management**

Threats	Management Actions
Clearing and fragmentation	Recognition of the value of all River Flat Eucalypt Forest remnant in land use planning. River Flat Eucalypt Forest remnant present at the Site was not disturbed during construction and will not be disturbed during operation. Undertake revegetation seeking species diversity using local provenance (where available) seed and tubestock at all vegetation layers. Carry out bush regeneration, maintenance planting and weed control.
Flood mitigation and drainage works	Inspect and manage any damage as required.
Grazing and trampling by stock, native and feral animals	Instigate feral animal control programs. Restrict stock access. Manage kangaroo population as required and appropriate. Regular monitoring and maintenance of fencing to identify any areas where stock or feral animals are accessing the EEC unrestricted.
Changes in water quality – particularly increased sedimentation and nutrients	Monitor rehabilitated areas as specified to identify any sign of erosion.
Weed invasion	Identify current weed infestations and take steps to manage and eradicate where possible.
Removal of dead wood	Restrict public access where possible. Maintain and monitor fencing.
Fire management regimes	Integrate awareness of the EEC in fire hazard reduction projects.

### 2.2.5. Monitoring

**Table 3** details the monitoring regime for the River Flat Eucalypt Forest EEC at the Site. Two types of monitoring are recommended – photographic monitoring and an annual riparian condition survey.

The aim of the annual riparian condition survey is assess the condition of the River Flat Eucalypt Forest EEC and the factors which determine this.

**Table 3: River Flat Eucalypt Forest Monitoring**

Monitoring and reporting	Method	When	By whom
Photographic monitoring	Photographs at fixed photo points	Every six months and after each flood event	Environment Officer or delegate
Riparian condition survey	Rapid Appraisal of Riparian Condition (RARC) ( <b>Appendix B</b> )	Annually for five years, and then as required	Environment Officer or delegate

## 3. Fishway Monitoring

This section details the monitoring program to regularly assess the functionality of the fishway before and after the project, focussing on the impact of the project on the fishway during the breeding season. (Consent Condition 6.4 (c)).

### 3.1. Introduction

The spatial distribution of organisms is of crucial importance for understanding ecosystem functioning. It is now accepted that most species segregate predominantly by habitat and community spatial heterogeneity is closely linked with habitat heterogeneity.

Organisms segregate by habitat along gradients of environmental parameters that are:

- physical, such as
  - current velocity
  - depth
  - density of flooded vegetation
  - substratum composition.
- chemical, such as
  - presence/absence of pollutants
  - pH
  - salinity
  - nutrients
  - toxicants
  - dissolved oxygen.
- biological, such as
  - predation
  - competition.

The augmentation works involve an additional pumping station, pipelines to transfer the water approximately 2.8 kilometres to Plashett Dam, a water discharge structure at Plashett Dam and associated power supply work that could potentially impact on the local fish communities.

There are two distinct components in the monitoring plan, associated with different phases of the augmentation works, i.e. construction and operation:

- Monitoring activities to be conducted as part of the construction process
- Ecological monitoring activities to be conducted yearly for up to two years post pump station commissioning and operation.

### 3.2. Management

Operation of the project may indirectly affect fish species through modification of the flow regimes at the fishway and changes such as water quality impacts.

**Table 4** identifies the threats and management recommendations (both short and long term) of these threats to the fish communities at the site.

**Table 4: Fishway Threats and Management**

Threats	Management Recommendations
<p><b>During Operation</b></p> <p>Exposure of previously submerged habitat such as woody debris resulting in reduced available habitat for fish and macroinvertebrates.</p> <p>Increased concentrations of sediments, nutrients and contaminants leading to degraded water and reduced available habitat for fish and macroinvertebrates.</p> <p>Loss of potential long term woody debris recruitment to stream for instream habitat.</p>	<p>Pump in accordance with allowable limits specified in the Water Licensing Package.</p> <p>Fish monitoring to assess community changes from pumping activities.</p> <p>Monitoring for erosion and rehabilitation of disturbed areas of the riparian corridor and upper catchment areas.</p> <p>Retain instream vegetation, timber, snags etc.</p>

### 3.3. Monitoring Program

**Table 5** details the monitoring regime that should be implemented to assess the potential impact of the project on the fish communities. Two types of monitoring are recommended – water quality monitoring during construction and fish community monitoring using the methodologies recommended in Section 3.4.

**Table 5: Fishway Monitoring Program**

Monitoring and reporting	Method	When	By whom
Fish communities	As per methods recommended in Section 3.4 or specified by fish ecologist.	<p>Annually for two years post the pumping station being commissioned and in operation.</p> <p>Year 1 – baseline data.</p> <p>Year 2 – comparison data. Completed.</p> <p>Every 5 years during the operation of the</p>	To be conducted only by an experienced fish ecologist.

		project.	
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### 3.4. Methods

It is of critical importance to establish baseline data of the water chemistry, vegetation community, soil thicknesses and types and channel bed materials, fish, platypus and other faunal communities in the vicinity of the proposed work area prior to commencement of works.

Fish communities provide an indication of water quality and habitat development with flow management etc. An intensive weekly fish monitoring effort was conducted between November 1996 and May 1997. The key findings from this monitoring need to be updated. It is recommended that an ongoing monitoring program be undertaken to look at the effect/impacts of the pumping station on the fish communities to assess the possible community changes associated with the water level fluctuations in the pumping area.

It is recommended to use a combination of active and passive sampling techniques to survey the fish communities at the site, i.e. a mixture of electrofishing, fyke nets, mesh nets and bait traps.

An experienced fish ecologist is to determine the most appropriate method for sampling at each site within the work area and is to record erosion, sediment management and vegetation cover (bank, wetland and aquatic vegetation including weeds).

It is anticipated that electrofishing would be used where possible, and if this is an unsuitable method at the site, fyke nets and baits traps should be developed overnight to collect large and small bodied fish.

#### 3.4.1. Passive Sampling Techniques

##### 3.4.1.1. Fyke Nets and Bait Traps

- dual wing fyke nets. Nets have 2 wings (each 4 m x 1.2 m) attached to the first supporting (diameter = 0.64 m) with a stretched mesh size of 2 mm
- bait traps that have a funnelled opening at each end (0.22 m x 0.22 m x 0.4m, with 2 mm stretched mesh) and are set baited in the littoral zone close to emergent vegetation, submerged macrophytes and woody debris.

All nets and traps would be set to ensure a diversity of structural habitat available to fish would be sampled in each creek (open water, amongst or against vegetation and woody material). This variety of passive gear types would increase the probability of sampling a wider range of species and size classes.

##### 3.4.1.2. Mesh Nets (Gill Nets)

Mesh-nets made of nylon monofilament that could be used in cases where other conventional methods are not possible. The nets consist of four mesh sizes (19 mm, 40 mm, 63 mm, 80 mm stretched mesh size) with a 25 m length of hung net for each mesh size. The nets have a drop of 2 m and are weighted at the base.



If the use of gillnets is required, the nets would be manned at all times with all fish immediately removed from the net upon capture. All fish would be immediately processed and returned to the water.

### **3.4.2. Calculating Sampling Effort**

It is important to note the time when the nets are deployed and removed from the water, as this information would be used to calculate netting hour (sampling effort).

### **3.4.3. Active Sampling Techniques**

#### **3.4.3.1. Backpack Electrofishing**

The purpose of electrofishing is to apply a suitable electrical field to a given body of freshwater in order to attract and induce a temporary state of narcosis in fish within the immediate area. This enables the fish scientists to carry out tasks such as detailed population studies, live capture and tagging. The most effective output for fish capture is within a voltage range adjustable from 100V to 600V DC.

Only the minimum power necessary to attract and stun the fish effectively would be used. If threatened species are observed that are not being targeted, appropriate measures would be undertaken to minimise the disturbances and stress to the fish.

Electrofishing would be halted within 50m of any animals standing in or about to enter the water. The utmost possible care would be taken to avoid shocking other aquatic animals.

All stunned specimens would be dip netted and transferred to an aerated holding tank for recovery. All native species would be weighed and measured and immediately returned to that water. All noxious species would be euthanized in benzocaine solution and removed from the site.

#### **3.4.3.2. Operational Practices for use of electrofishing**

- Team Size and personal protective equipment:
  - > A minimum of two operators would undertake all electrofishing operations
  - > Rubber waders plus 1000V rated linesmen gloves would be worn by all electrofishing team members during operation.
- Public Safety
  - > Spectators would be warned to keep away. No electrofishing is to be performed within 50m of boats and/or shore viewers. In public areas, signs would be erected warning people to not enter near use of the equipment.
- Weather and safety limitations
  - > Electrofishing would not be conducted during rain or rough water conditions. The Senior Operator would determine safe weather conditions such as water current, wind and other weather conditions.
- Working Procedure
  - > Senior Operators are responsible for checking correct setup of equipment, crew safety clothing and readiness before commencing electrofishing operations. The anode must be in the water and considered live at all times.

- > Relevant local authorities would be notified prior to any electrofishing.
- > Never place unprotected parts of the body in the water while conducting electrofishing operations. Stunned fish must only be removed from the water using insulated dip nets. Never attempt to grab a fish by hand.
- > If the anode becomes fouled on snags or trees, the electrofishing machine must be stopped before attempting to free them.
- > No smoking is allowed within the vicinity of electrofishing.
- > Electrofishing team must have access to communications at all times in case of an emergency.
- > All equipment should be stored in a dry, clean, secure place.
- Care of other Fauna
  - > electrofishing would be halted within 50m of any animals standing in, or about to enter the water
  - > the upmost care should be taken to avoid shocking other native aquatic animals.

### **3.4.3.3. Seine Net**

10 m seine and 5 m seine of 2 mm mesh size are routinely used to actively sample small mid-water and benthic fish species.

Two people operate the seine net, one at each end, and drag the net through open sections of water. Each seine trawl is standardised to 10m transects. Multiple replicates could be sampled from each site to target the following habitat types:

- stands of emergent and submerged vegetation (requiring great care during retrieval to prevent fish escaping)
- areas adjacent to snags/woody structure
- areas underneath overhanging vegetation
- open water

To minimise the stress placed on the fish caught in the seine nets, the content of the net would be emptied into an aerated holding tank. Fish would be removed for processing using a small 'enviro' dip net. All native species would be weighed and measured and immediately returned to that water to minimise handling time.

### **3.4.4. Euthanasia of Specimens**

All noxious species declared under relevant state and federal legislation, would be euthanized with the use of Benzocaine (ethyl aminobenzoate) solution. Benzocaine is a colourless crystal or white powder that is poorly water-soluble and needs to be prepared in either ethanol or acetone.

A standard solution would be prepared by adding 100g of benzocaine to one litre of acetone/ethanol. This is then used at a rate of 5mL per litre of water. At these levels the fish should lose equilibrium in 1-3 minutes.

Noxious species would be removed from the site and disposed appropriately.

## **4. Rehabilitation**

## 4.1. Rehabilitation Schedule

As indicated in the Independent environmental audit for the project, there was limited success associated with the rehabilitation undertaken in 2010. While there is adequate ground cover to avoid the risk of erosion, there is limited growth of native species and significant infestation of weeds in particular adjacent to the EEC and steep slope to the north of the pump station. As such AGL Macquarie will undertake targeted weed management and additional tubestock planting in all storeys to enhance the EEC composition and diversity adjacent river and the area at the outlet to Plachett Reservoir. Species selection for the follow-up tubestock planting will be generally based on the recommendations highlighted in the Flora and Fauna Management Plan for the Project as shown in **Table 6**. The rehabilitation schedule is specified in **Table 7**.

**Table 6: Recommended Species for Planting**

Species Name	Common Name	Strata
<i>Acacia cultriformis</i>	Knife-leaf Wattle	Midstorey
<i>Acacia falcata</i>	Sickle Wattle	Midstorey
<i>Acacia filicifolia</i>	Fern-leaf Wattle	Midstorey
<i>Acacia salicina</i>	Hickory Wattle	Midstorey
<i>Allocasuarina leuhmannii</i>	Bull Oak	Midstorey
<i>Breynia oblongifolia</i>	Coffee Bush	Midstorey
<i>Bursaria spinosa</i>	Blackthorn	Midstorey
<i>Casuarina cunninghamiana</i>	River She-oak	Overstorey
<i>Brachychiton populneus</i>	Kurrajong	Overstorey
<i>Corymbia maculata</i>	Spotted Gum	Overstorey
<i>Eucalyptus crebra</i>	Narrow-leaf Ironbark	Overstorey
<i>Eucalyptus moluccana</i>	Grey Box	Overstorey
<i>Eucalyptus tereticornis</i>	Forest Red Gum	Overstorey
<i>Harbenbrgia violaccaeae</i>	False Sarsparilla	Climber
<i>Lomandra longifolia</i>	Spiney-headed Mat-rush	Groundcover
<i>Limandra hystrix</i>	Green Mat-rush	Groundcover

**Table 7: Rehabilitation Monitoring**

Sector	Monitoring	Method	When	By whom
Area adjacent to EEC and Pumps	Supplementary planting vegetation survival survey	Visual inspection and quadrat count of survival status and health of tubestock	4 weeks post completion of supplementary revegetation works	Environment officer or delegate
	Site survey (including weed, pest animal, erosion and subsidence monitoring)	Site inspection checklist ( <b>Appendix A</b> ) and photographic monitoring	Annually (spring) until revegetation is deemed sustainable	Environment officer or delegate
Steep slope north of the pump station	Supplementary planting vegetation survival survey	Visual inspection and quadrat count of survival status and health of tubestock	4 weeks post completion of supplementary revegetation works	Environment officer or delegate
	Site survey (including weed, pest animal, erosion and subsidence monitoring)	Site inspection checklist ( <b>Appendix A</b> ) and photographic monitoring	Annually (spring) until revegetation is deemed sustainable	Environment officer or delegate
Pipeline corridor	Site survey (including weed, pest animal, erosion and subsidence monitoring)	Site inspection checklist ( <b>Appendix A</b> ) and photographic monitoring	Annually (spring) until revegetation is deemed sustainable	Environment officer or delegate
Outlet at Plashett Reservoir	Supplementary planting vegetation survival survey	Visual inspection and quadrat count of survival status and health of tubestock	4 weeks post completion of supplementary revegetation works	Environment officer or delegate
	Site survey (including weed, pest	Site inspection checklist ( <b>Appendix A</b> )	Annually (spring) until revegetation is	Environment officer or

	animal, erosion and subsidence monitoring)	and photographic monitoring	deemed sustainable	delegate
Infrastructure -roads	Site survey (including weed, pest animal, erosion and subsidence monitoring)	Site inspection checklist ( <b>Appendix A</b> ) and photographic monitoring	Annually (spring) until revegetation is deemed sustainable	Environment officer or delegate
Infrastructure - substation	Site survey (including weed, pest animal, erosion and subsidence monitoring)	Site inspection checklist ( <b>Appendix A</b> ) and photographic monitoring	Annually (spring) until revegetation is deemed sustainable	Environment officer or delegate
Stockpiled materials	Supplementary re-vegetation survival survey	Visual inspection and quadrat count of survival status and health revegetation	4 weeks post completion of supplementary revegetation works	Environment officer or delegate
	Site survey (including weed, pest animal, erosion and subsidence monitoring)	Site inspection checklist ( <b>Appendix A</b> ) and photographic monitoring	Annually (spring) until revegetation is deemed sustainable	Environment officer or delegate

## 5. Reporting and Review

The reports to be prepared as a result of monitoring activities addressed in the Ecology Management Plan include:

- Platypus monitoring:
  - > Completed survey/s
- River Flat Eucalypt Forest monitoring:
  - > Riparian condition surveys
- Fishway monitoring:
  - > Water quality monitoring
  - > Fish community monitoring
- Rehabilitation
  - > Initial survival survey for revegetation



> Annual site surveys

The Ecology Management Plan will be reviewed and updated as required or in the event of a significant change associated with the project.

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## **Appendix A**

# **Rehabilitation Monitoring Site Inspection Checklist**

## Rehabilitation Monitoring Site Inspection Checklist

### General Site Information

Site Name	
Date of inspection	
Inspected by	
Photo number	
Photo point easting	
Photo point northing	
Other Comments	

### Overstory <sup>1</sup>

Score	0	1	2	3	Comments
Average height of trees (m)	N/A	<5	5 – 10	>10	
Number of O/S species	N/A	1 – 2	2 – 5	>5	
Reproductive stage of majority of	N/A	Juvenile	Senescence	Adult	

overstorey					
Evidence of natural regeneration	N/A	Primary recolonisation of bare areas	Secondary recolonisation	Seedlings or young regeneration <1m tall	
<b>SCORE</b>					
List of key overstorey species					

<sup>1</sup>Do not count overstorey for grassland rehabilitation

Understorey – shrub layer					
Score	0	1	2	3	Comments
Tree canopy cover (%)	0	<30	30 – 70	>70	
Number of U/S species	N/A	1 – 2	2 – 5	> 5	
Average height of layer (m)	<1	1 – 2	2 – 3	>3	
Evidence of natural regeneration	N/A	Primary recolonisation of bare areas	Secondary recolonisation	Seedlings or young regeneration	
<b>SCORE</b>					

List of key understory species

Groundcover					
Score	0	1	2	3	Comments
Leaf litter depth (cm)	N/A	<5	5 - 10	> 10	
Bare soil (%)	>75	50 - 75	20 - 50	< 20	
Foliage cover (%)	<20	20 - 50	50 - 75	>75	
Groundcover height (cm)	0	0 - 10	11 - 50	>50	
Number groundcover species	1 - 2	3 - 10	11 - 20	>20	
<b>SCORE</b>					
List of key ground cover species					

**Introduced species (weeds)**

Score	0	1	2	3	Comments
% cover	>75	50 – 75	20 – 50	<20	
Number of species	>5	3 – 5	1 – 2	0	
Growth stage	Seed and vegetative propagation	Fruit	Flower/foilage	N/A	
<b>SCORE</b>					
List of key weed species					

<b>Pest Animal Activity</b>					
Score	0	1	2	3	Comments
Rabbits	Active warrens	Scat mounds	Soil disturbance	N/A	
Pigs	Visible vegetation damage, erosion and sign of wallowing	Scat mounds	Soil disturbance	N/A	
Dogs/foxes	Active dens	Scat mounds	Soil disturbance	N/A	

Other	Vegetation damage, erosion, etc	Scat mounds	Soil disturbance	N/A	
<b>SCORE</b>					
Comments					

Disturbance					
Score	0	1	2	3	Comments
Evidence of bushfire	Scorched earth, dead vegetation	Singed understory	Blackened trees	N/A	
Rubbish	Construction and other debris	Scattered rural litter	Scattered domestic litter	N/A	
Unauthorized access	Environmental vandalism e.g. dozer scale	Small scale environ damage e.g. limbs broken, unauthorized vehicle tracks	Broken gates, padlocks	N/A	
<b>SCORE</b>					
Comments					

Surface Stability					
Score	0	1	2	3	Comments
Presence of topsoil	N/A	Exposed/shallow	Stable	Stable with organic content	
Erosion present	Active	Partially stabilised	Stabilised	N/A	
Sheet	Severe	Moderate	Minor	N/A	
Rill	Severe	Moderate	Minor	N/A	
Tunnel	Severe	Moderate	Minor	N/A	
Gulley (>0.3m deep & wide)	Severe	Moderate	Minor	N/A	
Stream bank	Severe	Moderate	Minor	N/A	
Surface compaction	Severe	Moderate	Minor	N/A	
Runoff	Rapid	Moderate	Minor	N/A	
<b>SCORE</b>					
Comments					

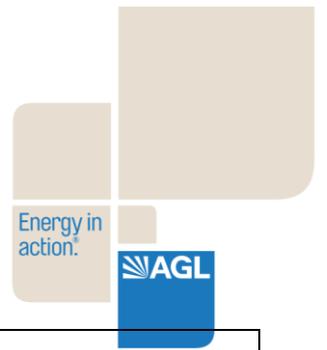
Microhabitat					
Score	0	1	2	3	Comments

Free water	N/A	Puddles	Dam	Perennial stream	
Rocks	N/A	Scattered rocks various sizes	Boulders – partially emerging – various sizes	Caves, scree slopes	
Timber	N/A	Twigs, sticks	Scattered logs	Mixed sizes, scattered piles	
<b>SCORE</b>					
Comments					

Summary		
Component	Survey Score	Total Possible Score
Overstory		12
Understory		12
Groundcover		15
Introduced species (weeds)		9
Pest animal activity		12
Disturbance		9
Surface stability		27
Microhabitat		9
<b>TOTAL SCORE</b>		<b>105</b>

<b>Interpretation of results</b>	
<b>Grassland rehabilitation</b>	<b>Interpretation</b>
Score <30	Poor – degraded and require high degree of active land management
Score 30 - 59	Satisfactory – require varying degrees of active land management
Score 60 - 80	Good
Score >80	Excellent – do not require active land management
Woodland	Interpretation
<b>Woodland rehabilitation</b>	<b>Interpretation</b>
Score <36	Poor – degraded and require high degree of active land management
Score 36 - 70	Satisfactory – require varying degrees of active land management
Score 71 - 95	Good – require maintenance works (e.g. small scale weed control)
Score >95	Excellent – do not require active land management

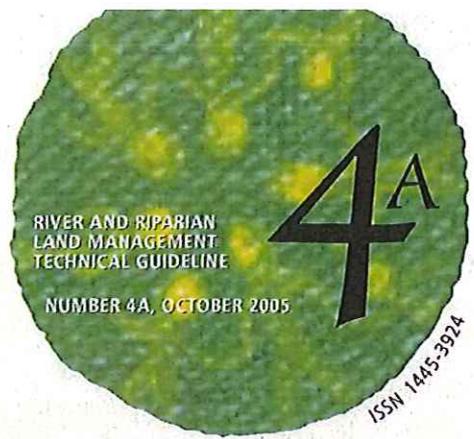
<b>Recommendations based on survey results<sup>2</sup></b>



<sup>2</sup>When interpreting survey results, attention is drawn to the individual components with low scores, which will require remedial action.



**Appendix B**  
**River and Riparian Technical Guideline**  
**- Rapid Appraisal of Riparian Condition**



# Rapid Appraisal of Riparian Condition

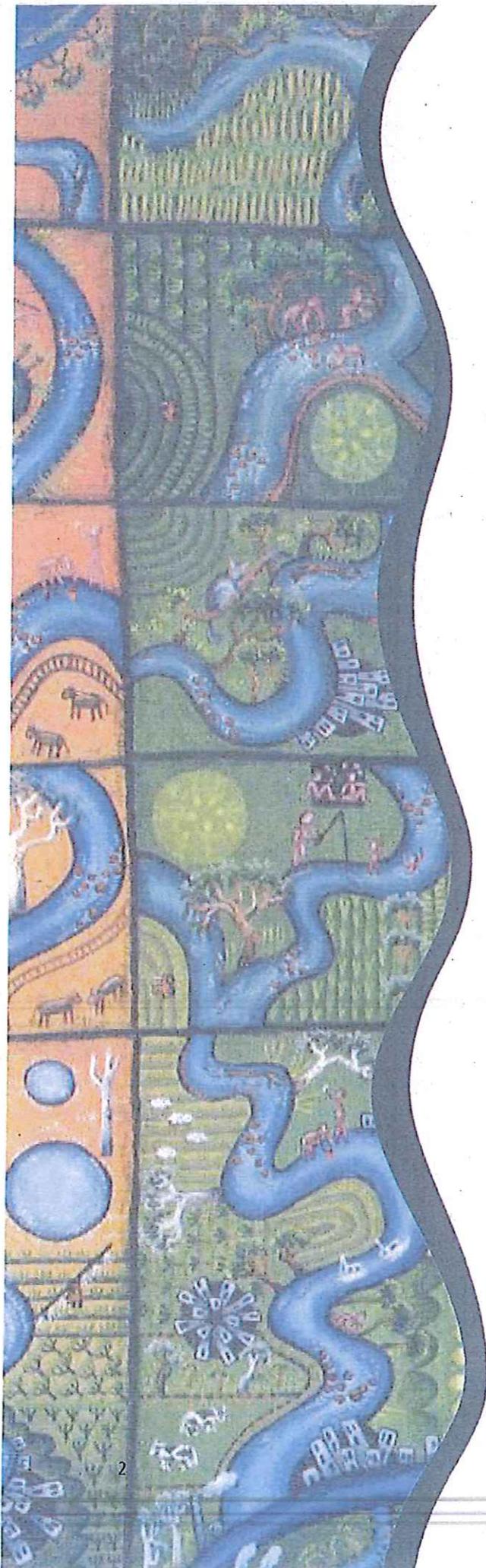
Version Two

*Amy Jansen, Alistar Robertson, Leigh Thompson and Andrea Wilson*

## Summary

- ~ Riparian habitats are where terrestrial and aquatic ecosystems meet. They are vital sites in a catchment supporting high levels of biodiversity.
- ~ Given the extensive degradation of riparian zones in Australia, there is a need for a rapid method of measuring riparian condition to underpin strategies for improved management.
- ~ Riparian condition refers to the degree to which human-altered ecosystems diverge from local semi-natural ecosystems in their ability to support a community of organisms and perform ecological functions.
- ~ The Rapid Appraisal of Riparian Condition assesses the ecological condition of riparian habitats using indicators that reflect functional aspects of the physical, community and landscape features of the riparian zone.
- ~ The Rapid Appraisal of Riparian Condition index is made up of five sub-indices, each with a number of indicators: Habitat continuity and extent (HABITAT), Vegetation cover and structural complexity (COVER), Dominance of natives versus exotics (NATIVES), Standing dead trees, hollows, fallen logs and leaf litter (DEBRIS), and Indicative features (FEATURES).
- ~ The Rapid Appraisal of Riparian Condition has been tested in three areas in south-eastern Australia: on the Murrumbidgee River, in Gippsland, and in the Goulburn-Broken catchment. In all three areas, there was a strong negative relationship between grazing intensity and riparian condition.
- ~ Testing of the Rapid Appraisal of Riparian Condition index confirms that it is a good indicator of the biodiversity and functioning of riparian zones.
- ~ This Technical Guideline Update is the second version of the Rapid Appraisal of Riparian Condition, and incorporates a simplified scoring system, additional indicators, and some adjustments to scoring of individual indicators.





## Background

Riparian habitats are where terrestrial and aquatic ecosystems meet. They are vital sites in a catchment, supporting high levels of biodiversity and being critical in controlling flows of energy and nutrients between terrestrial and aquatic ecosystems (Naiman & Decamps, 1997). Being at the boundary of terrestrial and aquatic ecosystems, riparian areas are powerful indicators of catchment quality (e.g. Rapport et al., 1998). Human settlement has always been focused on rivers and is often a major determinant of riparian structure and function (e.g. Dynesius & Nilsson, 1994). One of the biggest impacts on riparian areas has been the introduction of domestic stock, with grazing being the major land use over 60% of Australia's land surface (Wilson, 1990). Stock concentrate around water sources, which means riparian and wetland habitats, as well as those around artificial watering points in pastoral regions, suffer greater impacts from domestic and feral grazing herds than dryland areas (Robertson, 1997; James et al., 1999). These impacts have led to extensive loss of ecological condition in riparian areas in Australia.

Given the critical role of riparian areas within catchments, and their extensive degradation in Australia, there is a need for improved management of these areas. A baseline for improved management must be an understanding of current condition, and the factors which determine this. Thus, there is a need for a rapid method of measuring riparian condition, to enable assessment of a large number of sites in a catchment. There is an expanding field of research focused on rapid appraisal techniques to measure ecosystem condition or integrity (Fairweather, 1999; Boulton, 1999). We have developed a rapid appraisal method for use at a large number of sites which is responsive to changes in grazing management. Subsequent testing of the method and trialling with many willing workshop participants led to modifications to the original method. These modifications have greatly simplified the scoring system, but comparison of the versions showed that it makes little difference to the overall score given to a site. This Technical Guideline Update 4A is the second version of the Rapid Appraisal of Riparian Condition, and incorporates a simplified scoring system, additional indicators, and some adjustments to scoring of individual indicators.

Throughout this Guideline, *condition* refers to the degree to which human-altered ecosystems diverge from local semi-natural ecosystems in their ability to support a community of organisms and perform ecological functions (c.f. Karr, 1999).

## Rapid Appraisal of Riparian Condition (RARC)

Assessment methods incorporating indicators of geophysical and biological properties and processes are likely to provide reliable estimates of ecological condition in riverine ecosystems (Fairweather, 1999; Boulton, 1999). Ladson et al. (1999) described an index of stream condition based on 18 indicators that measure alterations to the hydrology, physical form, streamside vegetation, water quality and biota of streams. This project used a similar approach, and chose indicators to reflect functional aspects of the physical, community and landscape features of the riparian zone, as defined by Naiman & Decamps (1997) (see Table 1). Some of the indicators chosen reflect a variety of functions, e.g. different aspects

of vegetation cover can play a role in reducing bank erosion, providing organic matter and habitat for fauna, and providing connections in the landscape. The Rapid Appraisal of Riparian Condition (RARC) index is made up of five sub-indices, each with a number of indicator variables (see Table 2, overleaf). In summary they cover:

1. Habitat continuity and extent (HABITAT).
2. Vegetation cover and structural complexity (COVER).
3. Dominance of natives *versus* exotics (NATIVES).
4. Standing dead trees and fallen logs and leaf litter (DEBRIS).
5. Indicative features (FEATURES).

Table 1. Summary table of functions, components and indicators assessed in the Rapid Appraisal of Riparian Condition index.

Functions of the riparian zone at different levels of organisation	Components of the riparian ecosystem that perform those functions	Indicators of the functions used in the RARC
<i>Physical:</i>		
Reduction of erosion of banks	Roots, ground cover	Vegetation cover*
Sediment trapping	Roots, fallen logs, ground cover	Canopy cover, fallen logs, ground cover vegetation, leaf litter cover
Controlling stream microclimate/ discharge/water temperatures	Riparian forest	Canopy cover
Filtering of nutrients from upslope	Vegetation, leaf litter	Ground cover vegetation, leaf litter cover
<i>Community:</i>		
Provision of organic matter to aquatic food chains	Vegetation	Vegetation cover*, leaf litter cover
Retention of plant propagules	Fallen logs, leaf litter	Fallen logs, leaf litter cover
Maintenance of plant diversity	Regeneration of dominant species, presence of important species, dominance of natives <i>versus</i> exotics	Native canopy and shrub regeneration, grazing damage to regeneration, reeds, native vegetation cover*
Provision of habitat for aquatic and terrestrial fauna	Fallen logs, leaf litter, standing dead trees/hollows, riparian forest, habitat complexity	Fallen logs, leaf litter cover, standing dead trees, hollows, vegetation cover*, number of vegetation layers
<i>Landscape:</i>		
Provision of biological connections in the landscape	Riparian forest (cover, width, connectedness)	Vegetation cover*, width of riparian vegetation, longitudinal continuity of riparian vegetation, proximity to other habitat
Provision of refuge in droughts	Riparian forest	Vegetation cover*

\* Vegetation cover = canopy, understorey and ground cover

**Table 2.** Sub-indices and indicators of the Rapid Appraisal of Riparian Condition, the range within which each is scored, the method of scoring for each indicator, and the maximum possible total for each sub-index (note that in Table 2 the indicators are not grouped by function as they are in Table 1).

Sub-index	Indicator	Range	Method of scoring	Total
<b>HABITAT</b>				<b>11</b>
	Longitudinal continuity of riparian vegetation ( $\geq 5$ m wide)	0-4	0 = $< 50\%$ , 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = $\geq 95\%$ vegetated bank; with 1/2 point subtracted for each significant discontinuity ( $\geq 50$ m long)	
	Width of riparian vegetation (scored differently for channels $<$ or $\geq 10$ m wide)	0-4	Channel $\leq 10$ m wide: 0 = VW $< 5$ m, 1 = VW 5-9 m, 2 = VW 10-29 m, 3 = VW 30-39 m, 4 = VW $\geq 40$ m Channel $> 10$ m wide: 0 = VW/CW $< 0.5$ , 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW $\geq 4$ , where CW = channel width and VW = vegetation width	
	Proximity to nearest patch of intact native vegetation $> 10$ ha	0-3	0 = $> 1$ km, 1 = 200 m-1 km, 2 = contiguous, 3 = contiguous with patch $> 50$ ha	
<b>COVER</b>				<b>12</b>
	Canopy ( $> 5$ m tall)	0-3	0 = absent, 1 = 1-30%, 2 = 31-60%, 3 = $> 60\%$ cover	
	Understorey (1-5 m tall)	0-3	0 = absent, 1 = 1-5%, 2 = 6-30%, 3 = $> 30\%$ cover	
	Ground ( $< 1$ m tall)	0-3	0 = absent, 1 = 1-30%, 2 = 31-60%, 3 = $> 60\%$ cover	
	Number of layers	0-3	0 = no vegetation layers to 3 = ground cover, understorey and canopy layers	
<b>NATIVES</b>				<b>9</b>
	Canopy ( $> 5$ m tall)	0-3	0 = none, 1 = 1-30%, 2 = 31-60%, 3 = $> 60\%$ cover	
	Understorey (1-5 m tall)	0-3	0 = absent, 1 = 1-5%, 2 = 6-30%, 3 = $> 30\%$ cover	
	Ground ( $< 1$ m tall)	0-3	0 = none, 1 = 1-30%, 2 = 31-60%, 3 = $> 60\%$ cover	
<b>DEBRIS</b>				<b>10</b>
	Leaf litter	0-3	0 = none, 1 = 1-30%, 2 = 31-60%, 3 = $> 60\%$ cover	
	Native leaf litter	0-3	0 = none, 1 = 1-30%, 2 = 31-60%, 3 = $> 60\%$ cover	
	Standing dead trees ( $> 20$ cm dbh)	0-1	0 = absent, 1 = present	
	Hollow-bearing trees	0-1	0 = absent, 1 = present	
	Fallen logs ( $> 10$ cm diameter)	0-2	0 = none, 1 = small quantities, 2 = abundant	

dbh = diameter at breast height,  $<$  less than,  $\leq$  less than or equal to,  $>$  greater than,  $\geq$  greater than or equal to.

Table 2. continued

Sub-index	Indicator	Range	Method of scoring	Total
<b>FEATURES</b>				<b>8</b>
	Native canopy species regeneration (< 1 m tall)	0-2	0 = none, 1 = scattered, 2 = abundant; with 1/2 point subtracted for grazing damage	
	Native understorey regeneration	0-2	0 = none, 1 = scattered, 2 = abundant; with 1/2 point subtracted for grazing damage	
	Large native tussock grasses	0-2	0 = none, 1 = scattered, 2 = abundant	
	Reeds	0-2	0 = none, 1 = scattered, 2 = abundant	



**Photo 1.** A site in excellent condition on the Edward River (RARC score = 50; note continuous canopy of native trees, standing dead trees, hollow-bearing trees and fallen logs, native shrub understorey, reeds and regeneration of canopy trees).



**Photo 2.** A site in very poor condition on the Murrumbidgee River (RARC score = 14; note discontinuous canopy, lack of shrubs, small amounts of leaf litter, lack of native ground cover and reeds, little regeneration of canopy trees).

Photos 1 and 2 show contrasting sites in excellent and very poor condition. Details of the scoring for these sites can be found in the box below.

Example of scoring indicators for the sites shown in Photos 1 and 2 (see Table 2 for indicators and details)				
Sub-index	Excellent condition site (Photo 1)		Very poor condition site (Photo 2)	
Habitat	4 + 4 + 3 =	11	0 + 0 + 0 =	0
Cover	3 + 3 + 3 + 3 =	12	1 + 0 + 3 + 2 =	6
Natives	3 + 3 + 3 =	9	1 + 0 + 1 =	2
Debris	3 + 3 + 1 + 1 + 2 =	10	1 + 1 + 1 + 1 + 1 =	5
Features	2 + 2 + 2 + 2 =	8	1 + 0 + 0 + 0 =	1
Total		50		14

## Applications of the Rapid Appraisal of Riparian Condition index

The RARC was initially developed as a tool to determine the impacts of grazing management practices on riparian condition, and to identify those practices which resulted in minimal impacts. We have now tested this approach in three areas of south-eastern Australia (see Figure 1); some results are presented below. Note that these results were obtained using the original version of the RARC, but the two versions give very similar scores.

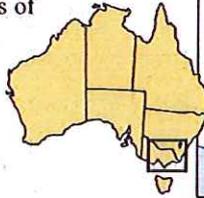
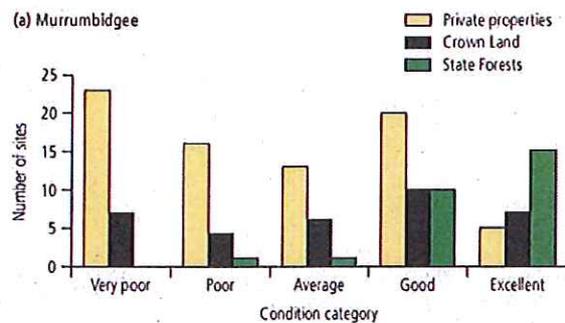


Figure 1. Location of sites where the Rapid Appraisal of Riparian Condition has been applied.

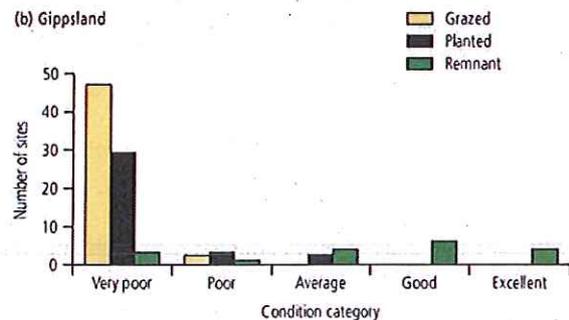
### Murrumbidgee River

A total of 138 sites (each 1 kilometre in length) were surveyed between Gundagai and Hay, on private properties, crown land and State Forests (Jansen & Robertson, 2001a). The majority of sites on private property were in very poor condition, while sites on Crown Land (mainly Travelling Stock Reserves) were very variable. Most State Forest sites were in good to excellent condition (Figure 2a).



### Gippsland

A total of 108 sites (each 150 metres in length) were surveyed in West and South Gippsland, at three types of sites — grazed paddocks on private properties, planted and fenced riparian areas on private properties, and remnant patches of uncleared native vegetation both on private properties and in reserves (Thompson et al., 2003). All private property sites were on dairy farms. The majority of sites were in very poor condition, with only remnant sites scoring above average (Figure 2b). It should be noted that most planted sites were relatively recently fenced, and their condition can be expected to improve as the plantings mature.



### Goulburn-Broken

A total of 46 sites (each 200 metres in length) were surveyed in the upper and mid-Goulburn-Broken catchment, at grazed and ungrazed sites on private properties, and at ungrazed sites in reserves (Wilson et al., 2003). Again, the majority of sites were in very poor condition (Figure 2c). Like the Gippsland planted sites, many of the Goulburn-Broken ungrazed sites on private properties were relatively recently fenced, and their condition can be expected to improve as plantings mature.

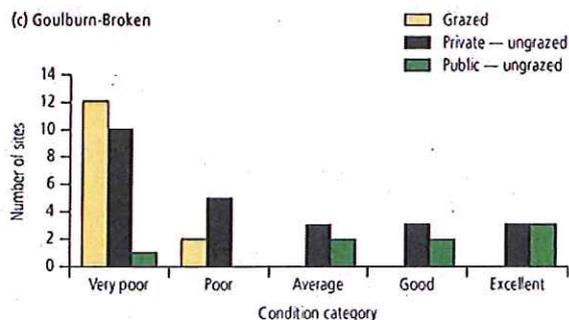


Figure 2. The number of sites scoring in each category (< 25 very poor, 25–30 poor, 30–35 average, 35–40 good and > 40 excellent) of the RARC index for three regions: (a) Murrumbidgee River, (b) West and South Gippsland, and (c) upper and mid-Goulburn-Broken catchment.

### Riparian condition in relation to stocking rates

In all three regions, we examined the relationship between stocking rates and riparian condition, with Figure 3 below showing our results. Clearly, riparian condition declined with increased stocking rates, across all regions and a large range of stocking rates. Given the large number of sites in poor condition in all catchments, this suggests that stocking rates commonly used on private properties are too high to maintain riparian zones in good condition.

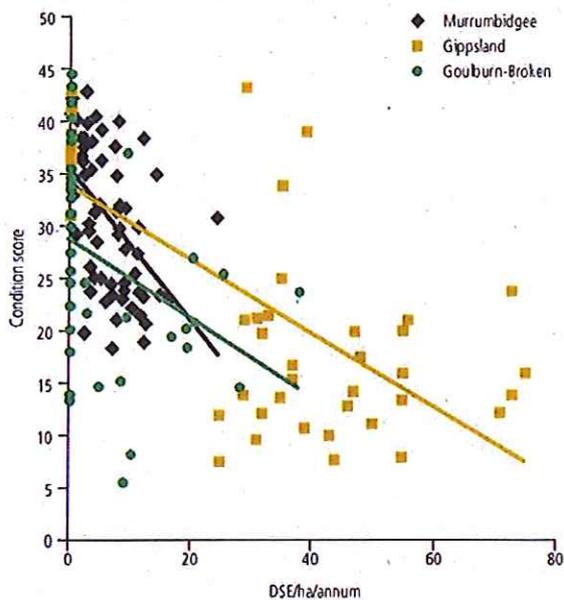


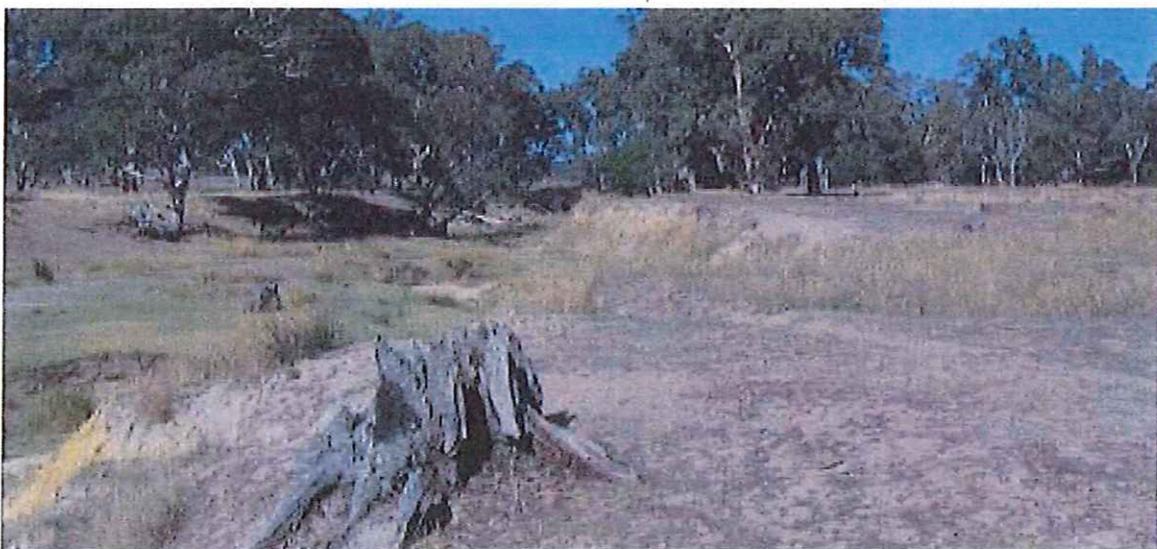
Figure 3. RARC condition scores in relation to stocking rates (DSE/ha/annum) for three regions: Murrumbidgee River, West and South Gippsland, and upper and mid-Goulburn-Broken catchment.

### Sub-indices of the riparian condition index

There was variation across regions in relation to which sub-indices accounted for most of the variation in the total riparian condition score (Table 3). In the Murrumbidgee region, 85% of the variance in the total condition score was explained by the DEBRIS sub-index (scoring for leaf litter, fallen logs and standing dead trees). In Gippsland, 90% of the variance in the total condition score was explained by the NATIVES sub-index (scoring for native species in the vegetation cover and debris). In the Goulburn-Broken, 79% of the variance in the total condition score was explained by the COVER sub-index (scoring for % cover in each vegetation layer, and the number of vegetation layers).

Sub-index	Murrumbidgee	Gippsland	Goulburn-Broken
COVER	0.42	0.83	0.79
DEBRIS	0.85	0.75	0.70
HABITAT	0.81	0.80	0.62
NATIVES	0.23	0.90	0.77
FEATURES	0.60	0.32	0.56

Table 3. Proportion of variance in the total riparian condition index score explained ( $R^2$  value) by each sub-index for three regions: Murrumbidgee River, West and South Gippsland, and upper and mid-Goulburn-Broken catchment. The  $R^2$  value was obtained by regressing the values for each sub-index against the total index scores for each site.

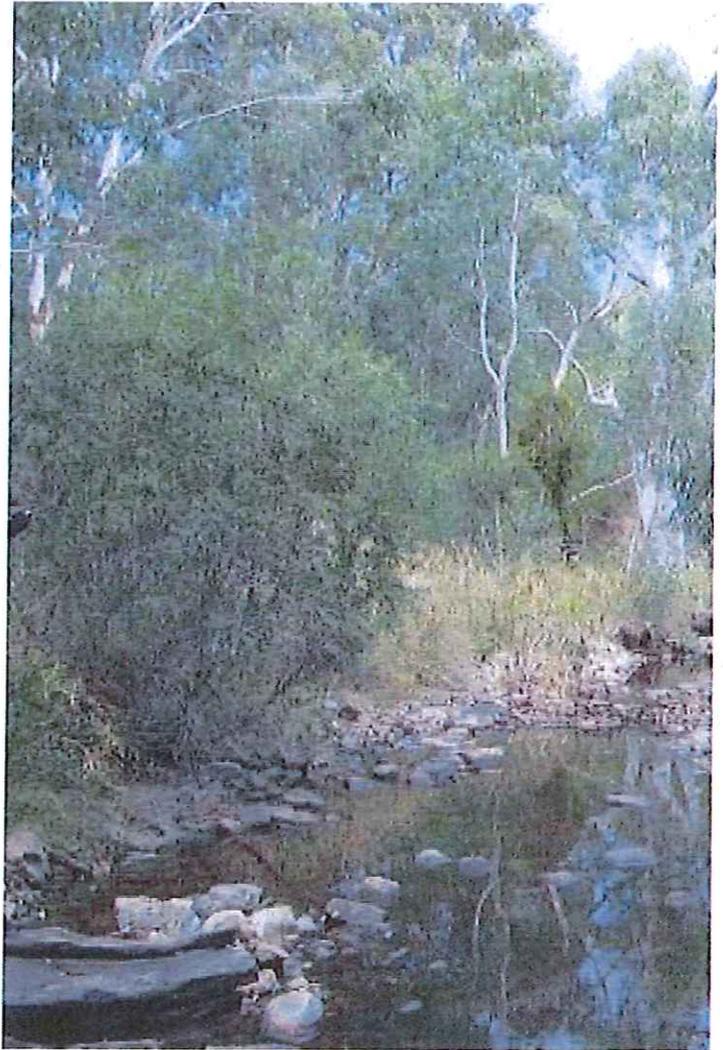


Clearing and overgrazing of riparian vegetation in the Mount Lofty Ranges, South Australia. Photo Amy Jansen.

The DEBRIS sub-index consistently explained at least 70% of the variance in the total condition score, suggesting that management practices aimed at retaining standing dead trees and fallen logs would improve riparian condition scores in all regions. The HABITAT sub-index was also relatively consistent across regions, explaining at least 62% of the variance in total condition scores. This suggests that maintaining or restoring a continuous canopy in the riparian zone is also important in all regions. In contrast, the NATIVES sub-index explained little of the variance in the Murrumbidgee but most of it in Gippsland. This sub-index indicates that in the Murrumbidgee, the canopy trees are predominantly native, there is little shrub cover, and the ground cover is predominantly exotic. In this region, there is little chance of altering this on a large scale. In Gippsland, however, the index indicates a lot of variability in the dominance of natives over exotics in all vegetation layers, and that management aimed at maintaining or restoring native species could significantly improve riparian condition.

Why is the RARC a useful tool?  
 What does riparian condition tell us about the biodiversity and functioning of riparian zones?

The RARC has been tested against more detailed measures of the biodiversity and functioning of riparian zones in the Murrumbidgee and Gippsland regions. There was a significant positive relationship between litter decomposition rates in the soil and the COVER sub-index of the RARC score in both Summer ( $r = 0.50, p < 0.05$ ) and Autumn ( $r = 0.78, p < 0.01$ ), indicating that decomposition rates were higher where there was more vegetation cover in the riparian zone of the Murrumbidgee River (Robertson, Wassens & Jansen, in prep.). There were highly significant relationships between bird communities and all sub-indices, as well as the total RARC score ( $r = 0.68, p < 0.0001$ ), indicating that riparian bird communities varied according to the condition of the riparian zone of the Murrumbidgee River (Jansen & Robertson, 2001b). Of particular significance ( $r = 0.74, p < 0.0001$ ) was the DEBRIS sub-index

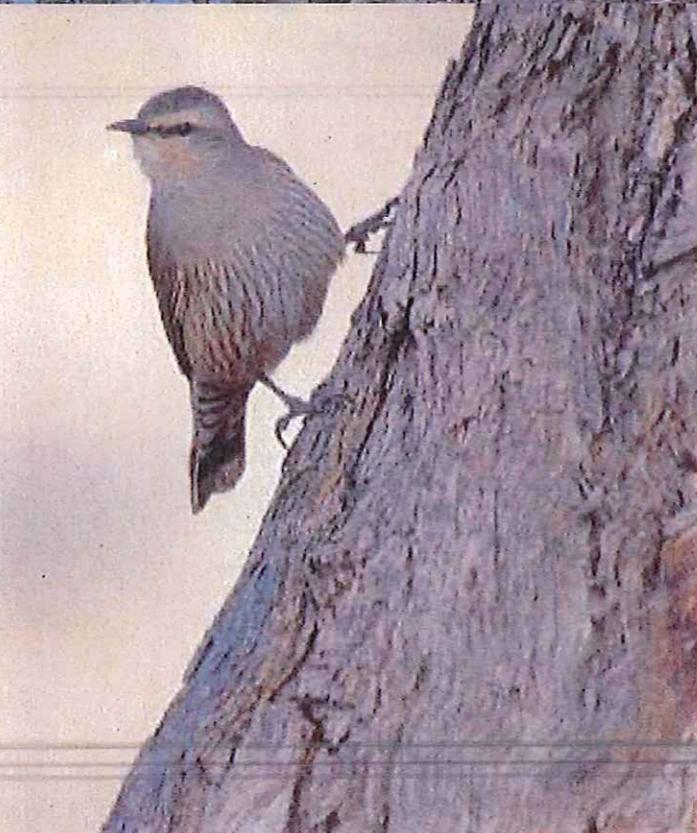
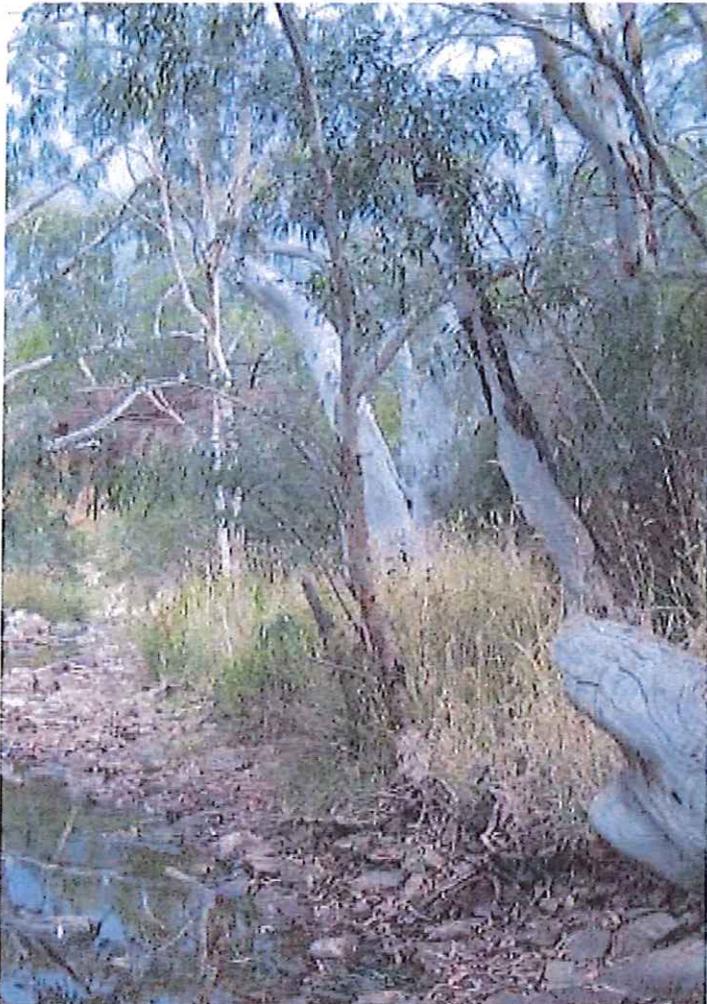


Above: Healthy riparian area with a diversity of vegetation providing habitat for both aquatic and terrestrial animals, Mount Lofty Ranges, South Australia. Photo Amy Jansen

Right: A brown tree creeper. These birds live in riparian areas and their presence can be used as an indicator of riparian health. Photo Andrew Tattell

(scoring for leaf litter, fallen logs and standing dead trees), indicating that retention of leaf litter and woody debris in riparian habitats is crucial to the survival of riparian bird communities. Many of the species most dependent on these features (e.g. Brown Treecreepers) are threatened or declining throughout the agricultural regions of southern Australia (Ford et al., 2001).

$r$  = correlation coefficient (indicates the strength of a relationship)  
 $p$  = significance (where  $p < 0.05$  indicates a significant relationship)



In Gippsland, there was also a significant relationship ( $r = 0.59$ ,  $p < 0.0001$ ) between bird communities and the total RARC score, indicating again that riparian bird communities varied according to the condition of riparian zones in Gippsland (Thompson et al., 2003).

Given the importance of riparian zones in supporting high levels of regional biodiversity (Naiman & Decamps, 1997), and the links between riparian condition and biodiversity demonstrated here, the RARC is a useful tool for assessing riparian condition and hence biodiversity and functioning of riparian zones.

### Applying the RARC: Steps in assessing riparian condition

The Rapid Appraisal of Riparian Condition index can be used for a variety of applications. Examples include determining relationships between riparian condition and management practices, as in the studies mentioned in the Guideline, or surveying overall condition within a catchment to determine priorities for future rehabilitation works in the catchment. Whatever the application, care should be taken to clearly define the question to be answered, determine the sampling design and select sites appropriately to answer the question. This may require help from a consultant with experience in experimental design and data analysis. In general, sampling of sites should be *random\**, rather than only sampling sites which are easily accessible by road.

A single observer should conduct all assessments, and they should undertake some training beforehand, to ensure consistency of data collection. The observer will need to have some experience in discriminating native and exotic plant species, and may benefit from previous experience in habitat surveys.

All sites should be surveyed at a similar time of year. Use a separate scoring sheet for each site. Allow 20–60 minutes per site, depending on size and accessibility.

\* If you were interested in surveying overall catchment condition, you could choose sites randomly by laying a grid over a map of the catchment, locating and numbering all squares which contain a riparian zone, then putting these numbers in a hat and pulling out as many sites as you wish to sample.

## 1 Determine site size

Site size must be determined according to the size of the management unit of interest. For example, our studies have examined impacts of grazing management on riparian condition, so management units have been individual paddocks. On the Murrumbidgee River, where paddocks are relatively large, a 1 kilometre length of the riparian zone was defined as a 'site', while in Gippsland, where paddocks are much smaller, a 150 metre length was used. Ideally, sites should be at least 200 metres long, with 500 metres being the preferred length where practicable. On larger rivers, only one side of the river is surveyed, while at smaller sites where it is practicable to do so, both sides may be surveyed (provided they are subject to the same management regime).

The transects at each site should ideally traverse the width of the riparian zone. However, this is not always easy to determine in the field. To simplify this, we use a transect length determined by the width of the river channel — 40 metres long for channels < 10 metres wide, and four times the channel width

for larger rivers. A minimum width of 40 metres should be assessed, unless there is a very clear distinction between riparian and non-riparian areas. Where the riparian zone is clearly narrower than 40 metres or four times the channel width (for example, in a gorge), the transect length should be adjusted accordingly. Where the riparian zone is much wider than this (for example, on a lowland floodplain river), four times the channel width should be adequate to represent the riparian zone. Figure 4 illustrates a hypothetical river with the layout of the survey area and the transects indicated.

## 2 Score indicators

A sample scoring sheet can be found on page 14 of this Guideline. The complete scoring system is summarised in Table 2. Longitudinal continuity and proximity are given single values for the whole site. All other indicators are scored along four transects (10 metres wide; perpendicular to the direction of river flow) evenly spaced along the bank.

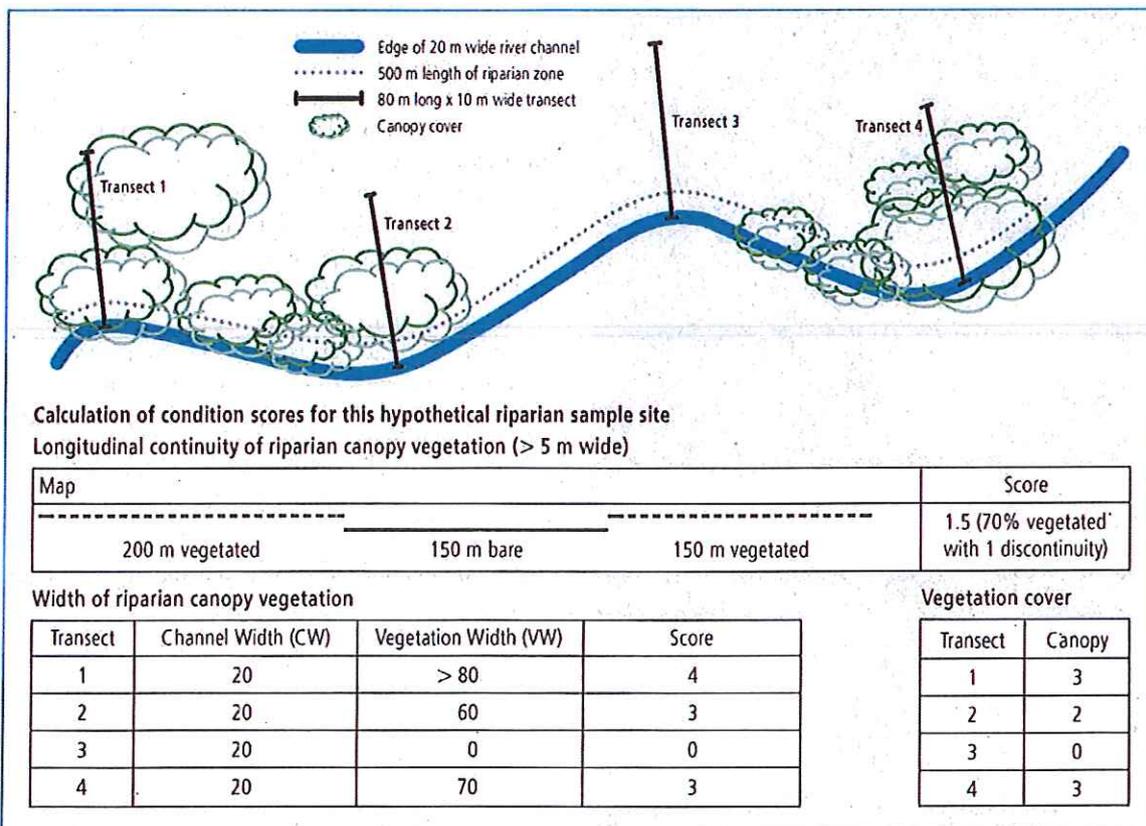


Figure 4. Hypothetical river with length and transects marked. The scoring for the indicators in this diagram is shown (see page 14 for full score sheet).

## HABITAT

At each site, canopy vegetation along the bank is mapped to show the length and number of any discontinuities (gaps of more than 50 metres) in canopy cover (the bank is considered to be vegetated if the riparian canopy vegetation is at least 5 metres wide). Longitudinal continuity is then scored as follows:

0 = < 50%, 1 = 50–64%, 2 = 65–79%, 3 = 80–94%,  
4 = ≥ 95% vegetated bank; with 1/2 point subtracted  
for each significant discontinuity (> 50 m long)

An assessment is made of the shortest distance to the nearest patch of at least 10 hectares of relatively intact native vegetation (with an extra point if the area being assessed is within a patch of at least 50 hectares of relatively intact native vegetation). This can be assessed on-site or later using aerial photographs.

Proximity is then scored as follows:

0 = > 1 km, 1 = 200 m–1 km, 2 = contiguous,  
3 = contiguous with patch > 50 ha

A patch of relatively intact native vegetation should have at least the dominant overstorey vegetation remaining. This may not be trees, if the area is a natural grassland or shrubland.

The channel width is defined by the area normally lacking any terrestrial or bankside vegetation. The width of the riparian canopy vegetation is the distance from the bank to the first gap of > 50 metres in the canopy vegetation. Channel width (CW) and width of the riparian vegetation (VW) are estimated to the nearest 5 metres in the field. For channels less than 10 metres wide, the vegetation width is converted directly to a score, while for channels more than 10 metres wide, the vegetation width is divided by the channel width to obtain the score as follows:

Channel ≤ 10 m wide: 0 = VW < 5 m, 1 = VW 5–9 m,  
2 = VW 10–19 m, 3 = VW 20–39 m, 4 = VW ≥ 40 m

Channel > 10 m wide: 0 = VW/CW < 0.5,  
1 = VW/CW 0.5–0.9, 2 = VW/CW 1–1.9,  
3 = VW/CW 2–3.9, 4 = VW/CW ≥ 4

For example, for a channel 12 metres wide and a vegetation width of 30 metres, VW/CW = 2.5, giving a score of 3.

## COVER (see Photo 3 below)

Vegetation cover within each layer is scored as follows:

Canopy cover (trees > 5 m tall): 0 = none,  
1 = 1–30%, 2 = 31–60%, 3 = > 60%

Understorey cover (herbs, reeds, shrubs and saplings  
1–5 m tall): 0 = none, 1 = 1–5%, 2 = 6–30%,  
3 = > 30%

(Note that understorey cover is scored on a different scale to the others, since it is normally less dense)

Ground cover (lichens, mosses, grasses, herbs,  
reeds and sedges to 1 m tall): 0 = none, 1 = 1–30%,  
2 = 31–60%, 3 = > 60%

The number of layers of vegetation is scored as follows:

0 = no vegetation layers to 3 = ground cover,  
understorey and canopy layers

## NATIVES (see Photo 4 overleaf)

Native vegetation cover within each layer is scored as for cover, but excluding the contribution of exotic species (to estimate cover of native species, imagine removing all exotic species and re-estimating vegetation cover with only the native species):

Canopy cover (trees > 5 m tall): 0 = none,  
1 = 1–30%, 2 = 31–60%, 3 = > 60%

Understorey cover (herbs, reeds, shrubs and saplings  
1–5 m tall): 0 = none, 1 = 1–5%, 2 = 6–30%,  
3 = > 30%

Ground cover (lichens, mosses, grasses, herbs, reeds  
and sedges to 1 m tall): 0 = none, 1 = 1–30%,  
2 = 31–60%, 3 = > 60%



Photo 3. Canopy cover increasing from 1 to 3 (left to right). Photos Amy Jansen.



Tussocky perennial (long-lived) grasses tend to be native species while annual (short-lived) grasses tend to be exotic species (with a few obvious exceptions such as *Phalaris* which is a perennial exotic species).

Photo 4. Exotic annual ground cover (left) versus native perennial tussock ground cover (right). Photos Amy Jansen.



Photo 5. Leaf litter cover increasing from 1 to 3 (left to right). Photos Amy Jansen.

#### DEBRIS (see Photo 5 above)

Cover of leaf litter on the ground, and cover of native leaf litter are scored as follows:

0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60% cover

Standing dead trees > 20 centimetres diameter at breast height, and hollow-bearing trees (look for dead branches and broken-off branch stubs in large trees which may have developed hollows) are scored as follows:

0 = absent, 1 = present

Fallen logs (> 10 cm diameter) are scored as follows:

0 = none, 1 = small quantities, 2 = abundant  
(where small quantities = one or two logs, and abundant = three or more logs)

#### FEATURES

The abundance of native canopy species regeneration (< 1 metre tall) and native understorey regeneration is scored as follows:

0 = none, 1 = scattered, and 2 = abundant, with 1/2 point subtracted for grazing damage (where scattered = one or two seedlings, and abundant = three or more seedlings; grazing damage is evidence that any of the seedlings have been browsed by grazing animals such as domestic livestock or kangaroos)

Photo 6 (right). *Poa labillardieri*, an example of a large native tussock grass found in riparian zones. Photo Amy Jansen

The abundance of large native tussock grasses (species such as *Poa labillardieri*) and reeds (species such as *Phragmites*, *Typha* (Cumbungi) and *Carex* which are normally only found on riverbanks or in swampy areas) is scored as follows:

0 = none, 1 = scattered, and 2 = abundant  
(where scattered = one or two plants, and abundant = three or more plants)



### 3 Analyse data

The indicators are averaged across transects, then summed into sub-indices. The final index score is then the sum of the sub-indices, with a possible maximum of 50 indicating best condition. To examine the results, it is helpful to categorise the index scores, e.g. less than 25 very poor, 25–30 poor, 30–35 average, 35–40 good and more than 40 excellent. It is also helpful to examine sub-index scores, and to determine which sub-indices contribute most to the final condition score. This can be done by regression of sub-index scores on the total index score.

### 4 Benchmarking

The scoring system given here has been developed for a generalised riparian area in south-eastern Australia, and may need to be adjusted for particular situations. Ideally, a number of relatively pristine sites in the region should be surveyed to provide a benchmark for the scoring system. The scores for each indicator can then be checked to ensure that all indicators are present, and that the maximum score can be achieved for each indicator. For example, in wet forests with a dense canopy, there may be no large tussock grasses but ferns could be used as an indicator instead. Also, ground cover may never reach > 60% due to shading, so this indicator may need to be adjusted accordingly

(for example, the scores given for different levels of ground cover could be rescaled similarly to those given for understorey cover). Benchmarking against relatively pristine sites is not always possible in highly modified catchments. In these situations, we can only make a 'best guess', based on local knowledge and historical information, about the appropriate scoring for each indicator in these catchments.

### Limitations of the RARC

While the condition index outlined in this Guideline has been tested in a number of catchments and situations, it has some limitations:

- ~ The RARC has been designed and tested on creeks and rivers in south-eastern Australia. Its usefulness in other regions is yet to be explored.
- ~ The RARC is designed for riparian zones that are naturally dominated by trees, with at least 60% canopy cover.
- ~ The RARC is designed for riparian zones of rivers and creeks which have relatively permanent water. In some situations it may work for temporary streams, but not if water availability is too low to support trees.
- ~ The RARC is intended as an indicator of *current* condition. Thus for restored areas, it will not indicate the potential for recovery of ecosystem function.

### Further information

We will be continuing to refine and update the RARC so to get the latest version visit [www.rivers.gov.au](http://www.rivers.gov.au). There you will find an Excel spread sheet which includes a printable field data sheet, and a data entry sheet. If you enter data for a site, it will automatically calculate the averages for each transect and the final sub-index and total scores for you. If you have a number of sites, you will need to save a separate worksheet for each site. There is also a field calculation sheet which you can print on the reverse of the field data sheet if you wish to calculate scores in the field (you may need a calculator to take the averages across the transects). There are also details about how the RARC can be tailored to a particular region and some examples of how this has been done. If you have a technical query about using the RARC, contact details for Dr Amy Jansen (the developer of the tool) are also listed. Hard copies of the RARC 4A are available from CanPrint Communications 1800 776 616.



## Rapid Appraisal of Riparian Condition

Site: \_\_\_\_\_ Site number: \_\_\_\_\_ GPS start: \_\_\_\_\_

Date: \_\_\_\_\_ Observer: \_\_\_\_\_ GPS end: \_\_\_\_\_

### Longitudinal continuity of riparian canopy vegetation (> 5 m wide)

Map	Score

0 = < 50%, 1 = 50–64%, 2 = 65–79%, 3 = 80–94%, 4 = ≥ 95% vegetated bank; with 1/2 point subtracted for each significant discontinuity (> 50 m long)

### Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1			
2			
3			
4			
Average			

### Proximity

Score

Nearest patch of native vegetation > 10 ha:  
 0 = > 1 km, 1 = 200 m–1 km,  
 2 = contiguous, 3 = contiguous with patch > 50 ha

Channel ≤ 10 m wide: 0 = VW < 5 m, 1 = VW 5–9 m, 2 = VW 10–19 m, 3 = VW 20–39 m, 4 = VW ≥ 40 m vegetated

Channel > 10 m wide: 0 = VW/CW < 0.5, 1 = VW/CW 0.5–0.9, 2 = VW/CW 1–1.9, 3 = VW/CW 2–3.9, 4 = VW/CW ≥ 4

### Vegetation cover: Canopy > 5 m, Understorey 1–5 m, Ground cover < 1 m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	Number of layers
1							
2							
3							
4							
Average							

Cover and ground cover: 0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60%

Understorey cover: 0 = none, 1 = 1–5%, 2 = 6–30%, 3 = > 30%

### Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1					
2					
3					
4					
Average					

Leaf litter and native leaf litter cover: 0 = none, 1 = 1–30%, 2 = 31–60%, 3 = > 60%

Standing dead trees (> 20 cm dbh) and hollow-bearing trees: 0 = absent, 1 = present

Fallen logs (> 10 cm diameter): 0 = none, 1 = small quantities, 2 = abundant

### Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1				
2				
3				
4				
Average				

Regeneration < 1 m tall: 0 = none, 1 = scattered, and 2 = abundant, with 1/2 point subtracted for grazing damage

Reeds and large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

## Calculation of scores

Site number: \_\_\_\_\_

### Longitudinal continuity of riparian canopy vegetation

Score	A
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### Width of riparian canopy vegetation

Average	B
---------	---

### Proximity

Score	C
-------	---

### Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	Number of layers
Average	D	H	E	I	F	J	G

### Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	K	L	M	N	O

### Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	P	Q	R	S

### Totals

Site number	Habitat	Cover	Natives	Debris	Features	Total
(out of)	11	12	9	10	8	50
	A+B+C	D+E+F+G	H+I+J	K+L+M+N+O	P+Q+R+S	



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