



Murrumbidgee to Googong Landscape Rehabilitation and Terrestrial Ecology Management Plan

Version 5, 14 March 2017

Document management

Document summary

Title	Murrumbidgee to Googong Landscape Rehabilitation and Terrestrial Ecology Management Plan
Version	5
Document status	Final
Date of issue	14 March 2017

Document development

	Name	Position	Date
Prepared by	Sally Wright	Team Leader Sustainability and Performance	06 February 2017
Reviewed by	Benjamin Bryant	Team Leader Environmental Services	27 February 2017
Approved by	Bronwen Butterfield	Manager Environment and Sustainability	14 March 2017

Version control

Version	Author	Date	Description	Approval
1	Craig Hardge	26 Aug 13	Consolidation of M2G Construction LRMP, TEMP and SWMP	26 Aug 13
2	May McDonald-Cox	20 Sept 13	Revision	20 Sept 13
3	Craig Hardge	11 Oct 13	Incorporation of comments from version 2	28 Jan 14
4	Chris Pulkkinen	15 July 15	Rebrand for Icon Water and review	15 July 15
5	Sally Wright	06 Feb 17	Update in new Icon Water template, to reflect audit and KPI recommendations	14 March 17

© 2017 Icon Water Limited (ABN 86 069 381 960)

This publication is copyright and is the property of Icon Water Limited. The information contained in this publication may not be reproduced in whole or in part to any except with Icon Water Limited's express written consent.

Contents

Acronyms	4
Register of changes to previous version	5
1 Introduction	6
1.1 Background	6
1.2 Purpose of the LRTEMP	6
1.3 Objectives of the LRTEMP	6
2 Governance Framework.....	7
2.1 Key risks to rehabilitation	7
2.2 Training and auditing.....	7
2.3 Community Engagement and Stakeholder Management.....	7
2.4 Inspection and Auditing.....	7
2.5 Review and revision of the LRTEMP	7
3 Landscape Rehabilitation	8
3.1 Landscape Rehabilitation Key Performance Indicators (KPI's)	8
3.2 Monitoring of Landscape Rehabilitation Performance	9
4 Terrestrial Ecology.....	10
Appendix A: M2G Conditions of Approval	11
Appendix B: Legislative and Regulatory Compliance.....	13
B1 Relevant Legislation	13
B.2 Licences and Permits	13
Appendix C: Key Risks to Rehabilitation	14
Appendix D: Terrestrial Vegetation and Fauna.....	15
D.1 Vegetation communities	15
D.2 Introduced flora.....	15
D.3 Fauna communities	16
D.4 Significant flora	17
D.5 Significant Fauna	18

Acronyms

ACT	Australian Capital Territory
ANBG	Australian National Botanical Gardens
CWLTH	Commonwealth
DA	Development Approval
DECC(W)	NSW Department of Environment, Climate Change (and Water) – now NSW Office of Environment and Heritage and NSW Office of Water
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
ERG	Environmental Reference Group
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)</i>
Ha	Hectare
KPI	Key Performance Indicator
LRMP	Landscape Rehabilitation Management Plan
LRTEMP	Landscape Rehabilitation & Terrestrial Ecology Management Plan
M2G	Murrumbidgee to Googong Water Transfer
NC (ACT)	Nature Conservation Act 2014
NSW	New South Wales
OEMP	Operation Environment Management Plan
PIP	Property Interaction Plan
PTWL	Pink-Tailed Worm Lizard
SWMP	Soil and Water Management Plan
TEMP	Terrestrial Ecology Management Plan
TSC (NSW)	Threatened Species Conservation Act 1995

Register of changes to previous version

Subject	Description of change/addition	Reference within OEMP
1. General	<ul style="list-style-type: none"> • The LRTEMP was transferred to the new Icon Water report template. • Information was rearranged to provide a more logical flow to the Plan. • Information was streamlined to reflect current and future requirements for the Plan. • The document was updated throughout to reflect Icon Water's name change. 	Throughout Plan
2. Governance framework	<ul style="list-style-type: none"> • A section was created to capture the governance elements of the Plan. 	Section 2
3. Landscape rehabilitation	<ul style="list-style-type: none"> • M2G landscape rehabilitation key performance indicators were amended following a review of the appropriateness of the original targets to consider the variability of climatic conditions of the site; consistent with the Plan's adaptive management framework. This incorporates the recommendations contained within the M2G Independent Audit in September 2016. 	Section 3.1
4. Legislative compliance	<ul style="list-style-type: none"> • A list of relevant legislation, regulations, licences and permits was moved to the Appendix. 	Appendix B
5. Key risks	<ul style="list-style-type: none"> • A list of the key risks to the rehabilitation was moved to the Appendix. 	Appendix C

1 Introduction

1.1 Background

The Murrumbidgee to Googong (M2G) Water Transfer is one of the projects implemented by Icon Water for delivering improved security to the water supply for the ACT and region. It involves pumping water from the Murrumbidgee River (within the ACT) and transferring it via a 12 kilometre (km) pipeline to Burra Creek (in NSW), from where it flows for approximately 13 km to the Googong Reservoir.

Key infrastructure features of the project are described in the Operational Environmental Management Plan (OEMP).

This Landscape Rehabilitation and Terrestrial Ecology Management Plan (LRTEMP) has been designed to guide operational management of landscape rehabilitation and terrestrial ecology along the pipeline easement, and to address risks related to ongoing landscape rehabilitation and management of terrestrial ecology.

Icon Water will ensure that rehabilitation and terrestrial ecology is monitored and audited to assess effectiveness. Changes to the stipulated controls will be instigated if they are not achieving their objectives.

1.2 Purpose of the LRTEMP

The purpose of the LRTEMP is to describe the post-construction rehabilitation and ongoing management of the easement.

This LRTEMP specifically addresses the methods, techniques and timing for rehabilitating and managing terrestrial flora and fauna during the operational phase.

1.3 Objectives of the LRTEMP

The objectives of the LRTEMP are to:

- outline post-construction landscape rehabilitation methods and techniques in rehabilitating the M2G pipeline corridor and associated construction areas
- address commitments raised in the M2G Water Transfer Environmental Impact Statement (EIS) relating to landscape rehabilitation and management of terrestrial ecology (see Appendix A)
- comply with ongoing ACT, NSW and Commonwealth legislative requirements relating to landscape rehabilitation and management of terrestrial ecology, and for conservation and reinstatement of native vegetation communities (see Appendix B)
- minimise the impact of operational activities on areas of native vegetation, particularly endangered ecological communities and threatened species and prevent the spread of noxious weeds and the dispersal of exotic plant and animal species
- ensure erosion control measures are effective and maintained in erosion prone areas.

2 Governance Framework

The governance framework for the LRTEMP is consistent with Icon Water's Integrated Management System (IMS) and allows for continual improvement.

For the purposes of this plan, continual improvement and adaptive management requires responding to monitoring outcomes, audit findings, changing risks and incident investigations.

2.1 Key risks to rehabilitation

The rehabilitation of the pipeline provides challenges due to:

- prevailing climatic conditions
- the slow nature of germination and rehabilitation of native species
- the predominantly western aspect of slopes
- the shallow depth of the topsoil, low organic matter and compaction of the soil
- the existing high abundance of weeds along the pipeline route
- impact of native and feral animals on revegetation.

Due to these challenges, this rehabilitation plan will be adaptively managed with the approval of respective regulators. Actions will be driven by the results of monitoring and in consultation as required with ecologists, landholders and other relevant stakeholders.

The key risks are detailed in Appendix C.

2.2 Training and auditing

Training and auditing requirements are covered in the relevant section of the OEMP.

2.3 Community Engagement and Stakeholder Management

Community engagement and stakeholder management is outlined in the OEMP, Community Interaction Plan, Customer Service procedures and plans relevant to the project.

Property Interaction Plans (PIPs) have been established for each individual landholder and outline the processes and requirements for ongoing management of each particular property along the pipeline easement. Management of the above is to be handled in the first instance through Icon Water's Customer Service area and actioned as appropriate by other relevant personnel.

2.4 Inspection and Auditing

Monitoring, auditing and review of the LRTEMP and its implementation and rehabilitation outcomes will be carried out in accordance with this Plan. The schedule and methodology of monitoring under this Plan is outlined in Section 3.2.

2.5 Review and revision of the LRTEMP

Review and improvement of this Plan will be undertaken as described in the OEMP.

3 Landscape Rehabilitation

3.1 Landscape Rehabilitation Key Performance Indicators (KPI's)

Key performance indicators were established prior to construction of the M2G pipeline to plan and measure the success of rehabilitation. These targets were based on vegetation composition against broadly grouped vegetation community types found along the pipeline route and required post-construction vegetation condition to be higher than pre-construction vegetation condition.

Revised targets have been proposed following a review of the efficacy of the original targets, consistent with the adaptive management framework outlined in Section 2. The revised targets more appropriately align with the condition of vegetation prior to construction works, and take into account the variable climatic conditions of the site and those factors identified in Section 2.1.

Once assessment of condition against the revised targets has been completed for each property, the corresponding landholder will be able to accept the condition of their land as 'rehabilitation complete'. Arrangements will be made to have fencing removed if required and the area handed over and signed off as to be managed by the landholder / leaseholder under the conditions of the Property Interaction Plans (PIPs) that are in place between Icon Water and the individual landholders.

These targets are outlined below in Table 3.1.

Table 3.1 M2G landscape rehabilitation KPIs

Vegetation community	Key Performance Targets	Comments
Non-native vegetation	Ground cover - > 70% vegetation cover of the species sown Weeds – lower cover abundance of declared weeds from the previous monitoring event.	No change to KPI is proposed. All sites of this category have been returned to landowners.
Native vegetation	Ground cover - > 70% vegetation cover, with 50% of the ground cover comprised of native species. Weeds – lower cover abundance of declared noxious or environmental weeds from the previous monitoring event.	This vegetation is representative of a non-listed native vegetation community (grassland or open woodland). The minimum 70% vegetation cover is considered the minimum requirement for soil stabilisation. The minimum requirement of 50% ground cover comprised of mixed native species is reflective of the vegetation condition prior to construction. Native species can be perennial or annual. This native cover also limits the amount of exotic species or environmental weeds allowed within each plot.
High conservation value grassland	Ground cover - > 70% vegetation cover, with 50% of the ground cover comprised of native species.	This vegetation represents Box-Gum Woodland (or Natural Temperate Woodland), listed ecological community

and grassy woodland	<p>Diversity - There is a range of native herbs and/or forbs present (non-grass understorey species), with at least one important species¹. The vegetation patch as a whole would meet the listing criterial for Box-Gum Woodland.</p> <p>Weeds – lower cover abundance of declared noxious or environmental weeds from the previous monitoring event.</p>	<p>under ACT, NSW and Commonwealth legislation.</p> <p>The KPT's reduce complexity but at the same time achieve the desired high conservation value vegetation and condition prior to construction.</p> <p>The minimum 70% vegetation cover is considered the minimum requirement for soil stabilisation.</p> <p>The minimum requirement of 50% ground cover can include perennial or annual species. This native cover limits the amount of exotic species or environmental weeds allowed within each plot.</p>
Plantings	<p>Native species (planting success)</p> <p>– A 70% survival rate of woody planted individuals. All species listed for planting are present.</p>	<p>This target is more reflective of what is achievable at the site, taking into consideration the high variation in rainfall, climatic conditions and exposed nature of many of the rehabilitation sites.</p>

3.2 Monitoring of Landscape Rehabilitation Performance

Monitoring will apply to all areas of landscape reinstatement such as vegetation cover, stability of riparian / waterway areas and success of landscape planting elements.

Environmental condition assessments of the pipeline will be undertaken by Icon Water personnel to identify issues such as erosion, fencing or other impacts that could affect the pipeline easement and the ongoing rehabilitation and maintenance requirements in accordance with the M2G Offset Delivery Plan.

¹ This is reflected in the Commonwealth listing criteria for Box-Gum Woodland. The diversity of native understorey species is an important component of good condition Box-Gum Woodland.

4 Terrestrial Ecology

There are numerous native flora and fauna species, and five main vegetation communities located along the pipeline route as surveyed during the pre-construction assessments by Biosis in 2009.

The approach to rehabilitate and manage the pipeline easement accounts for the protection of any native species.

The species lists and mapped location of these findings is found in Appendix D.

Specific activities have been undertaken to protect populations of the endangered plant species *Swainsona recta* (Small purple-pea), including micro-realignment of the pipeline route and a translocation and propagation program.

To avoid impacting fauna and flora of significance, the location and type of important species, and additional precautions necessary to mitigate potential impacts during operation and maintenance form part of the toolbox talks and training delivered to relevant personnel.

Weeds are a potential threat to terrestrial ecology. The objectives of operational phase weed management are to:

- ensure operational activities do not contribute new weed species to the area
- ensure weed control agreed as part of Property Interaction Plans (PIPs) is carried out as required
- minimise the impact of weed invasion to areas of active rehabilitation.

Potential weeds of interest are outlined in Appendix D.2

Appendix A: M2G Conditions of Approval

M2G Environmental Commitments and Conditions of Approval (Relevant to this Plan)

Table 1. M2G EIS Commitments

Commitment No.	Commitment / Condition	Reference
40	The pipeline route will be periodically inspected to ensure rehabilitation and stabilisation works have been effective in the longer term.	LRTEMP Section 3.3
44	Landscaping, vegetation rehabilitation, replacement planting and encouragement of natural regeneration will be undertaken in accordance with the rehabilitation plan.	LRTEMP

Table 2. M2G DA Conditions of Approval (ACT)

Condition No.	Commitment / Condition	Reference
B7 (b)	A Flora and Fauna management sub-plan that details the mitigation and management of impacts on flora and fauna including weed control during construction and operation phases.	LRTEMP Sections 4,5 and 6

Table 3. M2G NSW Department of Planning Conditions of Approval

Condition No.	Commitment / Condition	Reference
6.3 b) iii	Rehabilitation details and a program for reporting on the effectiveness of flora and fauna management measures, including a schedule for planting and seeding within areas supporting endangered ecological communities. Management methods shall be reviewed where found to be ineffective	LRTEMP
2.10	After construction is complete and for a period of two years after that time (or as otherwise required by the Director General) the proponent shall monitor areas along the project alignment for weed infestation. Any infestations shall be managed to remove or minimise their spread.	LRTEMP Section 6
3.3	Prior to the commencement of construction the Proponent shall prepare and implement an Ecological Monitoring Program to monitor the impact of the project on the ecology that may be impacted by the	

Condition No.	Commitment / Condition	Reference
	<p>proposal. The Program shall be developed in consultation with the DECCW and Department of Industry and Investment NSW and shall include but not necessarily be limited to:</p> <ul style="list-style-type: none"> a) set out monitoring requirements as detailed in the documents referred to in Condition 1.1 c), in order to assess the impact of the project on Ecology present along the easement and at Burra Creek at the pipeline outlet location and downstream including the Googong Reservoir. b) provisions for monitoring trench areas for any fauna impacts likely to result from this work. Any fauna found in the open trench shall be recorded and managed in consultation with DECCW; d) provisions for monitoring during construction, operational and non-operational phases; e) mechanisms for immediately investigating any anomalous monitoring results; g) details of how the monitoring results will be reported to the Director-General and the DECCW and the Department Industry and Investment NSW. 	

Appendix B: Legislative and Regulatory Compliance

B1 Relevant Legislation

Key legislation relating to landscape rehabilitation and terrestrial ecology management is detailed below in Table B.1. Other legislation associated with the M2G project is outlined in the OEMP.

Table 2.1 M2G legislation: landscape rehabilitation and terrestrial ecology

Jurisdiction	Relevant Act
Commonwealth	Environmental Protection and Biodiversity Conservation Act 1999
	Water Act 2007
Territory (ACT)	Environmental Protection Act 1997
	Water Resources Act 2007
	Nature Conservation Act 2014
	Fisheries Act 2000
	Pest Plant and Animals Act 2005
New South Wales (NSW)	Environmental Planning and Assessment Act 1979
	Protection of the Environment Operations Act 1997
	Fisheries Act 1935
	Fisheries Management Act 1994 and Amendment 2009
	Threatened Species Conservation Act 1995
	Water Management Act 2000
	Noxious Weeds Act 1993
	Catchment Management Authorities Act 2003
	Native Vegetation Act 2003

B.2 Licences and Permits

A licence to collect native seed is required by the appointed revegetation contractor should collection of native seed occur on State or Territory land. This licence will be sought prior to undertaking any seed collection activities. Any fauna which is to be removed or relocated due to operational issues will be undertaken in accordance with relevant state or territory guidelines, and by suitably qualified and licensed personnel.

Appendix C: Key Risks to Rehabilitation

Given the nature of the rehabilitation activities being undertaken along the M2G pipeline route, there are several key risks that may potentially impact on the success of rehabilitation works.

These may arise as a result of the prevailing climatic conditions, stakeholder feedback, impacts of weeds or damage by native or feral animals.

The key risks, and some potential mitigation measures are outlined below in Table C.3.

Table C.3 Key post-construction rehabilitation risks

Rehabilitation Aspect	Risk Level	Potential Mitigation measures	Residual Risk Level
Poor germination of native and/or exotic species	High	<ul style="list-style-type: none"> • Maintenance of plantings such as watering during extended dry periods • Assess seeding methodology (incl. treatment of seed) and re-sow with same or alternative method depending on the assessment • Adaptively manage species type and distribution • Avoid sowing during Summer months when rainfall is infrequent • Respond according to the prevailing climatic conditions (wet/dry etc.) 	Medium
Infestation of weeds along the pipeline route	High	<ul style="list-style-type: none"> • Take appropriate action in accordance with the Weed Management Strategy • Training and procedures/work instructions on presence of weed species, wash down procedures, & notification 	Medium
Damage from animals such as wombats, pigs, goats and rabbits	High	<ul style="list-style-type: none"> • Use deterrents such as tree guards, fencing or commercial chemical/biological products • Consider control methods or removal if required 	Medium
Landholder feedback with respect to landscape rehabilitation	Medium	<ul style="list-style-type: none"> • Landholder engagement throughout the rehabilitation process • Outline expectations in PIP's • Within reason, landholder requests are to be considered and acted upon 	Low

Appendix D: Terrestrial Vegetation and Fauna

D.1 Vegetation communities

The vegetation communities found along the pipeline route include;

- Natural Temperate Grassland (protected)
- Box Gum Grassy Woodland (protected)
- Dry Sclerophyll Woodland – other native vegetation
- Snow Gum Grassy Woodland
- Non-native vegetation (mainly exotic pastures).

Table D.1 Area of vegetation communities along the M2G pipeline route

Vegetation Type	Area
Natural Temperate Grassland	1.7 ha
Box Gum Grassy Woodland	11.1 ha
Snow Gum Grassy Woodland	0.3 ha
Other Native Vegetation (Native pastures, Kunzea/Acacia shrubland and <i>E.bridgesiana</i> , <i>E. dives</i> & <i>E. mannifera</i> woodland)	3.6 ha
Non-native vegetation	23.8 ha
Total Native Vegetation (Habitat Areas)	16.7 ha
Total Area	40.5 ha

The extent of each community provides the basis for the type and extent of rehabilitation to be undertaken post-construction and the total extent of the biodiversity offset package.

The mapped extent of each community along the pipeline route is shown in Appendix D Figure 1.

The offset package is dealt with separately and is detailed in the M2G Offset Delivery Plan and associated Sub-plans.

D.2 Introduced flora

Ten different weeds, declared in the ACT or Queanbeyan-Palerang Local Government Area (LGA) in NSW were found along the pipeline route. The declared weeds are listed in Table 5.1 below.

Table 5.1 Declared weeds observed along the M2G pipeline and locality

Common Name	Scientific Name	ACT Declaration	Queanbeyan - Palerang LGA (NSW)
African Love Grass	<i>Eragrostis curvula</i>	Must be contained	Class 4

Blackberry	<i>Rubus fruticosus</i>	Must be contained/prohibited	Class 4
Sweet Briar, Briar Rose	<i>Rosa rubiginosa</i>	Must be suppressed/prohibited	N/A
Chilean Needle Grass	<i>Nassella neesiana</i>	Must be contained	Class 4
Horehound	<i>Murrubium vulgare</i>	N/A	Class 4
Nodding Thistle	<i>Carduus nutans</i>	Must be suppressed	Class 4
Paterson's Curse	<i>Echium plantagineum</i>	Must be contained	Class 4
Saffron Thistle	<i>Carthamus lanatus</i>	Must be contained	N/A
Scotch and Illyrian Thistles	<i>Onopordum acanthium and illyricum</i>	Must be contained	Class 4
Serrated Tussock	<i>Nassella trichotoma</i>	Must be contained /prohibited	Class 4
St John's Wort	<i>Hypericum perforatum</i>	Must be contained	Class 3

D.3 Fauna communities

There are a number of important native fauna species which occur in the locality of the M2G pipeline including;

- Short-beaked Echidna *Tachyglossus aculeatus*,
- Common Brush-tail Possum *Trichosurus vulpecula*
- Sugar Glider *Petaurus breviceps*
- *Antechinus* sp.
- Common Dunnart *Sminthopsis murina*
- Microbats (such as the Eastern False Pipistrelle *Falsistrellus tasmaniensis*, Gould's Wattled Bat *Chalinolobus gouldii* and White-striped Freetail Bat *Tadarida australis*)
- Common Wombat *Vombatus ursinus*
- Eastern Grey Kangaroo *Macropus giganteus*
- Wallaroo *M. robustus*.

Several non-native (feral) introduced vertebrate pest species can be found in the locality of the pipeline and include:

- *Rattus* sp.
- Feral Pig *Sus scrofa*
- Feral Goat *Capra hircus*

- European Fox *Vulpes vulpes*
- European Rabbit/ Hare *Oryctolagus cuniculus/ Lepus europaeus*.

D.4 Significant flora

Four plant species listed under the *Environment Protection Biodiversity Conservation Act 1999 (Cth)* (EPBC Act), the *Threatened Species Conservation Act 1995 (NSW)* or the *Nature Conservation Act 2014 (ACT)* are known to occur locally. These species and their known occurrences are described in the table below.

Table 5.1 Significant terrestrial flora along the M2G pipeline

Species	CTH EPBC Act	NSW TSC Act	ACT NC Act	Known Occurrences
<i>Leucochrysum albicans</i> var. <i>tricolor</i> Hoary Sunray	Endangered			Common on roadside reserves and lightly grazed paddocks. Previously recorded in the locality.
<i>Swainsona recta</i> Small Purple-pea	Endangered	Endangered	Endangered	Known within the Goulburn-Cooma Railway corridor between Royalla and Williamsdale. Also at Mt Taylor in the ACT. Recorded at Burra Creek.
<i>Swainsona sericea</i> Silky Swainson's Pea		Vulnerable		Previously recorded in locality. Widely recorded west of Gibraltar Hill and Burra Creek.
<i>Discaria pubescens</i> Hairy Anchor Plant		Rare	Rare	Recorded east of Angle Crossing and Burra Creek.

Specific and additional management actions undertaken to protect *Swainsona recta* include the following;

- recorded specimens along the pipeline fenced off with signage
- the pipeline was micro aligned to avoid impacting this species
- propagation and translocation of specimens to outside of the construction area through partnerships with the Australian National Botanic Gardens (ANBG) and relevant stakeholders
- approximately 100 plants translocated into three plots on the southern Offset site as of September 2013
- ongoing monitoring and research of translocation success, with potential scope for further plantings and plots.

D.5 Significant Fauna

Significant fauna species potentially found in the area of the M2G are outlined in Table 5.2 below.

Table D.5 Significant terrestrial fauna along the M2G pipeline

Species	CWLTH EPBC Act	NSW TSC Act	ACT NC Act
<i>Aprasia parapulchella</i> Pink Tailed Worm Lizard (PTWL)	Vulnerable	Vulnerable	Vulnerable
<i>Callocephalon fimbriatum</i> Gang Gang Cockatoo		Vulnerable	
<i>Pyrrholaemus sagittata</i> Speckled Warbler		Vulnerable	
<i>Stagonopleura guttata</i> Diamond Firetail		Vulnerable	
<i>Lalage sueurii</i> White-winged Triller			Endangered
<i>Daphoenositta chrysoptera</i> Varied Sitella		Vulnerable	Vulnerable
<i>Myotis macropus</i> Large Footed Myotis		Vulnerable	
<i>Miniopterus schreibersii oceanensis</i> Eastern bent-wing Bat		Vulnerable	

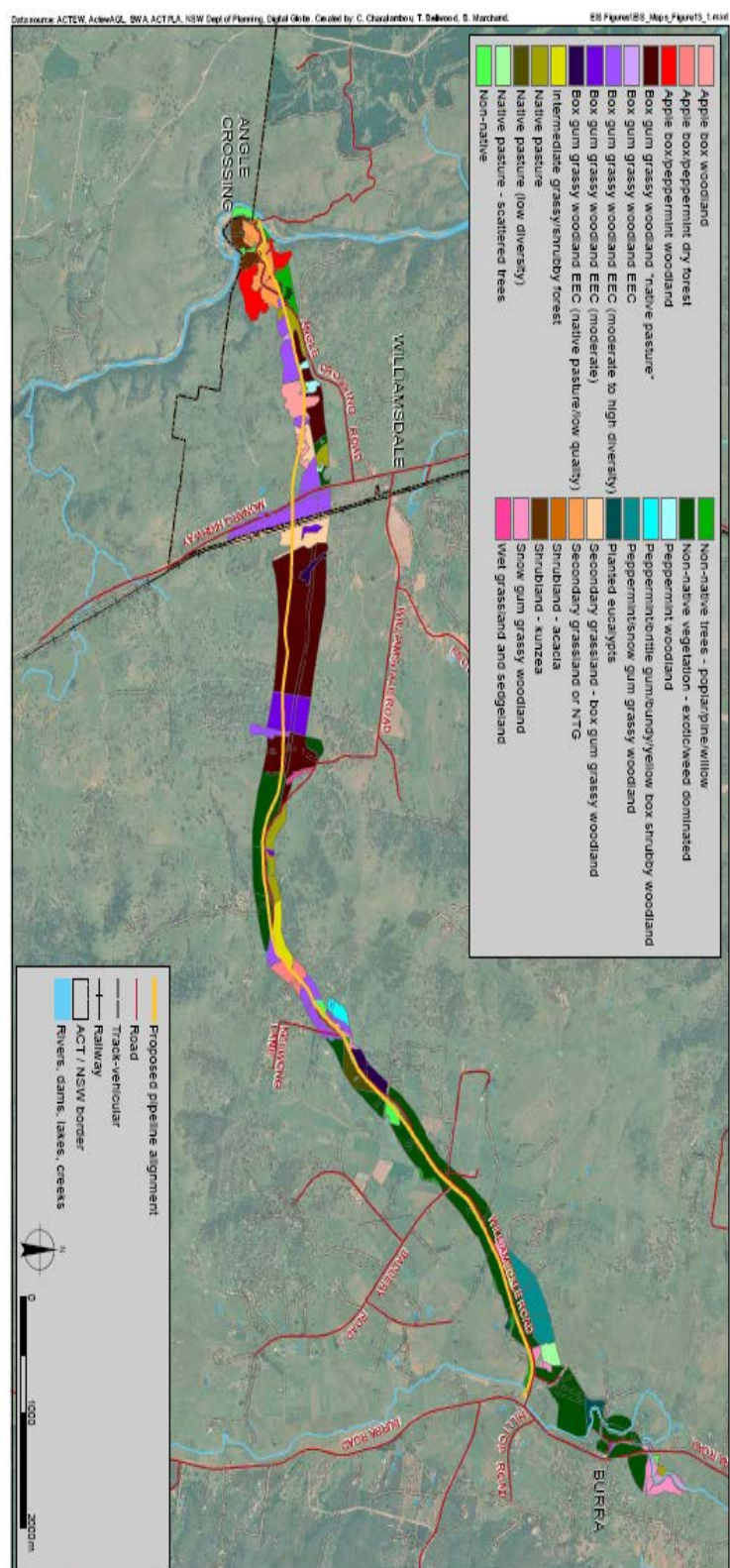


Figure 1. Vegetation communities along the M2G pipeline route (pre-construction)

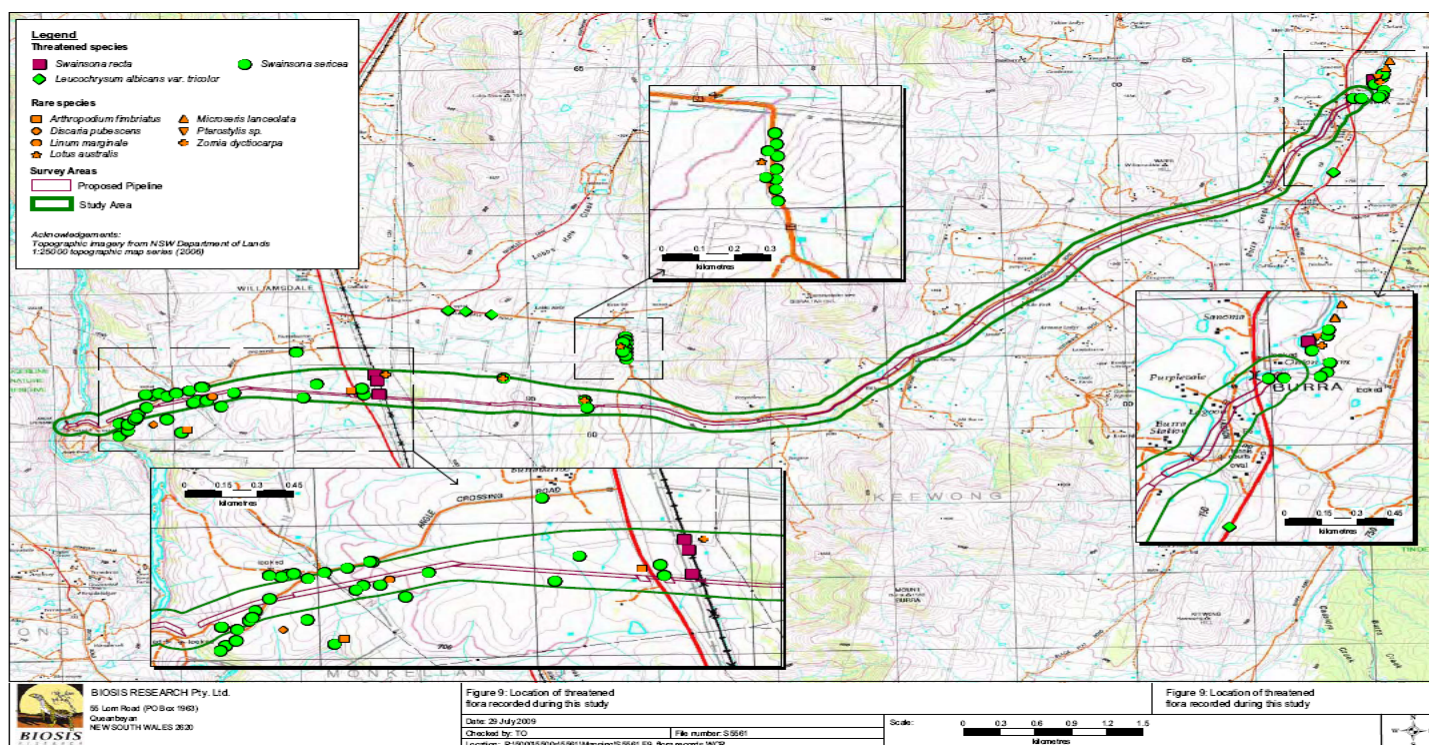


Figure 2. Rare and Threatened flora species found along the pipeline route

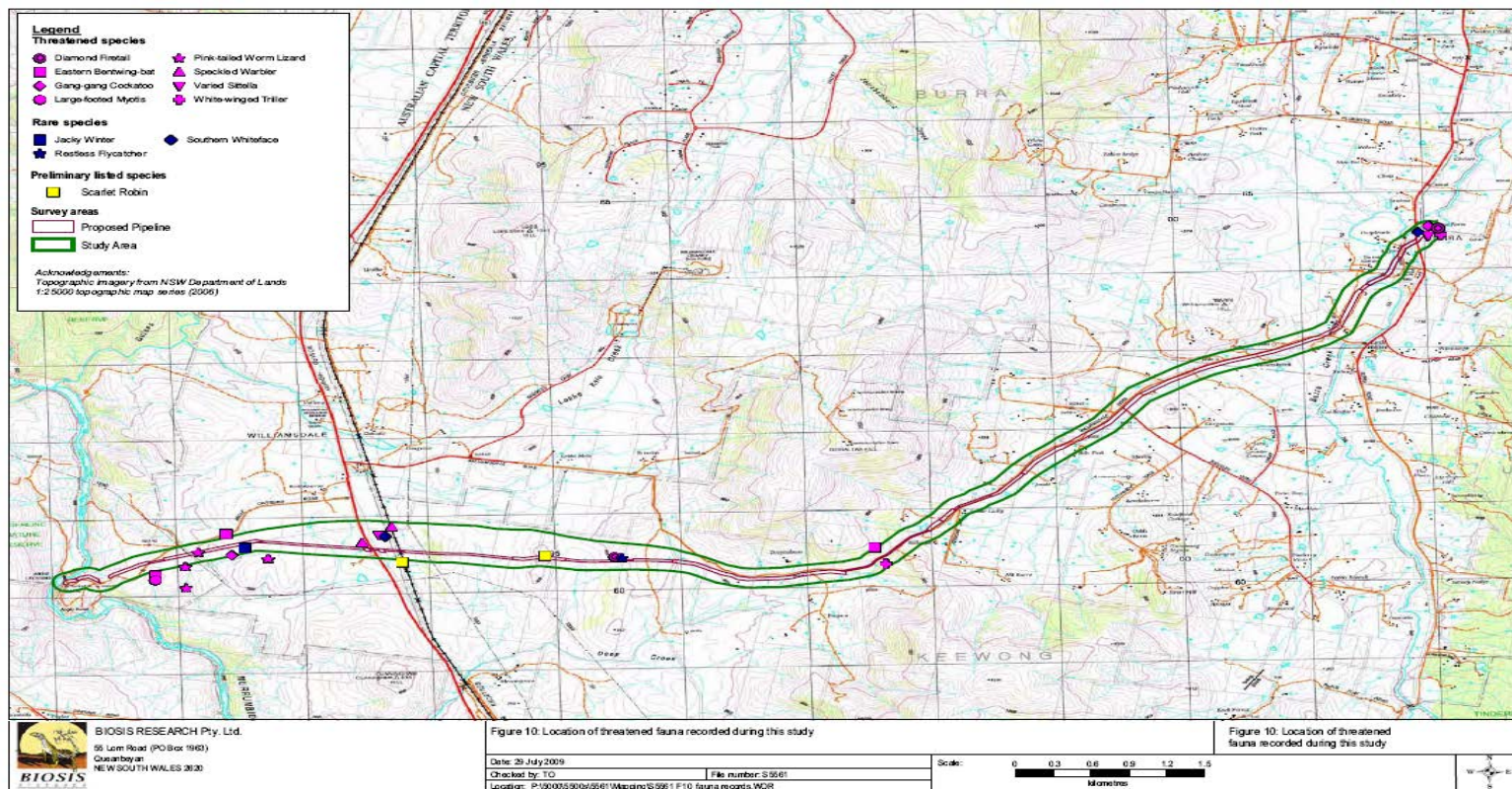


Figure 3. Location of threatened fauna recorded during pre-construction study