DURALIE COAL MINE
Giant Barred Frog Management Plan

DURALIE COAL MINE

GIANT BARRED FROG MANAGEMENT PLAN (GBFMP)

Revision Status Register

Section/Page/ Annexure	Revision Number	Amendment/Addition	Distribution	Approval Date
All	GBFMP-R01-A	Original	OEH and DP&I	-
All	GBFMP-R01-B	Revised draft	OEH and DP&I	-
All	GBFMP-R02-A	Edits made to: • reflect amended Project Approval conditions by Order of The Land and Environment Court of NSW dated 10 November 2011; • consider recommendations (where relevant) of an independent environmental audit dated November 2011; and • consider any outcomes of the Annual Review for the Duralie Coal Mine (dated September 2011).	OEH and DP&I	6 March 2012
All	GBFMP-R02-B	Edits made to: • address Commonwealth EPBC Project Approval conditions by the Department of Sustainability, Environment, Water, Population and Communities (dated 22 December 2010).	SEWPaC	-
All	GBFMP-R02-C	Edits made to: • address Department of Sustainability, Environment, Water, Population and Communities Document Review Comments (dated 8 June 2012).	SEWPaC	15 August 2012
All	GBFMP-R03-A	Edits made to: • address recommendations from the Annual Review (2014), DP&I Audit December 2013, Independent Environmental Audit November 2014 and OEH letter dated 8 December 2014.	DotE and DP&E	-
All	GBFMP-R04-A	Edits made to: • reflect approval of Project Approval (08_0203) MOD 2 and changes the GBF monitoring program.	DP&E	17 December 2015
			DotE	4 January 2016
All	GBFMP-R05-A	Review following incident report 10 February 2016.	DP&E	5 Sept 2017
All	GBFMP-R06-A	Updated to reflect current status of the DCM and mine closure planning.	DCCEEW	15 July 2025
All	GBFMP-R06-B	Updated to reflect current status of the DCM and mine closure planning.	DPHI	7 September 2023

OCTOBER 2025
Document No. GBFMP-R06-B

PREFACE

The requirement for this Giant Barred Frog Management Plan (GBFMP), and associated monitoring program, prepared in accordance with New South Wales (NSW) Project Approval (PA 08_0203) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval EPBC 2010/5396, was predicated on the commencement of irrigation on the Duralie Extension Project (DEP) irrigation areas.

Despite having approval to do so, Duralie Coal Pty Ltd (DCPL) did not commence irrigation of the additional irrigation areas approved under the DEP, and as such, the potential impact pathway to the Giant Barred Frog population did not commence. Despite this, the monitoring programs in accordance with the GBFMP were implemented by DCPL from 2010 to 2015, with further opportunistic surveys undertaken up to 2018.

Condition 5, Schedule 2 of NSW Project Approval (08_0203) authorised mining operations to be carried at the Duralie Coal Mine (DCM) until 31 December 2021. Accordingly, coal mining has now ceased and operations at the DCM now reflect mine closure.

All former irrigation activities for the purpose of reducing the total site water inventory at the DCM have now ceased and the DCM's Irrigation Area irrigation system has been decommissioned and removed. DCPL does not intend to recommence irrigation of the DCM Irrigation Areas during the mine closure phase.

As a result of the DEP additional irrigation activities never commencing, and the DCM now transitioning to closure, the requirement for, and the requirements of, the GBFMP are no longer relevant to the DCM and the plan is now redundant.

Accordingly, DCPL has revised the GBFMP to reflect its redundancy, noting that DCPL would recommence the GBFMP should relevant activities of impact (such as irrigation in the DEP areas) commence at the DCM.

In this regard, the GBFMP was updated in August 2023 and provided to the Commonwealth DCCEEW and the former Biodiversity and Conservation Division (BCD) within the Department of Planning and Environment (DPE) (now the Conservation Programs, Heritage and Regulation Division [CPHR] within the NSW Department of Climate Change, Energy, the Environment and Water [NSW DCCEEW]) for consideration.

On 7 September 2023, the (then) **BCD confirmed that it agreed the GBFMP is no longer considered relevant**, as the anticipated irrigation of the DCM did not eventuate (Appendix 3).

Further to this, on 15 July 2025 the **Commonwealth DCCEEW approved the revised GBFMP** (confirming its redundancy) under Condition 9 of EPBC 2010/5396 (Appendix 3).

Since approval of the GBFMP by the Commonwealth DCCEEW, DCPL has made a number of minor administrative updates to the plan in order to contemporise it and align it with other (more recent) management plans for the DCM, noting the approved GBFMP was last updated in August 2023.

DCPL now submits this GBFMP to DPHI for review and approval under Condition 32, Schedule 3 of Project Approval (08_0203).

GBFMP Monitoring Program & Long-term Study

Dr Arthur White (Biosphere Environmental Consultants Pty Ltd) was engaged by DCPL to undertake monitoring and surveys of the Giant Barred Frog (*Mixophyes iteratus*) in the Mammy Johnsons River (MJR) catchment, New South Wales (NSW), initially under the Giant Barred Frog Study and then continued under the GBFMP.

The original reason for the Giant Barred Frog monitoring and surveys was to establish baseline data so that potential impacts from the additional proposed mine water irrigation areas at the DCM approved under the DEP could be monitored over time. However, DCPL did not commence irrigation of the additional irrigation areas and mining operations at the DCM have now ceased.

Given the irrigation activities within the DEP irrigation areas never commenced, the Giant Barred Frog Long-term Study required in accordance with Condition 31A Schedule 3 of PA 08_0203 and Condition 10 of EPBC 2010/5396 is not considered relevant. Despite this, DCPL engaged Dr Arthur White in 2023 to prepare a summary paper titled "*A Study of the Giant Barred Frog (Mixophyes iteratus) in the Mammy Johnsons River Catchment"* (Appendix 1). The purpose of this report was to present a collation of the research and monitoring undertaken on the Giant Barred Frog in the MJR catchment and surrounds. It presents the data captured during the surveys from 2010 to 2018. The biology, habitat, population and distribution of the Giant Barred Frog are discussed, including key findings and conclusions.

A summary of the key conclusions are as follows:

- Giant Barred Frogs are widely distributed throughout the MJR catchment.
- Giant Barred Frogs were in high abundance in areas where the riparian ground and canopy vegetation was intact and where water quality was not compromised by agricultural or sustained salt influxes from surrounding geology.
- The populations in the MJR catchment and Crawford River are considered reasonably secure at present, but both populations could decline rapidly should conditions and impacts change.
- The detailed monitoring of the Giant Barred Frog has allowed for the collection and collation of detailed information about this species over a number of years, and under a range of climatic circumstances. This data is significant for the conservation of this species along the MJR and elsewhere within its range.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1 INTRODUCTION

1.1 MINE LOCATION AND APPROVAL

The Duralie Coal Mine (DCM) is an open cut coal mine situated approximately 35 kilometres (km) south of Gloucester in the Gloucester Valley, New South Wales (NSW) (Figure 1). Duralie Coal Pty Ltd (DCPL) (a wholly owned subsidiary of Yancoal Australia Limited) owns and operates the DCM.

The NSW Minister for Urban Affairs and Planning granted Development Consent (DA 168/99) for the DCM[1] in February 1999, with coal production commencing in 2003. The approved mine development included open cut mining, out of pit and in pit overburden emplacement, rail dispatch of run-of-mine (ROM) coal to the Stratford Mining Complex (SMC) for processing and export, diversion of Coal Shaft Creek and water management including mine water storage dams and irrigation areas to minimise the potential for discharge of mine water to Mammy Johnsons River (MJR). DA 168/99 was modified on a number of occasions to make minor changes to the DCM including coal extraction rate, disturbance and coal extraction extents, and water management infrastructure.

In December 2010 the Duralie Extension Project (DEP) was granted approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (EPBC 2010/5396). Subsequently, in November 2011, the DEP was granted approval by the NSW Land and Environment Court[2] (Project Approval [PA] 08_0203). The DEP includes (among other things) continuation and extension of open cut mining, in pit overburden emplacement, rail dispatch of ROM coal to the SMC, and water management, including increased mine water storage capacity and additional irrigation areas for disposal of excess mine water.

PA 08_0203 was modified in November 2012 and December 2014 to make changes to rail dispatch times, disturbance, coal extraction and overburden emplacement extents. The general arrangement of the approved DCM is shown on Figure 2.

In accordance with Condition 5, Schedule 2 of PA 08_0203, mining operations at the DCM ceased 31 December 2021.

1.2 GIANT BARRED FROG POTENTIAL IMPACT PATHWAYS

During the assessment of the DEP for both State and Commonwealth Approvals (including the Land and Environment Court proceedings) it was identified that rainfall runoff from the additional proposed mine water irrigation areas (when under irrigation) had the potential to adversely impact water quality in the MJR, with a subsequent potential threat to the health of the local Giant Barred Frog population[3]. Notwithstanding, DEP assessments concluded that runoff from non-irrigated mine areas was not a relevant Giant Barred Frog impact pathway.

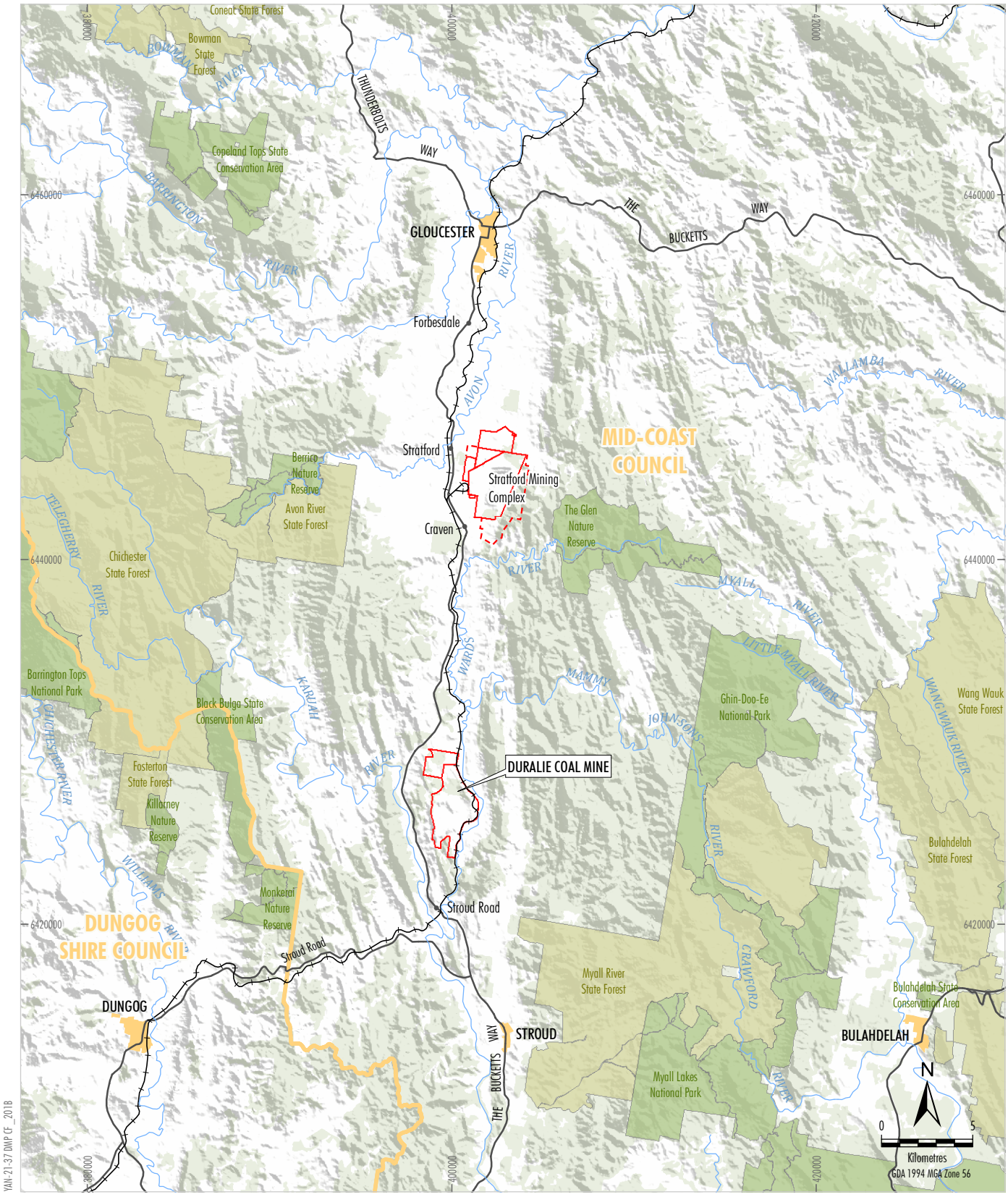
It was also acknowledged, during the assessment of the DEP (including the Land and Environment Court proceedings), that the DCM had been operating next to the MJR for over 7 years, with the irrigation system (as approved under the DCM's former Development Consent DA 168/99) operating for 5 of those years, without causing any adverse impacts on the water quality of the river.

---

1 The mine was originally granted consent in August 1997, however the development as approved was not commenced. A new application was subsequently submitted and approved in February 1999.

2 The Land and Environment Court approved the DEP following an objector appeal against the Minister for Planning's determination of the DEP in November 2011.

3 The expert report prepared by Dr Arthur White for the Land and Environmental Court Proceedings (No. 10090 of 2011, Annexure A) identified that the only potential impact of the DEP on the Giant Barred Frog would be due to salinity level changes in MJR associated with rainfall runoff from the proposed additional mine water irrigation areas (White, 2011).



YAN-21-37 DMP CF_201B

LEGEND

- Mining Lease Boundary
- NSW State Forest
- National Park, Nature Reserve or State Conservation Area
- Local Government Area Boundary

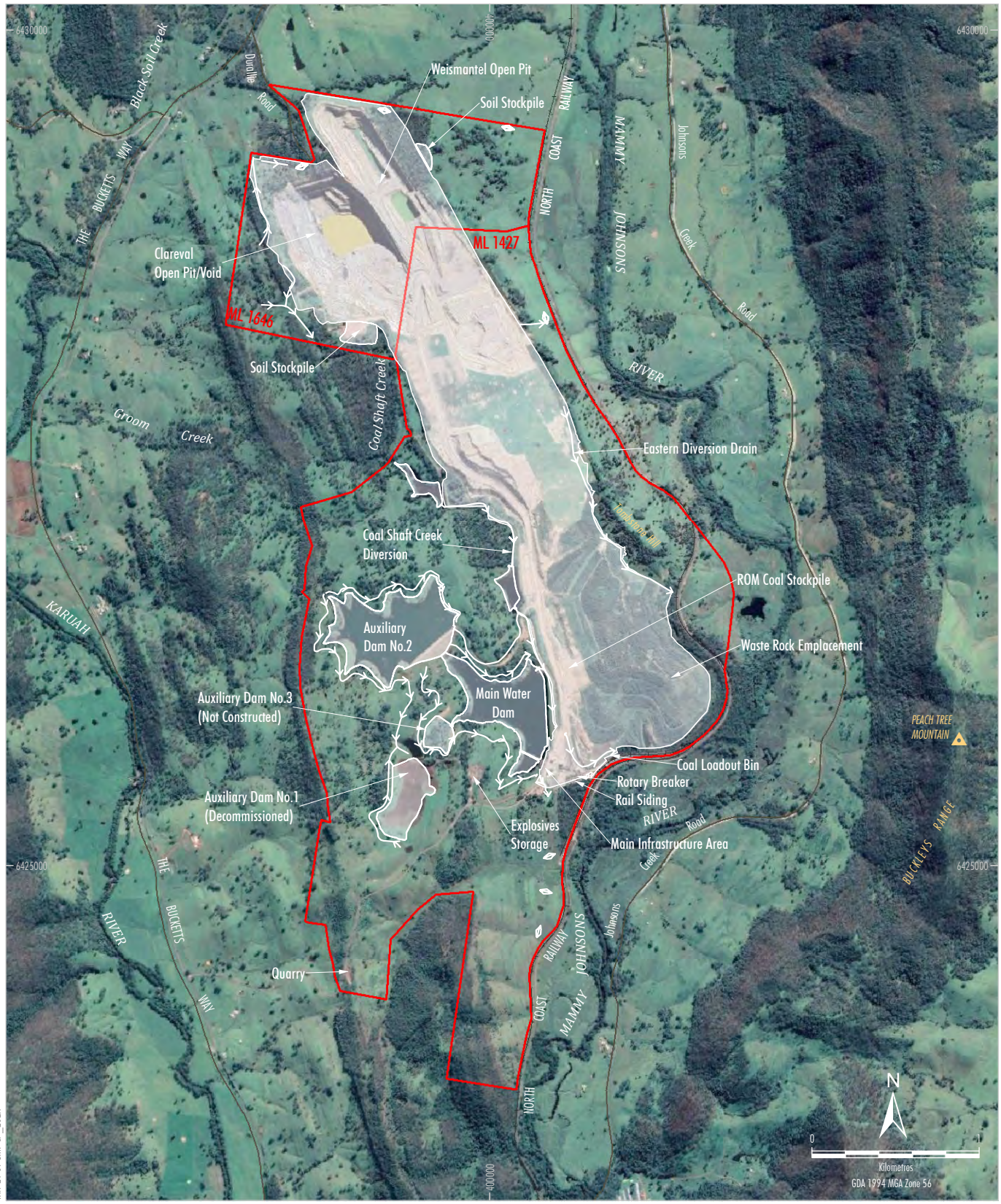
Source: Geoscience Australia (2006);
NSW Department of Planning & Environment (2017)

DURALIECOAL
Part of the Yancoal Australia Group

DURALIE COAL MINE

Regional Location

Figure 1



YAN-21-37 DMP CF _202A

LEGEND

- Mining Lease Boundary
- Approximate Extent of Existing/Approved Surface Development
- Existing/Approved First Flush Protocol Pump Back System
- Existing/Approved Up-catchment Diversion System

Source: © NSW Spatial Services (2019)
Orthophoto: Google Earth CENS/Airbus (2020)

DURALIECOAL
Part of the Yancoal Australia Group

DURALIE COAL MINE

DCM General Arrangement

Figure 2

This was demonstrated by extensive water quality and macroinvertebrate monitoring of Coal Shaft Creek, the MJR and the Karuah River in addition to detailed soil analysis of existing irrigation areas.

Ecotoxicity testing of mine water applied to the irrigation areas approved under the DCM's former Development Consent DA 168/99 further demonstrated that runoff from the additional proposed irrigation areas for DEP was unlikely to adversely affect the Giant Barred Frog population, provided that the runoff from the additional irrigation areas was appropriately controlled.

Despite having approval to do so, DCPL did not commence irrigation of the additional irrigation areas approved under the DEP, and as such, the potential impact pathway to the Giant Barred Frog population did not commence.

1.3 WATER MANAGEMENT

The objectives of the approved DCM water management system are to:

- maintain separation between runoff from undisturbed areas and water generated within actively managed post-mining activities, rehabilitation works and/or disturbance areas;
- minimise the potential for uncontrolled overflow of contained water storages;
- comply with the requirements of EPL 11701; and
- provide a reliable source of water to meet the requirements of the DCM during mine closure.

The water management system controls waters generated from surface development areas while controlling the capture of surface water runoff by diverting upslope water around such areas. The water management system includes a combination of permanent structures that continue to operate post closure and temporary structures that are required until the completion of rehabilitation works (e.g. sediment control structures) (DCPL, 2010).

The approved water management system includes the following components:

- water management storages;
- diversions for runoff from catchment areas upslope of the mine disturbance area (i.e. upslope diversions);
- runoff control structures and devices on disturbed and rehabilitated areas at the DCM;
- runoff control structures and devices on infrastructure areas;
- procedures, structures and devices for the control of erosion and sediment movement;
- open pit dewatering equipment;
- procedures and equipment for the disposal of excess water through on-site irrigation[4]; and
- sewage treatment plant and a system for the disposal of effluent.

[4] As stated in the approved DCM Irrigation Management Plan (IMP), the requirement for, and the requirements of, the IMP are no longer relevant to the DCM and the plan is now redundant. All irrigation activities for the purpose of reducing the total site water inventory at the DCM have now ceased and the DCM's Irrigation Area irrigation system has been decommissioned and removed. DCPL does not intend to recommence irrigation of the DCM Irrigation Areas during the mine closure phase. Notwithstanding, should irrigation activities at the DCM Irrigation Areas recommence, DCPL would recommence the Irrigation Management Plan.

Prior to 2018, water collected from operational areas was used for on-site irrigation in what was the existing approved irrigation areas. However, irrigation of the additional areas under the DEP never commenced. Furthermore, as described above, irrigation activities at the DCM ceased in 2018 and all irrigation equipment has subsequently been removed from the site.

The water management system is described in further detail in the approved DCM Water Management Plan (WMP).

1.4 CURRENT STATUS OF THE DURALIE COAL MINE

Condition 5, Schedule 2 of Project Approval (08_0203) authorised mining operations to be carried at the DCM until 31 December 2021 with the footnote:

> *Under this approval, the Proponent is required to rehabilitate the site and carry out additional undertakings to the satisfaction of both the Secretary and the Director-General of DTIRIS. Consequently, this approval will continue to apply in all other respects – other than the right to conduct mining operations – until the rehabilitation of the site and these additional undertakings have been carried out satisfactorily.*

Accordingly, DCPL has commenced the mine closure phase (i.e. after the cessation of mining operations on 31 December 2021) and has revised this management plan to reflect the current stage of closure planning. Key activities of the mine closure phase include:

- undertaking technical studies and site investigations to address closure knowledge gaps and develop detailed decommissioning and rehabilitation execution plans that will deliver optimal rehabilitation outcomes at the site;
- infrastructure decommissioning and demolition;
- bulk rehabilitation earthworks (which may include blasting to achieve final landform design);
- revegetation of final landform in accordance with the Rehabilitation Management Plan;
- removal of all mining fleet, major earthworks fleet and drilling fleet from the DCM; and
- refinement of monitoring programs and environmental management plans to reflect the rehabilitated site.

Rehabilitation work and post-mining activities at the DCM now reflect the transition towards mine closure. As a result, all irrigation activities for the purpose of reducing the total site water inventory at the DCM have now ceased and the DCM's Irrigation Area irrigation system has been decommissioned and removed. DCPL does not intend to recommence irrigation of the DCM Irrigation Areas during the mine closure phase.

The DCM's Mine Closure Planning Program (provided in the DCM's Forward Program (FWP0001484) and Rehabilitation Management Plan) describes the technical assessments and works that will be undertaken and implemented as the DCM transitions to mine closure.

Dr Arthur White's Review of DCM Giant Barred Frog Monitoring Program Results

As part of closure activities at the DCM, DCPL engaged Dr Arthur White (Biosphere Environmental Consultants) in 2023 to prepare a summary paper titled "*A Study of the Giant Barred Frog (Mixophyes iteratus) in the Mammy Johnsons River Catchment"* (Appendix 1), The purpose of this report was to present a collation of the research and monitoring undertaken on the Giant Barred Frog in the MJR catchment and surrounds. It presents the data captured during the surveys from 2010 to 2018. The biology, habitat, population and distribution of the Giant Barred Frogs are discussed, including key findings and conclusions.

Key findings and conclusions from Dr Arthur White's (2023a) report include:

> *The Giant Barred Frog is widely distributed throughout the MJR catchment.*
>
> …
>
> *Giant Barred Frogs were in high abundance in areas where the riparian ground and canopy vegetation was intact and where water quality was not compromised by agricultural or sustained salt influxes from surrounding geology.*
>
> …
>
> *Overall, the populations in the MJR catchment and Crawford River are considered as reasonably secure at present, but both populations could decline rapidly should conditions and impacts change.*

As irrigation in the additional irrigation areas was not commenced and mining operations have now ceased, the catalyst for monitoring and survey efforts of Giant Barred Frogs (and implementation of the Giant Barred Frog Management Plan [GBFMP]) is not considered relevant. Nonetheless, the detailed monitoring of the Giant Barred Frog has allowed for the collection and collation of detailed information about this species over a number of years, and under a range of climatic circumstances. This data is significant for the conservation of this species along the MJR and elsewhere within its range.

Dr Arthur White's report is included in Appendix 1 of this GBFMP. Details of study methods are described in Section 7 of this GBFMP.

1.5 MANAGEMENT PLAN PURPOSE AND SCOPE

DCPL prepared and implemented an approved GBFMP following the approval of the DEP, in accordance with the requirements of PA 08_0203 and EPBC 2010/5396. The approved GBFMP was prepared by Dr Arthur White (Biosphere Environmental Consultants) and DCPL, in consultation with the then NSW Office of Environment and Heritage (OEH) (now the Conservation Programs, Heritage and Regulation Division [CPHR] within the NSW Department of Climate Change, Energy, the Environment and Water [NSW DCCEEW]). Dr Arthur White was endorsed by the Secretary of the then NSW Department of Planning and Environment (DP&E) (now Department of Planning, Housing and Infrastructure [DPHI]) as a suitably qualified and experienced person to prepare the GBFMP.

Under EPBC 2010/5396, the GBFMP is required to be submitted to the Commonwealth Department of Climate Change, Energy, the Environment and Water (Commonwealth DCCEEW) for approval (and subsequently implemented) following commencement of irrigation activities within the DEP irrigation areas. Although the GBFMP was approved by the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (now the DCCEEW) in August 2012 DCPL did not commence irrigation of the additional irrigation areas approved under the DEP. Accordingly, the Commonwealth DCCEEW approved a revised plan in July 2025 confirming its redundancy (Appendix 3).

DCPL does not intend to commence irrigation of these areas during mine closure.

DCPL and Dr Arthur White consider the GBFMP is no longer applicable to the DCM and the plan is now redundant, given:

- DCPL did not commence irrigation of the additional irrigation areas approved under the DEP;
- that all irrigation activities for the purpose of reducing the total site water inventory at the DCM have ceased and the DCM's irrigation area irrigation system has been decommissioned and removed; and
- the conclusions of Dr Arthur White's (2023a) *A Study of the Giant Barred Frog (Mixophyes iteratus) in the MJR Catchment* (Appendix 1).

Accordingly, DCPL and Dr Arthur White have revised this GBFMP to describe the current status of the DCM and to reflect the redundancy of this plan. DCPL now seeks acknowledgement and approval from the DPHI confirming the redundancy of the GBFMP.

Dr Arthur White reviewed the draft version of this GBFMP in June 2023 (White, 2023b) (Appendix 2). Section 9 of this GBFMP has been updated to address Dr Arthur White's review commentary where relevant.

On 7 September 2023, the (then) **BCD confirmed that it agreed the GBFMP is no longer considered relevant**, as the anticipated irrigation of the DCM did not eventuate (Appendix 3).

Further to this, on 15 July 2025 the **Commonwealth DCCEEW approved the revised GBFMP** (confirming its redundancy) under Condition 9 of EPBC 2010/5396 (Appendix 3).

While minor edits have been made to this plan since June 2023, these edits are all administrative in nature and aimed at aligning the GBFMP with other (more contemporary) management plans at the DCM. In accordance with Condition 32, Schedule 3 of PA 08_0203, this revised GBFMP is now being provided to the NSW DPHI for review and approval.

In accordance with the requirements within PA 08_0203 and EPBC 2010/5396, the purpose of the GBFMP has been to describe:

- Baseline data for the Giant Barred Frog population on MJR collected from monitoring programs over the last seven years (2011 to 2018).
- Monitoring requirements for the Giant Barred Frog population and habitat on the MJR immediately upstream and downstream of the confluence with Coal Shaft Creek.
- Water quality triggers and performance objectives for rainfall runoff from the DEP irrigation areas (when under irrigation).
- Performance measures for evaluating the impact of rainfall runoff from the DEP irrigation areas (when under irrigation) on the Giant Barred Frog population in the immediate downstream areas of MJR.
- Contingency measures if monitoring on the MJR immediately downstream of Coal Shaft Creek confluence indicates that the Giant Barred Frog population is declining as a result of water quality changes due to rainfall runoff from the DEP irrigation areas (when under irrigation).
- Measures to be implemented to minimise the potential spread of the Chytrid fungus.

This plan applied in the event that mine water irrigation of the DEP irrigation areas was implemented.

1.6 STRUCTURE OF THE GBFMP

The remainder of the GBFMP is structured as follows:

Section 2: Outlines the statutory requirements applicable to the GBFMP.

Section 3: Provides a brief outline of the biology, distribution and conservation status of the Giant Barred Frog.

Section 4: Provides a brief outline of the local and regional hydrology.

Section 5: Summarises the Giant Barred Frog Study.

Section 6: Provides the detailed baseline data.

Section 7: Describes the Giant Barred Frog monitoring program (in the event irrigation of the DEP irrigation areas commences).

Section 8: Details the measures and indicators that will be used to assess the performance of the Project in relation to the Giant Barred Frog (in the event irrigation of the DEP irrigation areas commences).

Section 9: Describes the management measures that will be implemented (in the event irrigation of the DEP irrigation areas commences).

Section 10: Provides a Contingency Plan to manage any unpredicted impacts and their consequences (in the event irrigation of the DEP irrigation areas commences).

Section 11: Describes the annual review and improvement of environmental performance.

Section 12: Describes the review and update of the GBFMP.

Section 13: Outlines the management and reporting systems.

Section 14: Lists the references cited in this GBFMP.

2 STATUTORY REQUIREMENTS

DCPL's statutory obligations are contained in:

(i) the conditions of PA 08_0203;

(ii) the conditions of EPBC 2010/5396;

(iii) relevant licences and permits, including conditions attached to mining leases (MLs); and

(iv) other relevant legislation.

Obligations relevant to this GBFMP are described below.

2.1 NSW PROJECT APPROVAL

Condition 32, Schedule 3 of PA 08_0203 requires the preparation of a GBFMP. In addition, Condition 2, Schedule 5 of PA 08_0203 outlines general management plan requirements that are applicable to the preparation of the GBFMP. **Table 1** presents these conditions and indicates where each component of the conditions is addressed within this GBFMP.

Table 1
NSW Project Approval Management Plan Requirements

NSW Project Approval Condition	GBFMP Section
Condition 32, Schedule 3 ***BIODIVERSITY*** ***Giant Barred Frog***	
32. The Proponent shall prepare and implement a Giant Barred Frog Management Plan to the satisfaction of the Secretary. This plan must: *a) be prepared in consultation with OEH by a suitably qualified and experienced person, whose appointment has been endorsed by the Director-General;*	Section 1.5
b) be submitted to the Secretary for approval within 3 months of the date of this approval;	-
c) include a summary of the Giant Barred Frog Study;	Section 5
d) establish performance measures for evaluating the impact of the project on the local Giant Barred Frog population;	Section 8
e) describe the measures that would be implemented to minimise the potential spread of Chytrid fungus, including training of staff in site hygiene management in accordance with the NPWS Hygiene Protocol for the Control of Disease in Frogs 2001;	Section 9.6
f) include a program to monitor the potential impact of the project on the local frog population, which includes:	Section 7
• *detailed performance indicators for the project, with reference to the performance measures established in (d) above;*	Section 8
• *annual monitoring of the frog population and its habitat during the breeding season along Mammy Johnson River both upstream and downstream of the confluence of Mammy Johnsons River and Coal Shaft Creek;*	Section 7
• *trigger levels for further investigation; and*	Section 8
g) a contingency plan that would be implemented if monitoring suggests the frog population downstream of the confluence of Mammy Johnsons River and Coal Shaft Creek is declining due to the project, which may include a revision of the first flush salinity trigger or the implementation of additional water quality controls.	Section 10

Table 1 (Continued)
NSW Project Approval Management Plan Requirements

NSW Project Approval Condition	GBFMP Section
Condition 2, Schedule 5 ***ENVIRONMENTAL MANAGEMENT*** ***Management Plan Requirements***	
2. The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
a) detailed baseline data;	Section 6
b) a description of:	
• *the relevant statutory requirements (including any relevant approval, licence or lease conditions);*	Section 2
• *any relevant limits or performance measures/criteria;*	Section 8
• *the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures;*	Section 8
c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Sections 7, 8, 9 and 10
d) a program to monitor and report on the: • *impacts and environmental performance of the project;* • *effectiveness of any management measures (see c above);*	Sections 7, 8 and 11
e) a contingency plan to manage any unpredicted impacts and their consequences;	Section 10
f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Sections 7, 8 and 11
g) a protocol for managing and reporting any:	
• *incidents;*	PIRMP & Section 13
• *complaints;*	EMS & Section 13
• *non-compliances with statutory requirements; and*	EMS & Section 13
• *exceedances of the impact assessment criteria and/or performance criteria; and*	Section 10
h) a protocol for periodic review of the plan.	Section 12
Note: The Secretary may waive some of these requirements if they are unnecessary or unwarranted.	

Of relevance to this GBFMP, Condition 30, Schedule 3 and Condition 31, Schedule 3 of the PA 08_0203 also state:

> *30. The Proponent shall ensure that the project has no more than a negligible impact on the local Giant Barred Frog population.*
>
> *31. The Proponent shall prepare a Giant Barred Frog Study to the satisfaction of the Secretary. This study must:*
>
> *(a) be prepared, in consultation with BCD, by a suitably qualified and experienced person, whose appointment has been endorsed by the Secretary;*
>
> *(b) be submitted to the Secretary for approval within 2 months of this approval;*
>
> *(c) investigate the extent of the Giant Barred Frog population in the Mammy Johnson River Catchment;*
>
> *(d) assess the condition of the Giant Barred Frog habitat where it is recorded within the Catchment, including the presence of any Chytrid fungus;*
>
> *(e) analyse the age structure of the frog population and the health of tadpoles; and*
>
> (f) *document the relevant hydrological conditions both prior to and during the study, including rainfall, water flows and quality in Mammy Johnsons River, both upstream and downstream of the confluence of Mammy Johnsons River and Coal Shaft Creek, and in Coal Shaft Creek.*

Conditions 30 and 31 are addressed in Sections 8 and 5 of this GBFMP, respectively.

Condition 31A of PA 08_0203 is relevant to the expansion of the Giant Barred Frog Study required under Condition 31 of PA 08_0203. This condition is addressed in Section 5.3.

2.2 COMMONWEALTH PROJECT APPROVAL

Conditions 6 to 10 of EPBC 2010/5396 are of relevance to the Giant Barred Frog. Condition 8 requires the preparation of a GBFMP while Conditions 6, 7, 9 and 10 outline requirements of Giant Barred Frog Surveys and management. **Table 2** presents these conditions and indicates where each component of the conditions is addressed within this GBFMP.

As outlined in Section 1.5, the **Commonwealth Minister for the Environment and Water approved the revised GBFMP** (confirming its redundancy) on 15 July 2025 (Appendix 3).

Table 2
Commonwealth Project Approval Management Plan Requirements

Commonwealth Project Approval Condition	GBFMP Section
Giant Barred Frog Surveys and Management	
6. By the end of April 2011 and prior to undertaking Irrigation Activities, the person undertaking the action must conduct baseline frog surveys in order to investigate the local population of the Giant Barred Frog in the MJR. The surveys must: *a) be undertaken by a qualified ecologist approved in writing by the Department;*	Section 1.5
b) be conducted in accordance with DSEWPaC Survey guidelines for Australia's threatened frogs (http://www.environment.gov.au/epbc/publications/pubs/ survey-guidelines-frogs.rtf) and/or DECCW survey guidelines (DECC 2009, Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna- Amphibians);	Section 5.1
c) be undertaken during the known breeding season (September to March);	Section 5.1
d) assess the condition of identified and potential Giant Barred Frog habitat on the MJR and control sites, including the riparian ecosystem condition, stream characteristics (pool, riffles) and water quality 500m upstream and downstream of the confluence of MJR and Coal Shaft Creek;	Section 5.1
e) provide analysis of the frog populations including tadpoles and any observations of amplexus/oviposition/egg masses; and,	Section 5.1

Table 2 (Continued)
Commonwealth Project Approval Management Plan Requirements

Commonwealth Project Approval Condition	GBFMP Section
f) determine the presence of chytrid fungus within the MJR.. This may include locations at sites below the confluence of the MJR and Coal Shaft Creek, and at other sites accessed for Duralie Coal Pty Ltd activities situated on the MJR above the confluence of Coal Shaft Creek, such as water quality monitoring location.	Section 5.1
7. The surveys undertaken for Condition 6 must be repeated one year later between September 2011 and April 2012.	Section 6
8. In order to protect the Giant Barred Frog from impacts associated with the project, the person undertaking the action must within 3 months of the commencement of the Irrigation Activities, submit a Giant Barred Frog Management Plan. This plan must include:	
a) results of completed baseline surveys;	Section 6
b) description of the measures undertaken to control and prevent the spread of the amphibian chytrid fungus as a result of activities associated with the project;	Section 9.6
c) a mark-recapture monitoring program to measure and detect changes to Giant Barred Frog populations over the life of the mine. The monitoring methodology must have the ability to detect up to at least a 20 % decline in the frog population;	Section 7
d) management measures to mitigate and avoid adverse impacts to the Giant Barred Frog, including the management and reduction of identified threats to the species (such as feral animals), measures to monitor and manage relevant water quality parameters including pH, heavy metals and aromatic hydrocarbons, and measures to address and respond to the risk of overflow from the mine water voids and seepage of potentially contaminated groundwater;	Section 8
e) analysis of all aquatic invertebrate monitoring data using the Australian Rivers Assessment System (AusRivAS), and integration of AusRivAS modelling results into monitoring and management activities for the Giant Barred Frog, and for water quality, where relevant; and	Section 6.3
f) a Giant Barred Frog contingency plan that would be implemented if monitoring indicates a decline of 20% or more (in comparison with the results of surveys conducted in 2009 and surveys required under Condition 6 and 7) in the frog population within 500m of the project area. This should include, for example, a revision of first flush salinity trigger levels or the implementation of additional or alternative water quality controls. *Note: to avoid doubt, this contingency plan is in addition to the requirement at Condition 5 regarding the reduction of salinity trigger levels for released water in the event of an identified frog population decline of 20% or more.*	Section 10
9. The approved Giant Barred Frog management plan must be implemented. Any changes to the Giant Barred Frog management plan must be approved by the Minister and approved variations to the Plan must be implemented. The approved plan must be made publicly available on the internet by the person undertaking the action.	Section 12
10. The person undertaking the action must provide a report on the implementation of the Giant Barred Frog management plan annually for the first 5 years and then every 5 years thereafter. *Note: The management plan should include sufficient detail to inform field development decisions and ongoing management, to minimise adverse impacts on the Giant Barred Frog through the life of the project.*	Section 11

2.3 LICENCES, PERMITS AND LEASES

In addition to PA 08_0203 and EPBC 2010/5396, activities at or in association with the DCM will be conducted in accordance with a number of licences, permits and leases which have been issued or are pending issue.

Key licences, permits and leases pertaining to the DCM include:

- ML 1427 issued under Part 5 of the *Mining Act 1992* (the Mining Act) and approved by the then NSW Minister for Mineral Resources in April 1998.
- ML 1646 issued under Part 5 of the Mining Act and approved by the then NSW Minister for Primary Industries in January 2011.
- Duralie Mine Forward Program (FWP0001484) and Rehabilitation Management Plan (RMP) approved by the NSW Resources Regulator under the Mining Act.
- EPL 11701 issued under Part 3 of the NSW *Protection of the Environment Operations Act 1997* by the Environment Protection Authority in September 2002 (as modified by subsequent licence variations).
- Water Access Licence (WAL) 41518 for extraction of groundwater from the DCM open cut pits issued by the Water Group within NSW DCCEEW (originally granted 22 September 2002 under former Groundwater Licence 20BL168404).
- Water Supply Works Approval (20WA202053) under the *Water Management Act 2000* issued by the then Department of Water and Energy (now the Water Group within NSW DCCEEW) on 15 May 2009 for the Coal Shaft Creek diversion and various onsite water management structures[5].
- Mining and occupational health and safety related approvals granted by the NSW Resources Regulator and/or NSW Mining, Exploration and Geoscience (MEG) and SafeWork NSW.

2.4 OTHER LEGISLATION

DCPL will conduct the DCM consistent with PA 08_0203, EPBC 2010/5396 and any other legislation that is applicable to an approved Part 3A Project under the EP&A Act.

In addition to those Acts referred to above (Section 2.3), the following NSW Acts may be applicable to the conduct of the DCM:

- *Contaminated Land Management Act 1997;*
- *Dangerous Goods (Roads and Rail Transport) Act 2008;*
- *National Parks and Wildlife Act 1974;*
- *Biosecurity Act 2015;*
- *Roads Act 1993;*
- *Biodiversity Conservation Act 2016;*
- *Work Health and Safety Act 2011;*
- *Work Health and Safety (Mines and Petroleum Sites) Act 2013;*
- *Crown Land Management Act 2016;*
- *Dams Safety Act 2015;*
- *Fisheries Management Act 1994; and*
- *Petroleum (Onshore) Act 1991.*

[5] This approval replaced the previous *Water Act, 1912* Licence 20SL060324 for these structures.

3 GIANT BARRED FROG – BIOLOGY, DISTRIBUTION AND CONSERVATION STATUS

A brief description of the biology, distribution and conservation status of the Giant Barred Frog is provided below. Further information is available in the various scientific literature and other publications referenced.

3.1 BIOLOGY

3.1.1 Habitat

The Giant Barred Frog is associated with permanent flowing drainages, ranging from shallow rocky streams in rainforest to slow-moving rivers in lowland open forest (NSW Scientific Committee, 1999). Giant Barred Frogs are not found in ponds or ephemeral pools (Ehmann, 1997).

The Giant Barred Frog is known to inhabit various vegetation types including rainforest, moist eucalypt forest and nearby dry eucalypt forest (Department of the Environment [DotE], 2015). Populations of the Giant Barred Frog have also been found in disturbed areas within vegetated riparian strips on cattle farms (DotE, 2015). However, deep leaf litter provided by canopy vegetation and/or thick cover is necessary (Ehmann, 1997).

White (2008), conducted intensive surveys for the Giant Barred Frog to determine its current distribution in the greater Sydney Basin. The study recorded the Giant Barred Frog in second, third and fourth order streams, all permanent and slow flowing, that ranged in width from 1 to 5 metres (m) wide (White, 2008). At most of the sites, the riparian corridor of the stream was relatively narrow and varied between 5 and 25 m away from the banks (White, 2008).

Graded banks with undercuts and steep edges are typical of many known Giant Barred Frog sites (Ehmann, 1997).

3.1.2 Breeding

Male Giant Barred Frogs call in spring and summer (Anstis, 2002). A stream breeding species, the Giant Barred Frog breeds from late spring to summer around shallow, flowing, rocky permanent streams, where some riparian vegetation is present (Department of Environment, Climate Change and Water [DECCW], 2009; Lemckert and Brassil, 2000). Breeding is associated with rainfall events, however the Giant Barred Frog does not breed when streams are in full flow; rather at the time stream flow is receding.

Females lay eggs onto the moist creek banks or rocks above water level, from where tadpoles drop into the water when hatched (DECCW, 2009). The larval period of the Giant Barred Frog is from September to May (Goldingay *et al*., 1999; Mahony *et al.,* 1997; in DotE, 2015). The Giant Barred Frog has a long tadpole stage that may last up to 18 months (White, 2008). Tadpoles are large, growing to over 100 millimetres (mm) in length (DotE, 2015).

3.1.3 Foraging

Adult Giant Barred Frogs feed primarily on large insects and spiders (National Parks and Wildlife Service [NPWS], 2000), and tadpoles feed on plant material.

3.1.4 Movement

Various studies have found the Giant Barred Frog usually stays within approximately 50 m of its habitat (i.e. stream/riparian vegetation) (Streatfield, 1999 in DotE, 2015; Lemckert and Brassil, 2000; Koch and Hero, 2007).

Streatfield (1999 in DotE, 2015) monitored the spatial movements of four male and four female Giant Barred Frogs at Coomera River in Queensland. Over six weeks, it was found that the individuals moved a maximum distance of 268 m along the stream and 50 m away from the stream. After a night of activity, the displacement distances between diurnal refuges were found to be small, suggesting a high degree of fidelity to the previous day's shelter (Streatfield, 1999 in DotE, 2015).

Lemckert and Brassil (2000) undertook a four-year radio tracking study on the movements and habitat use of the Giant Barred Frog in the Coffs Harbour/Dorrigo area in NSW. The study found that frogs stayed within a 20 m band either side of the four streams monitored.

Koch and Hero (2007) radio tracked the Giant Barred Frog and demonstrated that males were found 7.2 m on average from the stream (range 0.5 to 32.0 m) and females were found on average 12.1 m from the stream (range 0 to 50 m).

Previous studies have shown that the Giant Barred Frog is not distributed evenly along streams; they cluster and reach highest densities around larger pools with overhanging banks (preferred breeding sites). In contrast they are not common near riffle zones. Studies have also found that adult males are territorial (i.e. they defend an area and exclude other males).

3.2 DISTRIBUTION

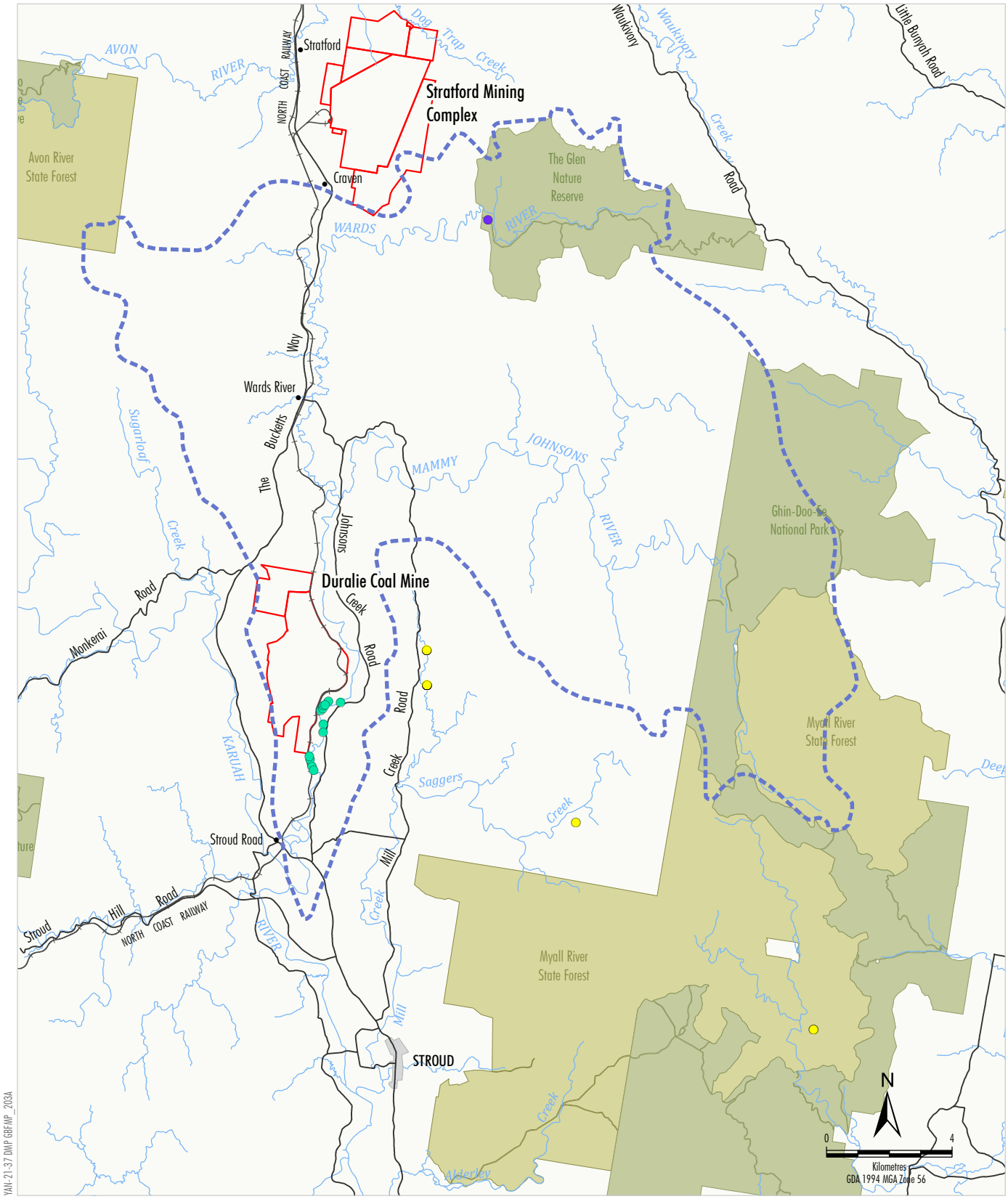
The general distribution of the Giant Barred Frog in Australia extends across the eastern coast and ranges from south-eastern Queensland to the Hawkesbury River in mid-eastern NSW (DECCW, 2009; Hines *et al*., 1999).

The Giant Barred Frog was first recorded in the MJR catchment in January/February 2009 (EcoBiological, 2009). Prior to the Giant Barred Frog Study, the Giant Barred Frog was only known from two locations in the MJR Catchment. However, the Giant Barred Frog is more widely distributed within the MJR catchment than previously thought (Figure 3). Following the Giant Barred Frog Study and subsequent baseline monitoring surveys, the Giant Barred Frog has been recorded in a number of locations in the catchment and surrounding areas (Figures 4 and 5).

3.3 CONSERVATION STATUS

The Giant Barred Frog (*Mixophyes iteratus*) was originally listed as Endangered under the NSW *Threatened Species Conservation Act 1995* and EPBC Act, however **its listing status has more recently been downgraded at both the State and Commonwealth level to Vulnerable.**

The distribution of the Giant Barred Frog in the MJR catchment and wider surrounds (Mill Creek, Saggers Creek and Crawford River) is relatively isolated from other known populations to the south and north (Figure 4). Given the known distribution of the Giant Barred Frog, the population in the MJR catchment is of regional significance.



YAN-21-37 DMP GBFMP_203A

LEGEND

- Mining Lease Boundary
- National Park, Nature Reserve or State Conservation Area
- NSW State Forest
- Mammy Johnsons River Catchment Boundary (approximate)

No. of Records	Giant Barred Frog Records
(1-20)	Atlas of NSW Wildlife (2012)
(1-20)	Ecobiological (2009)
(1-20)	Ecobiological (2011)

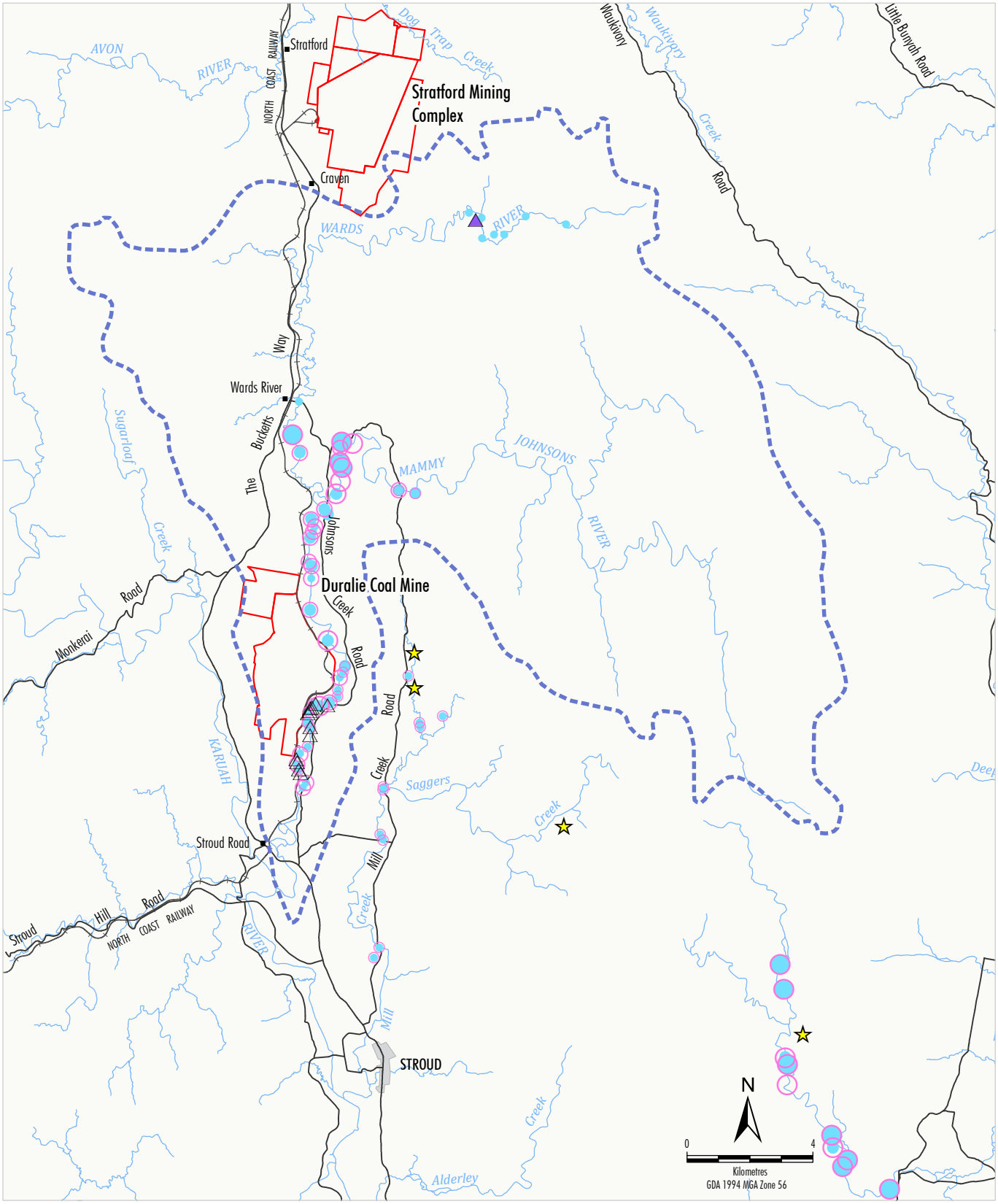
Source: Spatial Services NSW (2022)

DURALIECOAL
Part of the Yancoal Australia Group

DURALIE COAL MINE

Giant Barred Frog Records
Prior to Monitoring

Figure 3



YAN-21-37 DMP GBFMP_211A

LEGEND

Mining Lease Boundary

Mammy Johnsons River Catchment Boundary (approximate)

No. of Records	Source
(1-20)	Atlas of NSW Wildlife (2013)
(1-20)	Biosphere Environmental Consultants (2012-2013)
(21-50)	Biosphere Environmental Consultants (2012-2013)
(51+)	Biosphere Environmental Consultants (2012-2013)
(1-20)	Biosphere Environmental Consultants (2010-2012)
(21-50)	Biosphere Environmental Consultants (2010-2012)
(51+)	Biosphere Environmental Consultants (2010-2012)
(1-20)	Ecobiological (2011)
(1-20)	Ecobiological (2009)

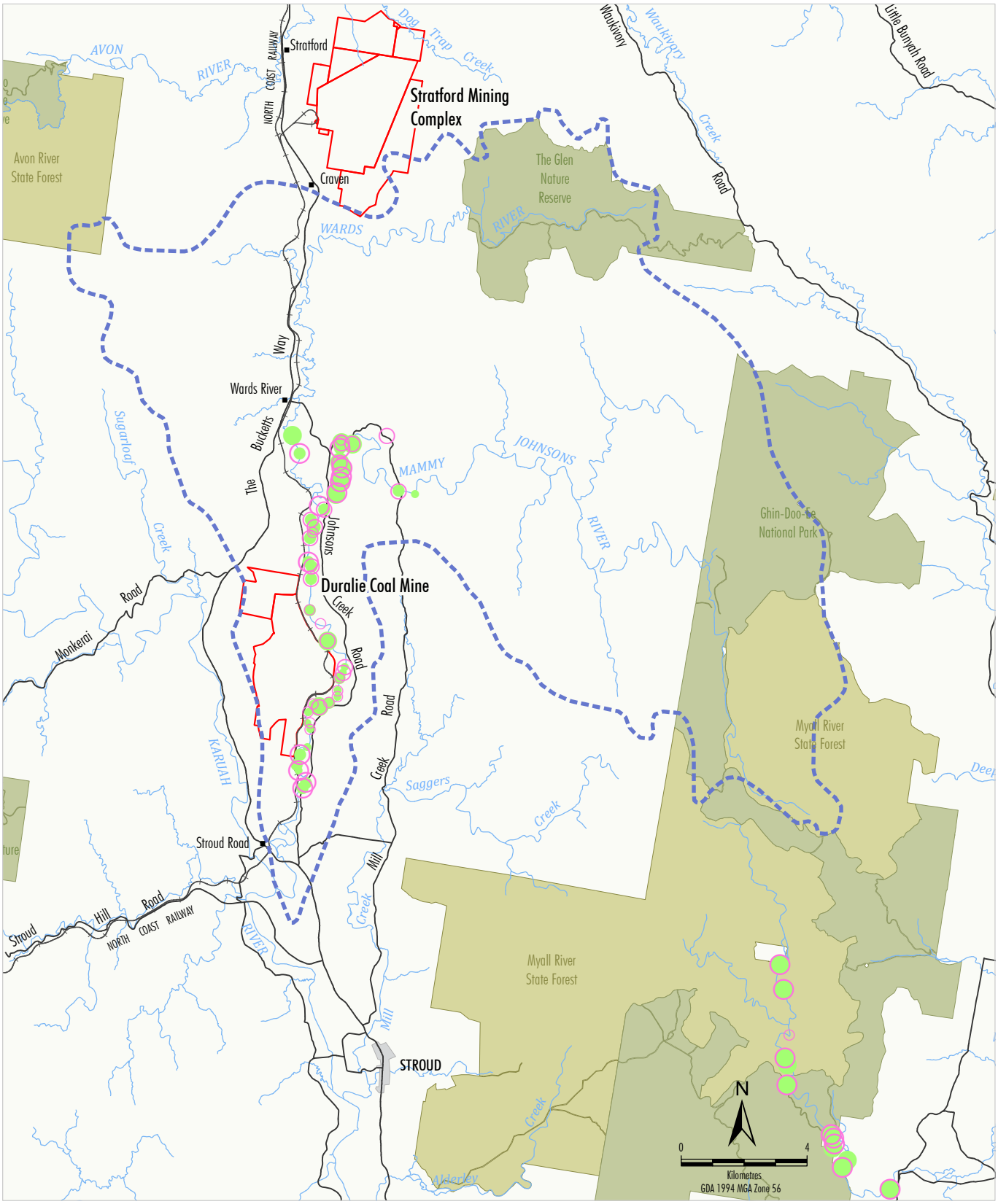
Source: Spatial Services NSW (2022)

DURALIECOAL
Part of the Yancoal Australia Group

GIANT BARRED FROG MANAGEMENT PLAN

Giant Barred Frog Records in the Wider Surrounds After Monitoring (2010-2013)

Figure 4



YAN-21-37 DMP GBFMP_210A

LEGEND

- Mining Lease Boundary
- National Park, Nature Reserve or State Conservation Area
- NSW State Forest
- Mammy Johnsons River Catchment Boundary (approximate)

No. of Records	Source
(1-20)	Biosphere Environmental Consultants (2014-2015)
(21-50)	Biosphere Environmental Consultants (2014-2015)
(51+)	Biosphere Environmental Consultants (2014-2015)
(1-20)	Biosphere Environmental Consultants (2013-2014)
(21-50)	Biosphere Environmental Consultants (2013-2014)
(51+)	Biosphere Environmental Consultants (2013-2014)

Source: Spatial Services NSW (2022)

DURALIECOAL
Part of the Yancoal Australia Group

GIANT BARRED FROG MANAGEMENT PLAN

Giant Barred Frog Records in the Wider Surrounds After Monitoring (2014-2015)

Figure 5

4 LOCAL AND REGIONAL HYDROLOGY

A comprehensive description of the local and regional surface water resources is provided in Section 5.4 and Appendix D of the *Duralie Open Pit Modification Environmental Assessment* (DCPL, 2014). A summary of this information is provided below.

The DCM is situated in the Gloucester Valley which is bounded by Buckleys Range to the east and the Linger and Die Ridge to the west. The area surrounding the mine has been extensively cleared for grazing on native and improved pastures and is also used for intensive poultry farming.

The DCM area is situated within the MJR catchment, a tributary of the Karuah River. The Karuah River, which rises in the Chichester State Forest, drains to Port Stephens some 40 km south of the mine. The Karuah River is located to the north-west and south of the DCM.

MJR has a similar catchment area and length to the Karuah River above their confluence near the village of Stroud Road (Gilbert & Associates Pty Limited, 2014). The MJR rises in the Myall State Forest to the east of the mine and flows generally north out of the State Forest area and then west through the locality of Tereel to its confluence with Wards River some 2.5 km south-east of the township of the same name. From the Wards River confluence, the MJR flows in a generally southerly direction through an undulating landscape which has been extensively cleared for cattle grazing.

Streamflows in the Karuah River and MJR are characterised by low to moderate flows for long periods, with periods of higher discharge following heavy rains, typical of small and medium sized upland catchments (Gilbert & Associates Pty Limited, 2010). The Karuah River appears to have stronger low flow persistence than MJR, with zero flow recorded only on 0.8% of days, compared to 5.3% of days for the MJR (Gilbert & Associates Pty Limited, 2010).

The DCM is situated in the catchment of Coal Shaft Creek, a small tributary which flows into the lower reaches of MJR, and the catchment of an unnamed minor tributary stream that flows north and east to join the MJR approximately 4 km upstream of the Coal Shaft Creek confluence.

Coal Shaft Creek has been diverted around the current mine workings. Tombstone Hill, at an elevation of approximately RL 130 m, and its associated ridgeline, divides the Coal Shaft Creek catchment from the MJR to the east.

The Coal Shaft Creek diversion comprises an approved, purpose-built diversion channel, which re-joins the original Coal Shaft Creek alignment near the DCM rail spur. The confluence of Coal Shaft Creek with the MJR is south of the DCM rail loading infrastructure and approximately 10 km upstream of the MJR/Karuah River confluence.

The upper reaches of Coal Shaft Creek are ephemeral and baseflow contributions in these portions of the creek are likely to be small (Gilbert & Associates Pty Limited, 2014).

The northern parts of the mining operations extend beyond the Coal Shaft Creek catchment boundary and into the catchment of a small unnamed drainage which is referred to as the Unnamed Tributary. The Unnamed Tributary flows generally eastward into the MJR (Gilbert & Associates Pty Limited, 2014).

5 GIANT BARRED FROG STUDY

A Giant Barred Frog Study (DCPL, 2012b) was prepared by Dr Arthur White (Biosphere Environmental Consultants), a suitably qualified and experienced person endorsed by the Director-General of the former Department of Planning and Infrastructure, and DCPL. The Giant Barred Frog Study was prepared in consultation with the former DECCW and approved by the former Secretary of the DPE on the 6 March 2012.

The Giant Barred Frog Study (DCPL, 2012b) outlined methods to gather information on the Giant Barred Frog to address Condition 31, Schedule 3 of PA 08_0203 and Condition 6 of EPBC 2010/5396. Surveys for the Giant Barred Frog Study were undertaken between 2010 and 2011. Since these initial surveys, additional baseline data on the Giant Barred Frog has been collected as described in Section 6.

5.1 SCOPE OF THE GIANT BARRED FROG STUDY

In accordance with Condition 6(b) of EPBC 2010/5396, the Giant Barred Frog Study (DCPL, 2012b) included:

- an assessment of the condition of identified and potential Giant Barred Frog habitat on the MJR and control sites, including the riparian ecosystem condition, stream characteristics (pool, riffles) and water quality 500 m upstream and downstream of the confluence of MJR and Coal Shaft Creek;
- an analysis of the frog populations including tadpoles and any observations of amplexus/ oviposition/egg masses; and
- a determination of the presence of Chytrid fungus within the MJR.

In accordance with Condition 31 Schedule 3 of PA 08_0203, the Giant Barred Frog Study (DCPL, 2012b) included:

- an investigation on the extent of the Giant Barred Frog population in the MJR catchment;
- an assessment of the condition of the Giant Barred Frog habitat where it is recorded within the catchment, including the presence of any Chytrid fungus;
- an analysis of the age structure of the frog population and the health of tadpoles; and
- documentation of the relevant hydrological conditions both prior to and during the study, including rainfall, water flows and quality in MJR, both upstream and downstream of the confluence of MJR and Coal Shaft Creek, and in Coal Shaft Creek.

Habitat assessments for the Giant Barred Frog Study were undertaken between November 2010 and March 2011 as well as between January and March 2011 (within the known breeding season consistent with Condition 6(c) of EPBC 2010/5396) (DCPL, 2012a). The survey methods were consistent with the Department of the Environment, Water, Heritage and the Arts (2010) *Survey Guidelines for Australia's Threatened Frogs* and Department of Environment and Climate Change (DECC) (2009) *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna-Amphibians* (DCPL, 2012b).

5.2 RESULTS FROM THE GIANT BARRED FROG STUDY

A summary of results from the Giant Barred Frog Study (undertaken between 2010 and 2011) are described below (in accordance with Condition 32c, Schedule 3 of PA 08_0203). Additional baseline data on the Giant Barred Frog has been collected since these initial surveys as described in Section 6.

Extent of the Giant Barred Frog Population in the MJR Catchment

Prior to the Giant Barred Frog Study, the Giant Barred Frog was only known from two locations in the MJR Catchment (Figure 3). However, the Giant Barred Frog is more widely distributed within the MJR Catchment than previously thought (Figure 4).

Condition of the Giant Barred Frog Habitat

The Giant Barred Frog Study identified Giant Barred Frog habitat along the MJR and Wards River within the MJR Catchment, as well as along Mill Creek and the Crawford River (within the adjacent catchment). Habitat assessment data is provided in the annual monitoring reports.

Chytrid Fungus

The Giant Barred Frog Study confirmed that Chytrid fungus is present within the MJR. Chytridiomycosis or Frog Chytrid Disease is a highly contagious, highly virulent disease of frogs. The disease has been implicated in the demise of several frog species in Australia as well as being partly or wholly responsible for the decline of many other species. Frog Chytrid Disease is listed as a key threatening process for frogs under the NSW *Threatened Species Conservation Act 1995* and continues to be listed as a key threatening process for frogs under Schedule 4 of the NSW *Biodiversity Conservation Act 2016*.

Age Structure of the Frog Population and the Health of Tadpoles

Survey data for the Giant Barred Frog (including adult frogs and tadpoles) was collected between January to March 2011. The Giant Barred Frog monitoring data is provided in the annual monitoring reports.

Hydrological Conditions

Hydrological conditions (including rainfall, water flows and quality) were documented prior to and during the Giant Barred Frog Study and provided in DCPL (2012a).

Rainfall, maximum and minimum temperature and relative humidity data is available from the on-site weather stations located at the DCM and SMC. A description of the weather conditions experienced during surveys is provided in the annual monitoring reports.

Biosphere Environmental Consultants collected water quality data at the habitat assessment sites from November 2010 to March 2011 using a Yeo-Kal portable water meter. Turbidity, dissolved oxygen content, percent oxygen saturation, oxidation-reduction potential, pH, salinity, conductivity and water temperature were recorded. The results of the water quality sampling is provided in the annual monitoring reports.

Stream water temperatures recorded during the conduct of the nocturnal Giant Barred Frog surveys are also provided in the annual monitoring reports.

5.3 GIANT BARRED FROG LONG-TERM STUDY

Within three months from commencement of the irrigation activities within the DEP irrigation areas, the Giant Barred Frog Study (DCPL, 2012b) was to be reviewed and expanded into a longitudinal study to be implemented until 5 years after the mine ceases to operate (the Giant Barred Frog Long-term Study).

As described in Section 1.4, DCPL did not commence irrigation of the additional irrigation areas approved under the DEP, therefore, the need for preparation of the Long-term Giant Barred Frog Study is not considered to be required. Notwithstanding, the study of the Giant Barred Frog in the MJR has instead provided a unique opportunity to observe and collect meaningful ecological data on an endangered frog species.

DCPL engaged Dr Arthur White in 2023 to prepare a summary paper titled "*A Study of the Giant Barred Frog (Mixophyes iteratus) in the Mammy Johnsons River Catchment"* (Appendix 1). The purpose of this report was to present a collation of the research and monitoring undertaken on the Giant Barred Frog in the MJR catchment and surrounds. It presents the data captured during the surveys from 2010 to 2018. Key findings on the Giant Barred Frog biology, habitat, population and distribution are discussed, including key findings and conclusions.

Dr Arthur White's (2023) *A Study of the Giant Barred Frog (Mixophyes iteratus) in the Mammy Johnsons River Catchment* (White, 2023a) has been included in Appendix 1 of this revised GBFMP and conclusions of the report are stated in Section 1.4.

6 BASELINE DATA

As of March 2023, irrigation in areas approved under PA 08_0203 has not been implemented[6], hence rainfall runoff from the DEP irrigation areas has not presented a potential impact on the Giant Barred Frog population. Consequently, all Giant Barred Frog monitoring data collected during implementation of the Giant Barred Frog Monitoring Program (i.e. between 2010 and 2015) (Section 7) is taken to be baseline data for the purposes of this management plan, and comprises:

- surveys for the DEP EA, undertaken between April 2007 and September 2009 (DCPL, 2010);
- surveys for the Giant Barred Frog Study undertaken between January and March 2011 (DCPL, 2012a);
- Annual monitoring carried out between:
  - September 2011 and March 2012 (Biosphere Environmental Consultants, 2012);
  - September 2012 and March 2013 (Biosphere Environmental Consultants, 2013);
  - October 2013 and January 2014 (Biosphere Environmental Consultants, 2014); and
  - October 2014 and February 2015 (Biosphere Environmental Consultants, 2015).

Note, the first annual monitoring event (i.e. between September 2011 and March 2012) satisfied Condition 7 of EPBC 2010/5396, as it was undertaken between September 2011 and April 2012.

Survey areas were nominated for the first monitoring season (September 2011 – March 2012) in the *Giant Barred Frog Management Plan* (DCPL, 2012a) and these sites were also largely adopted as a basis for the subsequent monitoring seasons. Areas 5 and 6 were not surveyed during the third and fourth monitoring seasons because of lack of frog numbers (Biosphere Environmental Consultants, 2014; 2015). The survey areas and monitoring sites are described in Section 7.1.

The GBFMP monitoring program was revised and approved by the (then) DPE on 17 December 2015 and by the (then) DotE (currently the Commonwealth DCCEEW) on 4 January 2016, which linked commencement of the Giant Barred Frog monitoring program with the commencement of irrigation of the additional irrigation areas approved under the DEP. As described in Section 1, DCPL did not commence irrigation of the additional irrigation areas approved under the DEP.

6.1 GIANT BARRED FROG AND TADPOLE DATA

The baseline surveys have demonstrated that the Giant Barred Frog has a much wider distribution in the catchment and surrounding areas than previously thought (Figures 3 to 5).

The population of Giant Barred Frogs in the MJR catchment vary from year to year, generally in response to environmental conditions (e.g. drought) (Biosphere Environmental Consultants, 2015).

A summary of the Giant Barred Frog baseline population estimates is presented in Table 3. The frogs are in highest concentrations in the middle sections of the MJR Catchment (in Survey Areas 3 and 4, upstream of the DCM). The baseline data presented in **Table 3** is based on a statistical analysis of frog capture data for the 2011 to 2015 monitoring periods.

[6] Irrigation activities at the DCM have ceased. The management of these irrigation areas was assessed and approved as to not present a risk to the Giant Barred Frog population.

Table 3
Giant Barred Frog Population Estimates between Survey Periods

Survey Area*	Location	Monitoring Period			
		2011-2012	2012-2013	2013-2014	2014-2015
1	Located on the Mammy Johnsons River , downstream of the confluence with Coal Shaft Creek (i.e. downstream of the Duralie Coal Mine).	51 (2)	50 (5)	30 (4)	39 (4)
2	Located on the Mammy Johnsons River , upstream of the confluence with Coal Shaft Creek and downstream of an unnamed minor tributary.	53 (3)	67 (5)	44 (4)	26 (5)
3	Located on the Mammy Johnsons River , upstream of the unnamed minor tributary to the confluence with Wards River.	96 (4)	75 (5)	67 (4)	78 (4)
4	Located on the Mammy Johnsons River , upstream of the confluence with Wards River.	110 (4)	125 (5)	88 (4)	128 (4)
7	Located on the Crawford River, outside of the Mammy Johnsons River Catchment.	202 (4)	140 (6)	178 (4)	267 (4)

* Following a review of the Giant Barred Frog monitoring programme in 2013, Dr Arthur White (Biosphere Environmental Consultants) and Ian Lenane (statistician at Gilbert & Associates) concluded that Study Areas 5 and 6 do not warrant further monitoring. A comparatively low number of Giant Barred Frogs have been recorded in these Study Areas and data from Study Area 6 would not be able to be statistically analysed in the way that was originally intended (i.e. to be able to measure and attribute the impact of agriculture to any changes in Giant Barred Frog numbers).

Source: Biosphere Environmental Consultants (2015).

Note: The number in brackets refers to the number of estimates used in deriving the final population number.

The baseline data indicates that MJR supports a viable population of Giant Barred Frogs. The frogs are not evenly distributed across the catchment; they are absent in sections or in low to medium densities in other sections. It is evident from **Table 3** that the lower parts of the MJR (Survey Areas 1 and 2) contain fewer Giant Barred Frogs than equivalent areas further upstream (Survey Areas 3 and 4).

Survey Area 7 (Crawford River) was established to provide comparative data to authenticate (or disprove) climatic impacts on frog populations. Survey Area 7 (Crawford River) supports a higher number of Giant Barred Frogs at densities almost equivalent to those found in Survey Area 4 on the MJR. The frog densities recorded in Survey Areas 4 and 7 are consistent with Giant Barred Frog densities recorded in northern NSW on land unaffected by agriculture similar to Survey Area 7. While more male frogs have been caught than female frogs, the baseline recapture data makes it clear that the two sexes are approximately equal in numbers in each of the survey areas. Male frogs are caught more often as they appear to be active on more nights and are more easily captured when they are calling. Female frogs are less active and do not call (Biosphere Environmental Consultants, 2015).

A total of 73 tadpoles were recorded during the 2012-2013 monitoring period, 56 tadpoles were recorded during the 2013-2014 monitoring period and 18 tadpoles were recorded during the 2014-2015 monitoring period (Biosphere Environmental Consultants, 2013; 2014; 2015). All of the tadpoles captured appeared to be healthy. There were no signs of deterioration of the denticles associated with chytrid fungus (Biosphere Environmental Consultants, 2013 & 2014). The number of tadpoles found is undoubtedly due to the difficulty in locating small tadpoles in a wide and flowing river (Biosphere Environmental Consultants, 2013).

6.2 CONDITION OF THE GIANT BARRED FROG HABITAT

The Giant Barred Frog population in the MJR catchment is subject to a range of impacts unrelated to the DCM, many arising from the past and current agricultural uses of the river and the surrounding land. Biosphere Environmental Consultants (2014), describes the observable impacts on the Giant Barred Frogs as habitat loss through land clearing, current or past agricultural practices, changes to river flow patterns and changes in the frequency of flash flooding, cattle trampling of riparian ground cover vegetation, cattle trampling of frogs and addition of agricultural chemicals to the river. Invasive weeds and predatory feral species (such as foxes and pigs) are also prevalent (Biosphere Environmental Consultants, 2014).

In relation to the condition of the Giant Barred Frog habitat downstream of the mine, Biosphere Environmental Consultants (2014) states:

> *The deep scoring of the middle and lower sections of the Mammy Johnsons River (Survey Areas 1, 2 and 3) has removed pool and backwaters from the water course creating a single, deep channel that is prone to sudden rises and drops in water level. The surging nature of the river under these conditions makes the survival of Giant Barred Frog tadpoles in the lower and middle Mammy Johnsons River (including Survey Areas 1 and 2, near the Duralie Coal Mine) very difficult.*

6.3 HYDROLOGICAL CONDITIONS AND WATER QUALITY

An overview of the local and regional hydrology is provided in Section 4. Baseline data on the hydrological conditions of the MJR was continually monitored in accordance with the DCM WMP. The hydrological parameters listed in **Table 4** are monitored.

Table 4
Hydrological Data Sources

Parameter	Description
Stream flow data	Stream flow data is available for the gauging station located at Pikes Crossing* (GS209002) on the Mammy Johnsons River from 1973 onwards.
Rainfall, maximum and minimum temperature and relative humidity data	Rainfall, maximum and minimum temperature and relative humidity data is available from the on-site weather stations located at the Duralie Coal Mine and Stratford Mining Complex.
Surface water quality data	Surface water quality data is available for the Mammy Johnsons River, Karuah River, Coal Shaft Creek and other tributaries of the Mammy Johnsons River. This included data recorded by continuous electrical conductivity (EC) sensors/loggers on the Mammy Johnsons River and its tributaries.

* The gauging station site is referred to by OEH (now CPHR) as Pikes Crossing. Pikes Crossing is known by DCPL as Mavis Tersteeg Crossing.

Biosphere Environmental Consultants (2012; 2013; 2014) collected water quality data at the habitat assessment sites using a Yeo-Kal portable water meter. Turbidity, dissolved oxygen content, percent oxygen saturation, oxidation-reduction potential, pH, salinity, conductivity and water temperature were recorded (Biosphere Environmental Consultants, 2012; 2013; 2014).

A detailed description of the ongoing water quality monitoring program is provided in the DCM WMP.

7 GIANT BARRED FROG MONITORING PROGRAM

A monitoring program was established to assess the impacts of rainfall runoff from the DEP irrigation areas on the Giant Barred Frog population on the MJR, in areas immediately downstream of the irrigation areas, in the event irrigation of these areas were to commence.

The results of the Giant Barred Frog Study (DCPL, 2012a) and baseline monitoring surveys have been used to inform the Giant Barred Frog monitoring requirements upon commencement of irrigation on the DEP irrigation areas. This includes an analysis of all monitoring data acquired up to and including the 2014-2015 annual monitoring survey and consideration of future potential initiation of irrigation on the DEP irrigation areas to inform the survey effort, intensity and duration required to monitor and assess rainfall runoff impacts on the Giant Barred Frog from these irrigation areas.

The timing and frequency of monitoring was to be triggered upon commencement of irrigation within the DEP irrigation areas. The monitoring program was to be reviewed subsequent to each September to March survey period (i.e. the breeding season) following the application of mine water onto these irrigation areas.

As described in Section 1, DCPL did not commence irrigation of the irrigation areas approved under the DEP, and does not intend to do so during mine closure, noting the DCM's irrigation system has been decommissioned and removed.

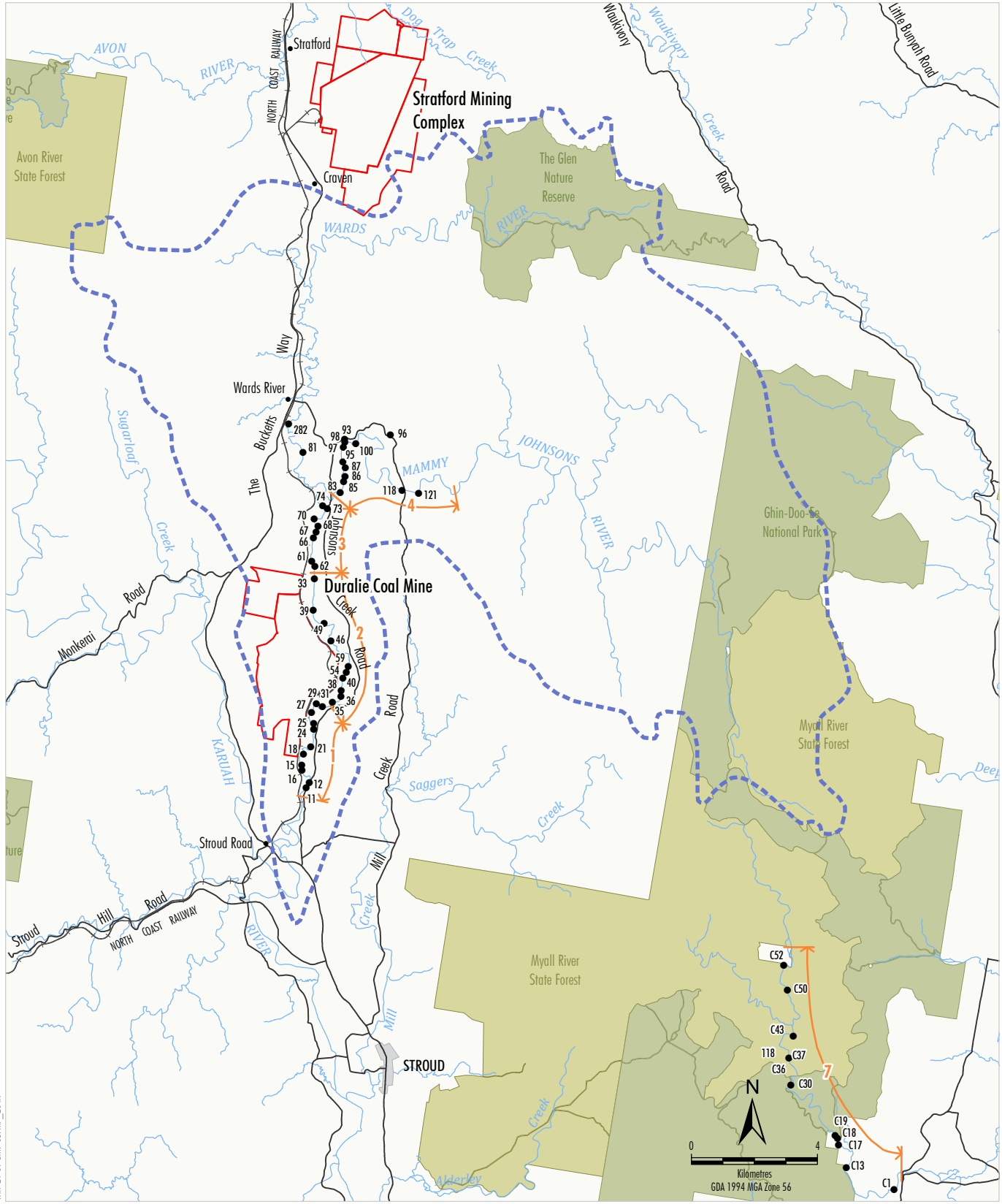
7.1 SURVEY AREAS AND MONITORING SITES

Survey areas and monitoring sites are listed in **Tables 3** and **5** and shown on Figure 6.

Table 5
Giant Barred Frog Survey Area and Monitoring Sites

Survey Area*	Location	Number of Monitoring Sites (Figure 6)	Survey Area Type	Frequency
1	Located on the Mammy Johnsons River, downstream of the confluence with Coal Shaft Creek (i.e. downstream of the Duralie Coal Mine).	10 (11, 12, 15, 16, 18, 21, 24, 25, 27, 31)	Potential impact survey area.	4 nights on 4 occasions during the breeding season (October to March)
2	Located on the Mammy Johnsons River, upstream of the confluence with Coal Shaft Creek and downstream of an unnamed minor tributary.	10 (29, 33, 35, 36, 38, 39, 40, 46, 54, 59)	Potential impact survey area.	4 nights on 4 occasions during the breeding season (October to March)
3	Located on the Mammy Johnsons River, upstream of the unnamed minor tributary to the confluence with Wards River.	10 (61, 62, 66, 67, 68, 70, 73, 74, 81, 96)	Upstream 'control' survey area.	3 nights on 4 occasions during the breeding season (October to March)
4	Located on the Mammy Johnsons River, upstream of the confluence with Wards River.	10 (282, 83, 85, 86, 87, 95, 98, 100, 118, 121)	Upstream 'control' survey area.	3 nights on 4 occasions during the breeding season (October to March)
7	Located on the Crawford River, outside of the Mammy Johnsons River Catchment.	10 (C1, C13, C17, C18, C19, C30, C36, C37, C50, C52)	Survey Area 7 was established to provide comparative data to authenticate (or disprove) climatic impacts on frog populations.	3 nights on 4 occasions during the breeding season (October to March)

* Following a review of the Giant Barred Frog monitoring programme in 2013, Dr Arthur White (Biosphere Environmental Consultants) and Ian Lenane (statistician at Gilbert & Associates) concluded that Study Areas 5 and 6 do not warrant further monitoring. A comparatively low number of Giant Barred Frogs have been recorded in these Study Areas and data from Study Area 6 would not be able to be statistically analysed in the way that was originally intended (i.e. to be able to measure and attribute the impact of agriculture to any changes in Giant Barred Frog numbers).



YAN-21-37 DMP GBFMP_204A

LEGEND

- Mining Lease Boundary
- National Park, Nature Reserve or State Conservation Area
- NSW State Forest
- Mammy Johnsons River Catchment Boundary (approximate)
- Monitoring Area
- Monitoring Site

Source: Spatial Services NSW (2022)

DURALIECOAL
Part of the Yancoal Australia Group

GIANT BARRED FROG MANAGEMENT PLAN

Giant Barred Frog Survey Area and Monitoring Sites

Figure 6

7.2 SURVEY TIMING AND FREQUENCY

The Giant Barred Frog monitoring program was planned to begin in the breeding season following commencement of the irrigation activities within the DEP irrigation areas (Figure 7), in the event irrigation of these areas were to commence. However, irrigation of these areas did not commence. Instead, annual baseline monitoring studies were undertaken from 2011 to 2015.

Survey Areas 1 and 2 (potential impact survey areas) were monitored over four nights on four occasions during the breeding season (October to March) (Table 5). Survey Areas 3, 4 and 7 were monitored over three nights on four occasions during the breeding season (October to March) (Table 5). Where practicable, the surveys were not conducted during periods of heavy rainfall or significant stream flow. Weather conditions were recorded prior to and during the surveys as described in Section 7.5.

7.3 SURVEY METHODS

The survey methods that were used for the Giant Barred Frog monitoring program are consistent with the Department of the Environment, Water, Heritage and the Arts (2010) *Survey Guidelines for Australia's Threatened Frogs* and DECC (2009) *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna-Amphibians*. The monitoring program included nocturnal frog surveys and diurnal tadpole surveys as described below.

Personnel conducting amphibian surveys on behalf of DCPL or personnel undertaking any other work within known Giant Barred Frog habitat and where there is potential for transport of Chytrid Fungus observed appropriate hygiene protocols in accordance with the NPWS (2008) *Hygiene Protocols for the Control of Disease in Frogs* and the OEH (2006) *Threat Abatement Plan for infection of amphibians with chytrid fungus resulting in chytridomycosis.*

Nocturnal Frog Surveys

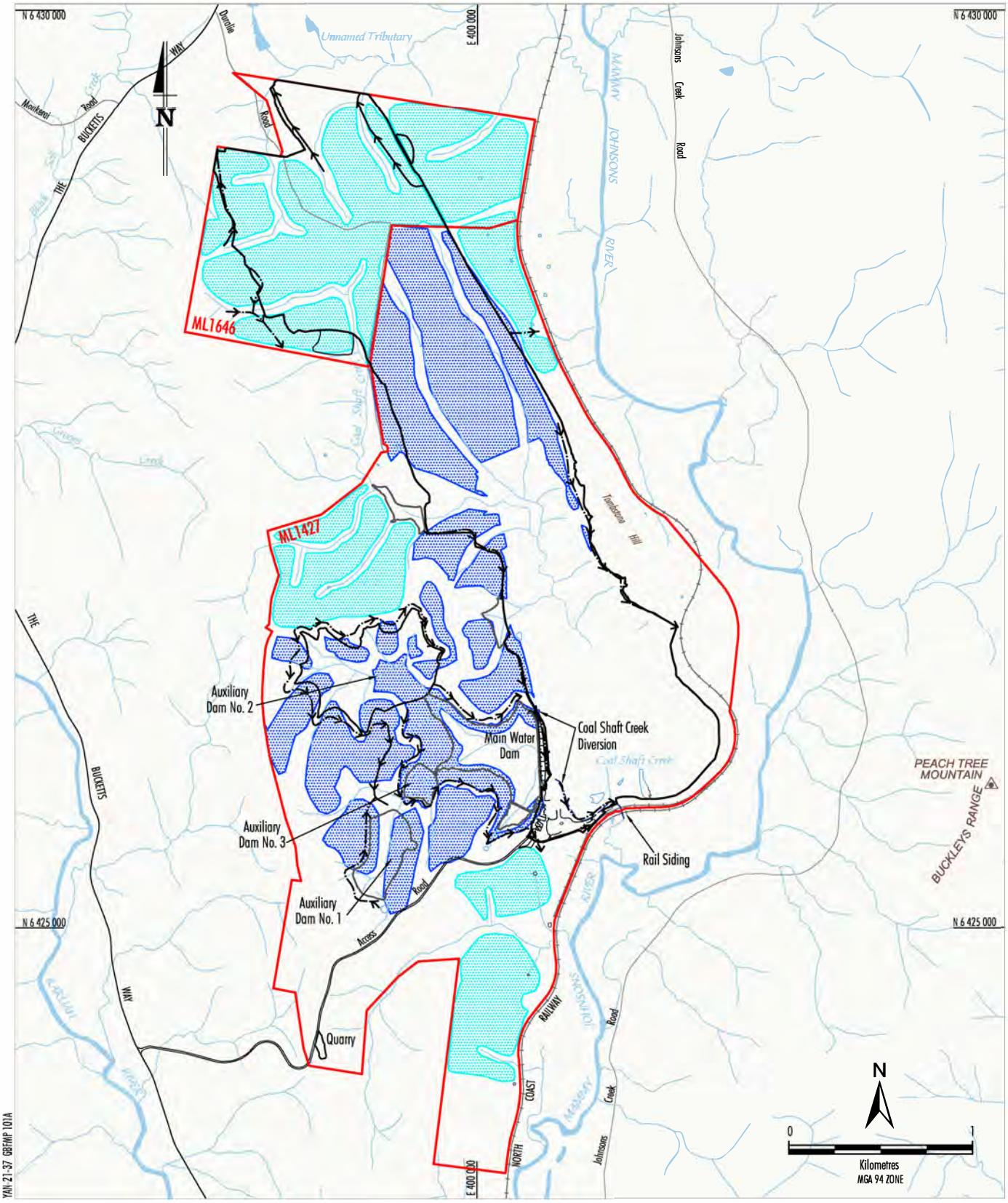
A 200 m transect was used to monitor the Giant Barred Frog monitoring sites. Each 200 m stream bank transect was surveyed by two personnel. The survey included 30 minutes per 200 m length (i.e. the total search time per site will be 1 person hour).

Upon arrival at each transect, the surveyors listened for three minutes and recorded all calling frogs. The surveyors then moved slowly through the transect area using headlamps to detect calling and non-calling Giant Barred Frogs. Call imitation was used at the start, near the middle and at the end of each transect to try to elicit calling by male Giant Barred Frogs.

Any Giant Barred Frogs detected were caught if possible. Captured frogs were:

- sexed (i.e. male or female);
- if female, examined to determine if the frog is gravid;
- classified as adult, sub-adult or juvenile;
- weighed (using spring balances);
- measured for snout-vent length (using dial callipers) and classified using a growth index, as described in Tables 6 and 7;
- micro-chipped[7];
- visually inspected for signs of injury or disease;
- swabbed for Chytrid testing; and
- released at the site of capture.

[7] Only individuals classified as adults or sub-adults will be micro-chipped.



LEGEND

- Mining Lease Boundary
- Approximate Extent of Approved Major Surface Development
- Up-catchment Water Diversion
- Approximate Extent of Existing/Approved* Irrigation Areas
- Additional Irrigation Areas Approved Under The Duralie Extension Project

*Irrigation Management Plan (2008)

Source: Department of Lands (May 2009) and DCPL (2009)

Note: As a result of operational changes at the DCM, the requirement for, and the requirements of, the DCM Irrigation Management Plan are no longer relevant to the DCM and the plan is now redundant.

DURALIECOAL

GIANT BARRED FROG MANAGEMENT PLAN

Irrigation Areas

Figure 7

Table 6
Growth Index for Giant Barred Frog Tadpoles

Growth Index Category	Growth Stages	External Features	Age (Approximate Only)
A	1-23	Cornea transparent; external gills present	1-10 days
B	24-25	Cornea pigmented, no limb buds	10-20 days
C	26-42	Hind limbs present	20-120 days
D	43-46	Fore limbs present	80-300 days

Table 7
Growth Index for Giant Barred Frog Juveniles and Adults

Growth Index Category	Snout-Vent Length Ranges (cm)
E	3-5
F	>5-7
G	>7-9
H	>9

Observations of behaviours including amplexus, oviposition and egg masses were also noted.

In addition, each survey recorded an estimate of the number of calling males at each site (both banks).

Other species of non-target riparian frogs were also recorded including an estimate of the number of individuals of each species.

Each site was surveyed over three nights (during the same survey period).

Diurnal Tadpole Surveys

Diurnal tadpole surveys were also undertaken at each Giant Barred Frog monitoring site. Ten sweeps using a long-handled net on one occasion during the survey period was used to sample the water along the stream bank for tadpoles.

Tadpoles caught in the sweeps were:

- measured for snout-vent length (using dial callipers);
- classified using a growth index (as described in Tables 6 and 7);
- visually inspected for external signs of injury (e.g. from fish or bird attack); and
- inspected using a magnifying glass to assess the condition of their buccal disc and denticles, including the possible early stages of Chytrid infection.

All tadpoles were released at the site of capture.

During the diurnal tadpole surveys, observations of behaviours including amplexus, oviposition and egg masses were also noted.

7.4 CONDITION OF THE GIANT BARRED FROG HABITAT

Habitat attributes recorded at each Giant Barred Frog monitoring site included stream characteristics (e.g. stream width, stream depth, flow rate, the presence of pools and riffles), water quality observations (e.g. clarity and presence of algae), stream bank characteristics (e.g. profile, composition, vegetation cover and litter depth) and potential impacts (e.g. siltation/clearing, pollution sources and introduced species).

The Giant Barred Frog monitoring program used the habitat assessment results compiled to date to assess changes in habitat at each site at the time of the surveys. Where a habitat assessment was not been completed for a particular site, a habitat assessment was conducted.

7.5 HYDROLOGICAL CONDITIONS

The hydrological conditions of the MJR were documented prior to and during the Giant Barred Frog monitoring surveys[8]. In summary, this included:

- rainfall, maximum and minimum temperature and relative humidity data obtained from the on-site weather stations located at the DCM and SMC;
- a description of the weather and stream flow conditions experienced during each survey;
- stream flow monitoring data from Gauging Station 209002 and at the 'High Noon' site on the MJR;
- surface water quality data for the MJR, Karuah River, Coal Shaft Creek and other tributaries of the MJR including data from continuous EC sensors/loggers on MJR and on tributaries of the MJR;
- the measurement of turbidity, dissolved oxygen content, percent oxygen saturation, oxidation-reduction potential, pH, salinity, conductivity and water temperature at the Giant Barred Frog monitoring sites using a Yeo-Kal portable water meter during the conduct of the tadpole surveys; and
- the measurement of water temperature during the nocturnal Giant Barred Frog monitoring surveys.

[8] A report outlining the results of the surveys (including hydrological conditions of the MJR of relevance to the Giant Barred Frog) will be provided to CPHR should the monitoring program recommence.

8 ASSESSMENT OF PERFORMANCE INDICATORS AND MEASURES

In accordance with Conditions 32(f) and 32(d), Schedule 3 of PA 08_0203 and Conditions 8 (c) and (d) of EPBC 2010/5396, DCPL has:

- developed performance indicators (triggers) to monitor the potential impact of rainfall runoff from the DEP irrigation areas (in the event of commencement of irrigation) on the local frog population; and
- established performance measures to evaluate the impact of rainfall runoff from the DEP irrigation areas (in the event of commencement of irrigation) on the local Giant Barred Frog population.

DCPL committed to assessing the use of irrigation and management of rainfall runoff associated with the DEP irrigation areas (in the event of commencement of irrigation) against the Giant Barred Frog performance indicators and measures outlined in Table 8.

Table 8
Summary of Project Giant Barred Frog Performance Indicators and Measures

Project Performance Measure	Project Performance Indicators [3, 4]
The Project will have no more than a negligible[1] impact on the local Giant Barred Frog population[2].	*Negligible change in the sub-population of the Giant Barred Frog downstream of the irrigation rainfall runoff areas following the commencement of the expanded irrigation when compared to sub-populations recorded in areas not subject to irrigation rainfall runoff.* *The sub-population of the Giant Barred Frog downstream of the irrigation rainfall runoff areas following commencement of the expanded irrigation activities is similar to the age class structure and population profile, or has enhanced proportions of sub-adult and young adult frogs present (i.e. the sub-population is not becoming senescent) prior to the commencement of the expanded irrigation activities.* *Juvenile and sub-adult recruitment rates are similar or are improved for the sub-population of the Giant Barred Frog downstream of the irrigation rainfall runoff areas following the commencement of expanded irrigation activities.*

1 The term 'negligible' is defined in PA 08_0203 as small and unimportant, such as to be not worth considering.

2 This performance measure is consistent with the requirement of Condition 30, Schedule 3 of PA 08_0203.

3 The 'irrigation rainfall runoff areas' are represented by sites on the MJR that are situated downstream of locations at which rainfall runoff from the mine's irrigation areas enters the MJR (i.e. sites downstream of the MJR - Coal Shaft Creek confluence, and as mining develops, at sites downstream of the MJR - unnamed tributary confluence, Figure 7).

4 The 'expanded irrigation' means the expansion of mine water irrigation associated with the DEP (i.e. the commencement of irrigation in areas that are additional to those approved at the DCM prior to the receipt of the DEP approval).

As described in Section 7, monitoring of the Giant Barred Frog population has been conducted to monitor the potential impact of the DEP irrigation areas on the Giant Barred Frog population and whether a greater than negligible impact on the Giant Barred Frog population has occurred as a result of rainfall runoff from these irrigation areas, in the event that irrigation of the DEP irrigation areas commenced.

The monitoring results were used to assess the DEP against the performance indicators and performance measures detailed in Table 9. If data analysis indicated a performance indicator had exceeded a trigger level, an assessment was to be made against the performance measure. If the Giant Barred Frog performance measure was considered to have been exceeded, the Contingency Plan would have been implemented (Section 10). DCPL implemented suitable contingency measures (Section 10) and continued to monitor (Section 7). If data analysis indicated that the performance measure had not been exceeded, DCPL would have reviewed the monitoring requirements.

Table 9
Monitoring Against Performance Indicators and Measures

Performance Measure	Environmental Monitoring			Data Analysis to Assess against Performance Indicator(s)	Performance Indicator(s)	Trigger Level (Performance Indicator Exceedance)	Assessment of Performance Measure	Relevant Management and Contingency Measures
	Sites	Parameters	Frequency					
No more than a negligible impact on the local Giant Barred Frog population associated with rainfall run-off from Duralie Extension Project irrigation areas, in the event that irrigation of the Duralie Extension Project irrigation areas were to commence.	• Sites on the Mammy Johnsons River, downstream of the Coal Shaft Creek – Mammy Johnsons River confluence (i.e. downstream of the Duralie Extension Project southern irrigation areas – Survey Area 1). • Sites on the Mammy Johnsons River, upstream of the confluence with Coal Shaft Creek and downstream of the confluence with the unnamed tributary (i.e. downstream of the Duralie Extension Project northern irrigation areas – Survey Area 2).	• Mark-recapture (i.e. micro-chip) data, along 200 m transects.	• Nocturnal frog surveys - each site surveyed over three nights during the same survey period. Four sampling periods within the period September to March.	• Use of population techniques to estimate the size of the Giant Barred Frog population (e.g. the model POPAN in the program MARK, Lincoln-Peterson Index or other suitable estimation technique).	• 20% decline (accounting for natural variation) in the sub-population of the Giant Barred Frog downstream of the irrigation rainfall runoff areas following the commencement of the Duralie Extension Project expanded irrigation when compared statistically to the baseline data for these sub-populations and control site sub-populations (i.e.in areas not subject to irrigation rainfall runoff).	• This performance indicator will be considered to have been exceeded if data analysis indicates a greater than 20% decline (accounting for natural variation) in the Giant Barred Frog sub-population downstream of the confluence of Mammy Johnsons River and Coal Shaft Creek (and adjacent riparian areas), when compared statistically to the baseline data for these sub-populations and control site sub-populations (i.e. in areas not subject to irrigation rainfall runoff). • If data analysis indicates the performance indicator has been exceeded, an assessment will be made against the performance measure.	• The performance measure, the Project will have *no more than a negligible impact on the local Giant Barred Frog population*, will be assessed by considering the changes in the Giant Barred Frog sub-populations. Key assessment considerations in determining whether the Project has had a greater than negligible impact on the local Giant Barred Frog population will include: - whether the change is due to the monitoring results obtained at one site or a number of sites, and the potential influence of the mine's irrigation activities on these sites; - whether the change is consistent across all sampling sites or limited to sites upstream or downstream of Project irrigation activities; - a review of electrical conductivity data including upstream and downstream of Project irrigation activities; - a review of the site irrigation activities undertaken; - consideration of the meteorological conditions prevailing and preceding the monitoring surveys; and - consideration of other significant events that may have an influence on the Giant Barred Frog population (e.g. agricultural activities). • The performance measure will be considered to have been exceeded if analysis of the monitoring results indicates that the Project has resulted in a greater than negligible impact on the local Giant Barred Frog population. • The results will be reported to DPHI. • If the performance measure has been exceeded, the Contingency Plan will be implemented (Section 10).	• Additional monitoring (e.g. increase in monitoring frequency or additional sampling) and statistical analysis (where required) to confirm an exceedance of the performance indicator and that it is associated with rainfall run-off from the Duralie Extension Project irrigation areas. • Adaptive management – modification of irrigation management and/or first flush irrigation water salinity levels. • Investigation of offsets.
		• Snout-vent length measurements of captured frogs (using dial callipers).	• Nocturnal frog surveys - each site surveyed over three nights during the same survey period. Four sampling periods within the period September to March each year.	• Analysis of the age structure of the Giant Barred Frog population using a growth index (described in Tables 6 and 7).	• The sub-population age class structure of the Giant Barred Frog downstream of the Duralie Extension Project irrigation rainfall runoff areas following commencement of the expanded irrigation activities in these areas is statistically similar to the age class structure and population profile, or has enhanced proportions of sub-adult and young adult frogs present (i.e. the sub-population is not becoming senescent), prior to the commencement of the expanded irrigation activities.	• This indicator will be considered to have been exceeded if data analysis over two consecutive survey seasons indicates the sub-population of the Giant Barred Frog is not statistically similar (within 20%) to the age class structure and population profile, or has reduced proportions of sub-adult and young adult frogs present (i.e. the sub-population appears to be becoming senescent) after the commencement of the expanded irrigation activities. • If data analysis indicates the performance indicator has been exceeded, an assessment will be made against the performance measure.	
		• Classification of captured frogs as adult, sub-adult or juvenile.	• Nocturnal frog surveys - each site surveyed over three nights during the same survey period. Four sampling periods within the period September to March each year.	• Analysis of the occurrence of adults, sub-adults and juveniles in the Giant Barred Frog population.	• Juvenile and sub-adult recruitment rates are statistically similar or are improved for the sub-population of the Giant Barred Frog downstream of the Duralie Extension Project irrigation rainfall runoff areas following the commencement of expanded irrigation activities in these areas.	• This indicator will be considered to have been exceeded if data analysis over two consecutive survey seasons indicates a statistically significant reduction (20%) in juvenile and sub-adult recruitment rates for the sub-population of the Giant Barred Frog downstream of the irrigation rainfall runoff areas following the commencement of expanded irrigation activities. • If data analysis indicates the performance indicator has been exceeded, an assessment will be made against the performance measure.	

9 MANAGEMENT MEASURES

9.1 MAMMY JOHNSONS RIVER WATER QUALITY

Water quality data obtained to date shows that the irrigation of areas approved under DA 168/99 have not resulted in an increase in downstream salinity concentrations (i.e. EC concentrations) in Coal Shaft Creek or the MJR, nor deterioration in water quality in either waterway.

Notwithstanding, expansion of irrigation into the DEP irrigation areas would have had the potential to result in an increase in salinity concentrations in the MJR (via re-mobilisation of irrigated solutes in rainfall runoff), in the event that irrigation of the DEP irrigation was to commence.

9.1.1 Site Water Management

Water stored on-site includes groundwater inflows to the open pit and incident rainfall and runoff from mine disturbance areas. Water from sumps in the open pit is pumped to the Main Water Dam. This dam (and others) is also used to store water collected from selected sediment dams and runoff from the main infrastructure area.

The DCM historically required the water management system to dispose of excess water through on-site irrigation. However, as described in Section 1.4, irrigation activities for the purpose of reducing the total site water inventory at the DCM have now ceased and the DCM's Irrigation Area irrigation system has been decommissioned and removed.

Due to the change in operations at the DCM as outlined in Section 1.4, DCPL has revised the WMP to reflect the changes to the DCM water management system and to describe the redundancy of the IMP. The revised WMP was approved by DPHI and the Commonwealth DCCEEW on 24 December 2021. Subject to approval of the revised WMP, DCPL has revised this GBFMP accordingly.

9.1.2 Irrigation System

Irrigation activities at the DCM have now ceased. As a result of closure, the requirement for, and the requirements of, the DCM IMP are no longer relevant to the DCM and the plan is now redundant. The updated DCM IMP (outlining its redundancy) was approved by DPHI on 24 December 2021.

9.2 OFFSET STRATEGY

In accordance with DCPL's commitments in the DEP EA (DCPL, 2010), Conditions 33 to 39, Schedule 3 of PA 08_0203 and Conditions 13 to 16 of EPBC 2010/5396, an Offset Strategy has been implemented for the Project. The management of the Offset areas (Figure 8) is described within the DCM Biodiversity Management Plan (BMP).

9.3 WEED CONTROL

Weed species are effective competitors for resources and have the potential to invade the habitat of the Giant Barred Frog.

Weed management measures to be implemented for the Project are described in the BMP.

Weed control measures will be implemented by DCPL within the mining lease and Offset area to limit the spread and colonisation of weeds, including:

- identification of weeds via regular site inspections and communication with leases and regulatory authorities;
- irrigation areas will be managed such that a vegetation cover is maintained as much as possible to suppress the establishment of weeds;
- mechanical removal of identified weeds and/or the application of approved herbicides in authorised areas;
- control of priority weeds as required under the general biosecurity duty of the *NSW Biosecurity Act 2015* and NSW Department of Primary Industries requirements;
- follow-up inspections to assess the effectiveness of the weed management measures implemented and the requirement for any additional management measures; and
- minimisation of seed transport from the site through the use of the site's vehicle wash bay.

With regards to weed management measures, physical removal and chemical application are the main weed control methods available. Due to the potential adverse impacts of herbicides on amphibians, weed control methods implemented at the mine will be restricted to mechanical removal and/or "environmentally friendly" products.

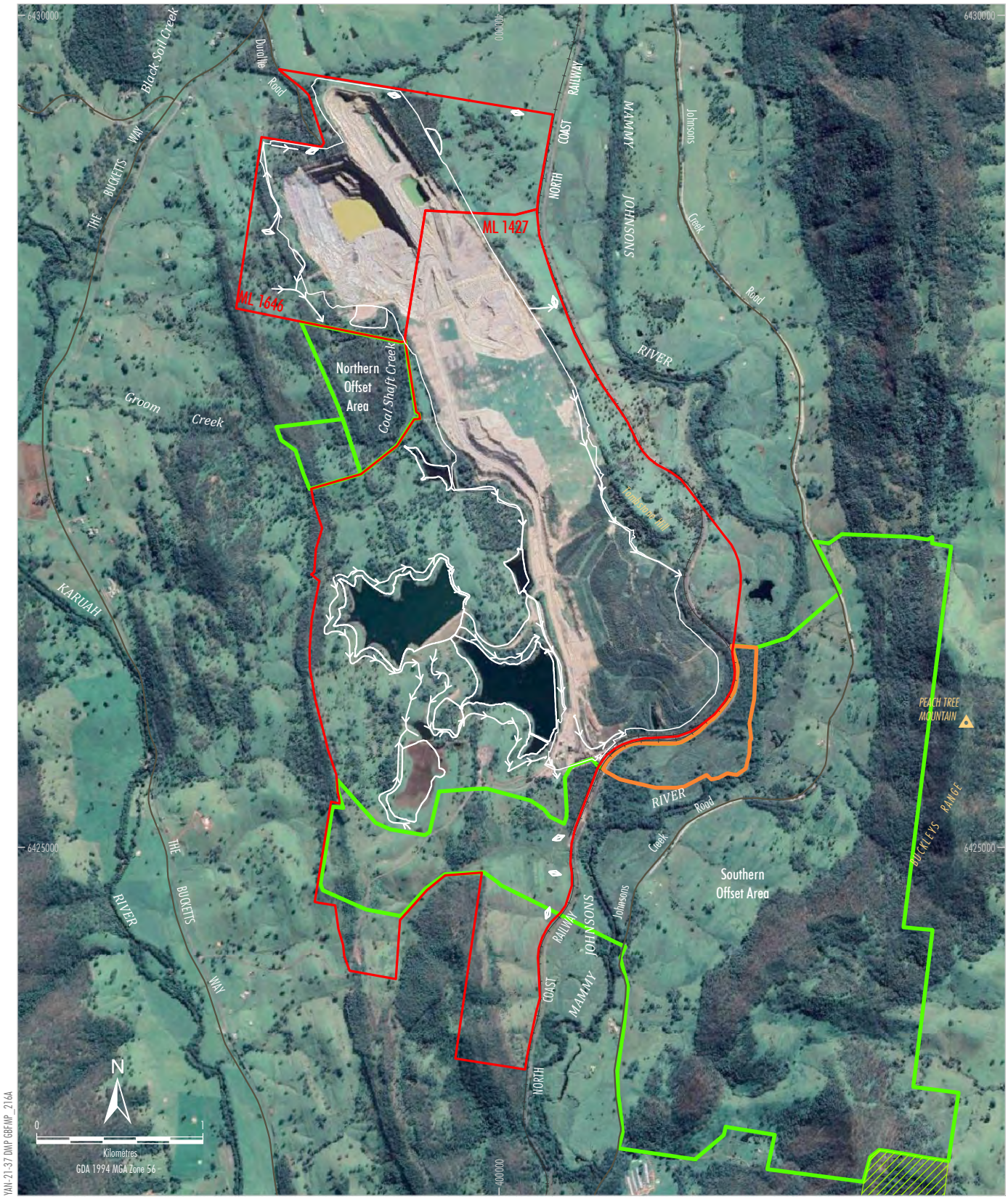
In areas in and immediately adjacent to the MJR, a herbicide registered for use in aquatic situations by the National Registration Authority will be used for the control of weeds where physical control methods are not suitable. The National Registration Authority registration is indicated on the label of the herbicide.

The implementation of alternate measures that favour the restoration of healthy native vegetation is also considered an effective method of weed management. The use of mechanical slashers and other such machinery may be used to control weeds in an effective manner. The use of weed removal machinery available to DCM now and in the future shall be assessed on a case by case basis appropriate to the area in question in consultation with Dr Arthur White (or another suitably qualified person) as slashers and other mechanical removal devices also pose the risk of injuring sheltering frogs in leaf litter.

Following the redundancy of the GBFMP, weed control management measures that relate to reducing ongoing risks to the Giant Barred Frog, including weed removal machinery and herbicide application conditions, would be incorporated as management measures within the DCM BMP as part of the next BMP revision/update.

Other methods of weed control which may be utilised by the mine in appropriate areas in consultation with Dr Arthur White (or another suitable qualified person), may include activities such as crash/pulse grazing and the use of fire for burning off areas of vegetation and areas which are heavily infested by weeds.

Weed management activities are reported in the Annual Review (Section 11).



LEGEND

- Mining Lease Boundary
- Approximate Extent of Existing/Approved Surface Development
- Existing/Approved First Flush Protocol Pump Back System
- Existing/Approved Up-catchment Diversion System
- Private Land Under Conservation Agreement
- Offset Area
- Bowens Road North Offset Area

Source: © NSW Spatial Services (2019)
Orthophoto: Google Earth CENS/Airbus (2020)

DURALIECOAL
Part of the Yancoal Australia Group

GIANT BARRED FROG MANAGEMENT PLAN

Location of the Offset Areas

Figure 8

9.4 PEST CONTROL

Some animal pests have the potential to impact on the habitat of the Giant Barred Frog or through predation. Pest management measures to be implemented for the Project are described in the BMP.

Pest control measures have been implemented by DCPL within the MLs and offset area to minimise impacts of pest species, including:

- regular property inspections to assess the status of pest populations;
- implementation of pest control measures as required (e.g. the destruction of rabbit burrows, baiting of foxes, trapping of feral cats);
- follow-up inspections following the conduct of pest control measures to assess the effectiveness of the control measures and the requirement for any additional control measures; and
- maintenance of a clean, rubbish-free environment, in order to discourage scavenging and reduce the potential for colonisation of areas by non-endemic fauna.

Pest management activities are reported in the Annual Review (Section 11).

9.5 BUSHFIRE MANAGEMENT

Bushfire has the potential to impact on streamside habitats of the Giant Barred Frog, including the availability of moist leaf-litter. Bushfire management measures to be implemented for the Project are described in the BMP.

In the case of a bushfire incident, the NSW Rural Fire Service (RFS) will be called upon as the primary response unit to contain, fight and manage bushfires. DCM personnel may provide secondary support roles, services and equipment where requested by the RFS and where practical as approved by the sites Operations Manager.

To reduce the risk of bushfire, management measures at the DCM will include:

- Controlled grazing – cattle will be grazed on portions of ML 1427 and ML 1646 upon which active mining operations are not occurring and appropriate fencing is available. Sustainable stocking levels result in minimal pasture presence and hence low residual fuel loads. It is noted that the use of cattle may impose habitat damage and potential injury or death to the Giant Barred Frog through destruction of riparian zones and trampling. This risk is addressed in Section 6.6 of the DCM BMP, which provides for the exclusion of livestock from the riparian corridor along the MJR.
- Hazard reduction burns of vegetation (including weeds) or mechanical slashing in areas where controlled grazing is not possible or appropriate and fuel loads are high, hazard reduction burns may be undertaken. It is noted that burning has potential to harm or increase the mortality of Giant Barred Frogs sheltering in leaf litter. Accordingly, where burning is used, it would be controlled to maintain a “low intensity” burn and excluded from areas of known Giant Barred Frog shelter sites.
- Fire fighting equipment – in the case of a bushfire incident, the RFS will be called upon as the primary response unit to contain, fight and manage bushfires. The RFS, if required, may be assisted by mine personnel and mine resources on the approval of the mines Operation Manager.
- DCPL personnel will assist the RFS with providing access as required to fight fires on the ML, biodiversity offset area and mine owned property.
- Access tracks/firebreaks are to be maintained to ensure free access at all times.

Following the redundancy of the GBFMP, bushfire management measures that relate to reducing ongoing risks to the Giant Barred Frog, including exclusion of cattle crash grazing and backburning in riparian zones, would be incorporated as management measures within the DCM BMP as part of the next BMP revision/update.

9.6 HYGIENE PROTOCOLS

Infection of frogs by amphibian chytrid fungus causing the disease Chytridiomycosis is listed as a key threatening process under the NSW *Biodiversity Conservation Act 2016* and EPBC Act. A water-borne fungal pathogen *Batrachochytrium dendrobatidis*, commonly known as the amphibian or frog chytrid fungus, is responsible for the disease Chytridiomycosis (Berger *et al.*, 1999). Chytridiomycosis has been detected in over 40 species of native amphibians in Australia (Mahony and Werkman, 2000 in NPWS, 2008).

Infection occurs through water-borne zoospores released from an infected amphibian in water (NPWS, 2008). Collection and handling of frogs and inadvertent transport of infected material between frog habitats may also promote the disease's spread (NSW Scientific Committee, 2003).

Personnel conducting amphibian surveys for DCPL or personnel undertaking any other work within known Giant Barred Frog habitat and where there was potential for transport of Chytrid Fungus were required to observe the following hygiene protocols in accordance with the Hygiene Protocols for the Control of Disease in Frogs (NPWS, 2008):

- thorough cleaning and disinfecting of footwear;
- thorough cleaning and disinfecting of equipment (such as nets, callipers, headlamps and waders);
- wearing new disposable gloves (wetted previously) when handling every frog; and
- where necessary, cleaning of vehicle tyres in high-risk areas.

All personnel were trained in site hygiene management prior to working in areas of known Giant Barred Frog habitat.

9.7 PROTOCOL FOR SICK OR DEAD FROGS

As described in Section 7, the Giant Barred Frog monitoring program has been conducted by a qualified ecologist (Dr Arthur White).

Table 10 details the range of symptoms that may be exhibited by sick or dying frogs, while Table 11 provides diagnostic behaviour tests which can be used to determine if a frog is sick (NPWS, 2008).

Table 10
Symptoms of Sick and Dying Frogs

Appearance	Behaviour
• Darker or blotchy upper (dorsal) surface. • Reddish/pink-tinged lower (ventral) surface and/or legs and/or webbing or toes. • Swollen hind limbs. • Very thin or emaciated. • Skin lesions (sores, lumps). • Infected eyes. • Obvious asymmetric appearance.	• Lethargic limb movements, especially hind limbs. • Abnormal behaviour (e.g. a nocturnal burrowing frog sitting in the open during the day and making no vigorous attempt to escape when approached). • Little or no movement when touched.

Table 11
Diagnostic Behaviour Tests

Sick frogs will fail one or more of the following tests:		
Test	**Healthy**	**Sick**
• Gently touch with finger. • Turn frog on its back. • Hold frog gently by its mouth.	• Frog will blink. • Frog will flip back over. • Frog will use its forelimbs to try to remove grip.	• Frog will not blink above the eye. • Frog will remain on its back. • No response from frog.

In the event a frog appeared to be sick or dead, the guidelines contained in NPWS (2008) *Hygiene Protocols for the Control of Disease in Frogs* (NPWS, 2008) were followed. In summary:

- Disposable gloves were worn when handling sick or dead frogs. When gloves are unavailable an instrument can be used to transfer the frog to a container rather than using bare hands.
- To prevent cross-contamination, new gloves and a clean plastic bag was used for each frog specimen.
- Frogs considered unlikely to survive transportation (i.e. death appears imminent) were euthanised. Dead frogs were kept cool and preserved as soon as possible.
- The recipient of the sick or dead frog was contacted to confirm the appropriate procedure prior to transport.
- Containers were labelled and provided the following details: date, location and species (if known).
- A standardised collection form was filled out and a copy sent with the specimen.
- Individual containers were used for each specimen.

9.8 POST-MINING PROPERTY MANAGEMENT

Dr Arthur White's review of the GBFMP (White, 2023b) (provided in Appendix 2) raises the concern for post-mining land uses (e.g. agricultural uses) at the DCM and properties fronting the MJR following the completion of rehabilitation and the relinquishment of various tenements. Dr Arthur White notes that the current agricultural practices undertaken on land surrounding the DCM are highly detrimental to the Giant Barred Frogs and that their encroachment on Giant Barred Frog habitat post-mining would be contradictory to the findings of *Study of the Giant Barred Frog (*Mixophyes iteratus*) in the Mammy Johnsons River Catchment* (White, 2023a).

DCPL has incorporated this post-mining property management issue within the DCM Closure Project as a new risk.

10 CONTINGENCY PLAN

In the event a Giant Barred Frog performance measure detailed in Section 8 was considered to have been exceeded, DCPL would have implemented the following Contingency Plan:

- The Environment and Community Superintendent (or delegate) would have reported the exceedance to the Operations Manager within 24 hours of assessment completion.
- DCPL would have reported the exceedance of the performance measure to DPHI, Commonwealth DCCEEW and CPHR immediately after DCPL became aware of the exceedance.
- DCPL would have identified an appropriate course of action with respect to the identified impact(s), in consultation with specialists and relevant agencies, as necessary. For example, identification of proposed contingency measure(s) and a program to review the effectiveness of the contingency measures. Contingency measures would have been developed in consideration of the specific circumstances of the exceedance and the assessment of environmental consequences. Potential contingency measures are described in Section 10.1 below.
- DCPL would have submitted the proposed course of action to DPHI and the Commonwealth DCCEEW for approval.
- DCPL would have implemented the approved course of action to the satisfaction of DPHI and the Commonwealth DCCEEW.
- DCPL would have reported the exceedance of the Giant Barred Frog performance measure and the success of the approved course of action as a component of the Annual Review (Section 11).

Results from the aquatic ecology monitoring may have been used to inform the likely cause of impacts on Giant Barred Frog.

10.1 POTENTIAL CONTINGENCY MEASURES

Potential contingency measures for an exceedance of the Giant Barred Frog performance measure included, but were not necessarily limited to:

- Temporary cessation of irrigation within the DEP irrigation areas (should irrigation of the DEP irrigation areas were to have commenced).
- Alteration of soil moisture deficit triggers used in irrigation management.
- Modification of the first flush protocol used in irrigation management.
- Installation of additional water storage infrastructure.
- Treatment of Main Water Dam water used for irrigation, for example reverse osmosis treatment to reduce salinity.
- Provision of suitable offsets.

Prior to consideration or implementation of contingency measures additional monitoring (e.g. increase in monitoring frequency or additional sampling) and subsequent statistical analysis would have been undertaken to:

- confirm the exceedance of the performance indicator;
- confirm the exceedance was the result of rainfall runoff from DEP irrigation areas; and
- inform development and implementation of the proposed contingency measure(s).

The potential contingency measures described above that are relevant to irrigation management and water quality, are consistent with those described in the WMP. The requirement for any contingency measures would have been evaluated on a case-by-case basis considering any potential exceedance of the Giant Barred Frog performance measure and any potential exceedance of the water management or water resource performance measures described in the WMP.

The cause in Giant Barred Frog decline would determine the primary contingency measure to be implemented. Should any cause in decline have been as a result of rainfall runoff from the DEP irrigation areas (if irrigation of the DEP irrigation areas were to have commenced), remedial actions would have been applied to alleviate that impact. The provision of offsets was considered a last resort and only as a result of permanent damage to frog habitat.

11 ANNUAL REVIEW AND IMPROVEMENT OF ENVIRONMENTAL PERFORMANCE

In accordance with Condition 3, Schedule 5 of PA 08_0203, DCPL will prepare an annual review of the environmental performance of the DCM (including DEP) by the end of December each year.

The annual review would specifically address the environmental performance of the GBFMP (should irrigation of the DEP irrigation areas were to have commenced) and would:

- describe the development (including any rehabilitation) carried out in the past year, and the development proposed to be carried out over the next year;
- include a comprehensive review of the monitoring results and complaints records of the Project over the past year, including a comparison of these results against:
  - the relevant statutory requirements, limits or performance measures/criteria;
  - the monitoring results of previous years; and
  - the relevant predictions in the Project EA;
- identify any non-compliance over the past year, and describe what actions were (or are being) taken to ensure compliance;
- identify any trends in the monitoring data over the life of the Project;
- identify any discrepancies between the predicted and actual impacts of the Project, and analyse the potential cause of any significant discrepancies; and
- describe what measures will be implemented over the next year to improve the environmental performance of the Project.

As described in Section 12, the GBFMP has been reviewed within three months of the submission of an annual review, and revised where appropriate.

As described in Table 2 of Section 2.2 and in accordance with Condition 10 of EPBC 2010/5396, DCPL would have provided a report to the Commonwealth DCCEEW on the implementation of the GBFMP annually for the first five years (following commencement of irrigation activities within the DEP irrigation areas) and then every five years thereafter. Note that under Condition 8 and 9 of EPBC 2010/5396 the approved GBFMP is only required to be implemented following commencement of irrigation activities within the DEP irrigation areas. As described in Section 1, DCPL has not commenced irrigation of the DEP irrigation areas and does not intend to do so during mine closure.

12 GBFMP REVIEW AND UPDATE

In accordance with Condition 4, Schedule 5 of PA 08_0203 this GBFMP will be reviewed, and if necessary revised, within three months of:

(a) an annual review, in accordance with Condition 3, Schedule 5;

(b) an incident report, in accordance with Condition 6, Schedule 5;

(c) an audit, in accordance with Condition 8, Schedule 5;

(d) any modification to the conditions of approval; or

(e) prior to the commencement of clearing associated with the approved Duralie Open Pit Modification.

The revision status of this GBFMP is indicated on the title page of each copy.

Any changes to the GBFMP will be approved by the Commonwealth DCCEEW and DPHI.

In accordance with Condition 10, Schedule 5 of PA 08_0203 and Condition 9 of the EPBC 2010/5396, DCPL will make the GBFMP publicly available on the Duralie Coal website. A hard copy of the GBFMP will also be maintained at the DCM.

13 REPORTING PROTOCOLS

In accordance with Condition 2 (g), Schedule 5 of PA 08_0203, DCPL has developed protocols for managing and reporting the following:

- incidents;
- complaints;
- non-compliances with statutory requirements; and
- exceedances of the impact assessment criteria and/or performance criteria.

The management of incidents is described in the DCM Pollution Incident Response Management Plan. The management of complaints and non-compliances is described in detail in the DCM Environmental Management Strategy. The management of exceedances of performance criteria is described in Section 10 of this plan.

14 REFERENCES

Anstis, M. (2002) *Tadpoles of South-eastern Australia – a Guide with Keys*.

Berger, L., Speares, R. and Hyatt, A. (1999) *Chytrid fungus and amphibian declines: Overview, implications and future directions*. In Campbell, A. (1999) (ed.) *Declines and Disappearances of Australian Frogs. Environment Australia,* Canberra.

Biosphere Environmental Consultants (2012) *Duralie Coal Mine Giant Barred Frog (Mixophyes iteratus) Monitoring Results September 2011 to March 2012*.

Biosphere Environmental Consultants (2013) *Duralie Coal Mine Giant Barred Frog (Mixophyes iteratus) Monitoring Results September 2012 to March 2013*.

Biosphere Environmental Consultants (2014) *Duralie Coal Mine Giant Barred Frog (Mixophyes iteratus) Monitoring Results October 2013 to January 2014*.

Biosphere Environmental Consultants (2015) *Duralie Coal Mine Giant Barred Frog (Mixophyes iteratus) Monitoring Results October 2014 to February 2015*.

Department of Environment and Climate Change (2009) *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna-Amphibians.*

Department of Environment, Climate Change and Water (2009) Threatened Species Home Page. Website: www.threatenedspecies.environment.nsw.gov.au.

Department of the Environment, Water, Heritage and the Arts (2010) *Survey Guidelines for Australia's Threatened Frogs.*

Department of the Environment (2015) *Mixophyes iteratus* in Species Profile and Threats Database,

Duralie Coal Pty Ltd (2010) *Duralie Coal Project Environmental Assessment*.

Duralie Coal Pty Ltd (2012a) *Duralie Coal Mine Giant Barred Frog Management Plan* (R02).

Duralie Coal Pty Ltd (2012b) *Duralie Coal Mine Giant Barred Frog Study*.

Duralie Coal Pty Ltd (2014) *Duralie Open Pit Modification Environmental Assessment*.

Duralie Coal Pty Ltd (2015a21) Duralie Coal Mine Water Management Plan.

EcoBiological (2009) *Flora and Fauna Survey Report: Duralie Coal Mine, Gloucester, New South Wales. Report prepared for Duralie Coal Pty Ltd*.

Ehmann, H. (1997) (ed.) *Threatened Frogs of New South Wales: Habitats, Status and Conservation. Published by the Frog and Tadpole Study Group of New South Wales Inc*.

Gilbert & Associates Pty Limited (2010) *Appendix A Duralie Extension Project - Surface Water Assessment. Report prepared for Duralie Coal Pty Ltd*.

Gilbert & Associates Pty Limited (2014) *Duralie Open Pit Modification Surface Water Assessment*.

Goldingay, R., Newell, D., and Graham, M. (1999) *The status of Rainforest Stream Frogs in north-eastern New South Wales: decline or recovery?*

Hines, H., Mahony, M., McDonald, K. (1999) *An Assessment of Frog Declines in Wet Subtropical Australia*.

Koch, AJ. and Hero, JM. (2007) *The relationship between environmental conditions and activity of the Giant Barred Frog (Mixophyes iteratus) on the Coomera River, South-East Queensland*. Australian Journal of Zoology, 55: 89–95.

Lemckert, F. and Brassil, T. (2000*) Movements and habitat use of the endangered giant barred river frog (Mixophyes iteratus) and the implications for its conservation in timber production forests*. Biological Conservation 96(2): 177-184.

Mahony, M., Knowles, R. and Pattinson, L. (1997) *Gold-eyed Barred Frog, Mixophyes iteratus in Ehmann, H., ed. Threatened* Frogs of New South Wales: Habitats, Status and Conservation. Page(s) 78-83. Sydney, NSW: Frog & Tadpole Study Group of NSW

Mahony, M. and Werkman, H. (2000) *The distribution and prevalence of Chytrid fungus in frog populations in eastern New South Wales and developing a means to identify presence or absence of Chytrid fungus in the field.* Unpublished report to NSW National Parks and Wildlife Service.

National Parks and Wildlife Service (2000) *Threatened Species of the Lower North Coast of New South Wales*. NSW National Parks and Wildlife Service, Coffs Harbour.

National Parks and Wildlife Service (2008) *Hygiene Protocols for the Control of Disease in Frogs*.

NSW Scientific Committee (1999) *Giant Barred Frog – Endangered Species Listing. NSW Scientific Committee Final Determination.*

NSW Scientific Committee (2003) *Final Determination for Infection of Frogs by the Chytrid Causing the Disease Chytridiomycosis – Key Threatening Process*.

Office of Environment and Heritage (2006) *Threat Abatement Plan for infection of amphibians with chytrid fungus resulting in chytridomycosis.*

Streatfield, C. (1999). *Spatial movements of Mixophyes iteratus and M. fasciolatus in southeast Queensland*. Hons. Thesis. Brisbane, Queensland; Griffith University.

White, A.W. (2008) *The distribution and conservation status of Barred Frogs in the Sydney Basin. Part 1. Giant Barred Frog Mixophyes iteratus*. Herpetofauna, 38(1):24-33.

White, A. (2011) Annexure A – Expert Report Prepared by Dr Arthur William White. Prepared for the Land and Environment Court Proceedings No. 10090 of 2011.

White, A. (2023a) A Study of the Giant Barred Frog (Mixophyes iteratus) in the Mammy Johnsons River Catchment.

White, A (2023b) Review: Duralie Coal Mine Giant Barred Frog Management Plane 2023.

APPENDIX 1

A STUDY OF THE GIANT BARRED FROG (MIXOPHYES ITERATUS) IN THE MAMMY JOHNSONS RIVER CATCHMENT (WHITE, 2023a)

A Study of the Giant Barred Frog (*Mixophyes iteratus*) in the Mammy Johnsons River Catchment

Report by Dr Arthur White
Prepared for Duralie Coal Pty Ltd

March 2023

PREFACE

Dr Arthur White (Biosphere Environmental Consultants Pty Ltd) was engaged by Duralie Coal Pty Ltd (DCPL) to undertake monitoring and surveys of the Giant Barred Frog (*Mixophyes iteratus*) in the Mammy Johnsons River catchment, New South Wales.

The original reason for the monitoring and surveys was to establish baseline data so that potential impacts from the additional proposed mine water irrigation areas approved under the Duralie Extension Project could be monitored over time. However, DCPL did not commence irrigation of the additional irrigation areas and mining operations at the Duralie Coal Mine have also now ceased.

The purpose of this document is to present a collation of the Giant Barred Frog research and monitoring undertaken. It presents the data captured during the surveys from 2010 to 2018. Key findings on the Giant Barred Frog habitat, population and distribution are discussed.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PLATES

LIST OF TABLES

LIST OF ATTACHMENTS

EXECUTIVE SUMMARY

Dr Arthur White (Biosphere Environmental Consultants Pty Ltd) was engaged by Duralie Coal Pty Ltd (DCPL) to undertake monitoring and surveys of the Giant Barred Frog (*Mixophyes iteratus*) in the Mammy Johnsons River catchment, New South Wales (NSW).

The original reason for the monitoring and surveys was to establish baseline data so that potential impacts from the additional proposed mine water irrigation areas approved under the Duralie Extension Project could be monitored over time. However, DCPL did not commence irrigation of the additional irrigation areas and mining operations at the Duralie Coal Mine (DCM) have now ceased.

The study of the Giant Barred Frog in the Mammy Johnsons River (MJR) has instead provided a unique opportunity to observe and collect meaningful ecological data on an endangered frog species.

Prior to the commencement of the assessments and surveys implemented for the DCM, Giant Barred Frogs were scarcely recorded within the MJR catchment. The detailed monitoring of the Giant Barred Frog allowed for the collection and collation of detailed information about the species over a number of years, and under a range of climatic circumstances. This data is significant for the conservation of this species along the MJR and elsewhere within its range.

Key findings from this study are:

- The Giant Barred Frog is widely distributed throughout the MJR catchment.
- The Giant Barred Frog is most common along the middle sections of the MJR, from north of Stroud to the Mavis Tersteeg Crossing.
- Giant Barred Frogs occur in reasonable numbers in Mill Creek, and Saggers Creek, close to the MJR, and are present in high numbers along the lower and middle sections of Crawford River.
- Giant Barred Frogs were in high abundance in areas where the riparian ground and canopy vegetation was intact and where water quality was not compromised by agricultural or sustained salt influxes from surrounding geology.
- The population of Giant Barred Frogs in the MJR was estimated to be 271-317 adult frogs.
- An average recruitment rate of approximately nine percent (%) was found. It appeared that the main contributors to population influx were tadpoles which survived by overwintering and produced young frogs in early spring.
- *Batrachochytrium dendrobatidis*, the pathogen that causes the fatal frog Chytrid Disease, is widespread throughout the MJR catchment. Antibody data collected during the surveys revealed that typically between 40-50% of the Giant Barred Frogs swabbed have had a previous exposure to the disease. As deaths to the disease appeared to be relatively modest, it was assumed that the frogs may have developed some degree of resistance to the pathogen. It is also possible that Chytrid infection rates are kept to sub-lethal levels by the incipient salt that leeches into the river during times of low water flow.
- Habitat quality varies greatly within the catchment. The majority of the riparian habitat in the MJR catchment had been degraded through earlier vegetation clearing and timber felling, as well as more recent degradation from cattle grazing and agricultural activity. Despite these impacts, some high-quality habitat areas persist where the riparian vegetation is either completely or partially intact, where cattle have been fenced out of the river, and where agricultural activity is minimal.
- Overall, the populations in the MJR catchment and Crawford River are considered secure at present. However, both populations could decline rapidly should conditions and impacts change.

1. INTRODUCTION

1.1 PURPOSE OF THIS REPORT

Dr Arthur White (Biosphere Environmental Consultants Pty Ltd) was engaged by Duralie Coal Pty Ltd (DCPL) to undertake monitoring and surveys of the Giant Barred Frog (*Mixophyes iteratus*) in the Mammy Johnsons River (MJR) catchment, New South Wales (NSW) (Figure 1).

The original reason for the monitoring and surveys was to establish baseline data so that potential impacts from the additional proposed mine water irrigation areas at the Duralie Coal Mine (DCM) approved under the Duralie Extension Project could be monitored over time. However, DCPL did not commence irrigation of the additional irrigation areas and mining operations at the DCM have now ceased.

The purpose of this report is to present a collation of the research and monitoring undertaken on the Giant Barred Frog in the MJR catchment and surrounds. It presents the data captured during the surveys from 2010 to 2018. Key findings on the Giant Barred Frog biology, habitat, population and distribution are discussed, including key findings and conclusions.

1.2 STRUCTURE OF THIS REPORT

The structure of this report is as follows:

Section 1 Introduction including purpose, background and overview

Section 2 Baseline monitoring for the Giant Barred Frog Study undertaken between January and March 2011

Section 3 The first monitoring season - September 2011 and March 2012

Section 4 The second monitoring season - September 2012 and March 2013

Section 5 The third monitoring season - October 2013 and January 2014

Section 6 The fourth monitoring season - October 2014 and February 2015

Section 7 Results of incidental surveys between 2015 and 2018

Section 8 Summary of the key findings

1.3 BACKGROUND

The Giant Barred Frog (*Mixophyes iteratus*) is listed as Endangered under NSW *Biodiversity Conservation Act 2016* and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The general distribution of the Giant Barred Frog in Australia extends across the eastern coast and ranges from south-eastern Queensland to the Hawkesbury River in mid-eastern NSW (Department of Environment, Climate Change and Water [DECCW], 2009; Hines et al., 1999) (Figure 2).

In 2009, as part of the environmental assessments for an extension to the DCM, Giant Barred Frogs were located in a number of sites along the MJR (Ecobiological, 2009) (Figure 3). The frogs had not been recorded in the MJR catchment prior to this time.

The distribution of the Giant Barred Frog in the MJR catchment and wider surrounds (Mill Creek, Saggers Creek and Crawford River) is relatively isolated from other known populations to the south and north. Given the known distribution of the Giant Barred Frog, the population in the MJR catchment was considered of regional significance.

During the assessment of the Duralie Extension Project for both State and Commonwealth Approvals (including the Land and Environment Court proceedings), it was identified that rainfall runoff from the additional proposed mine water irrigation areas (when under irrigation) had the potential to adversely impact water quality in the MJR, with a subsequent potential threat to the health of the local Giant Barred Frog population.

To address the potential impact on the Giant Barred Frog, the approval conditions of the Duralie Extension Project required DCPL to undertake a Giant Barred Frog Study (the Study) that would gather habitat and important biological information about the Giant Barred Frogs in the MJR catchment. Additionally, a Giant Barred Frog Management Plan (GBFMP) was required to be prepared including an intensive monitoring program that could detect and respond to any adverse impacts found on the local frog population.

Despite having approval to do so, DCPL did not commence irrigation of the Additional Irrigation Areas approved under the Duralie Extension Project, and as such, the potential impact pathway to the Giant Barred Frog population did not commence. Despite this, the monitoring programs in accordance with the GBFMP were implemented by DCPL from 2010 to 2015, with further opportunistic surveys undertaken up to 2018.

The Giant Barred Frog monitoring program was a unique opportunity for observing and collecting meaningful baseline ecological data on an endangered frog species.

Mining operations at the DCM ceased in 2021.

1.4 GIANT BARRED FROG STUDY

The Giant Barred Frog Study had three primary aims, including:

- assess distribution and population status of Giant Barred Frogs in MJR catchment;
- assess habitat condition and availability of habitat for the frogs; and
- assess impacts on habitats and the Giant Barred Frog population.

The latter aim, while being primarily intended to assess any potential impacts from the release of saline runoff water from the DCM also included other local impacts such as those from agriculture and previous riparian disturbance.

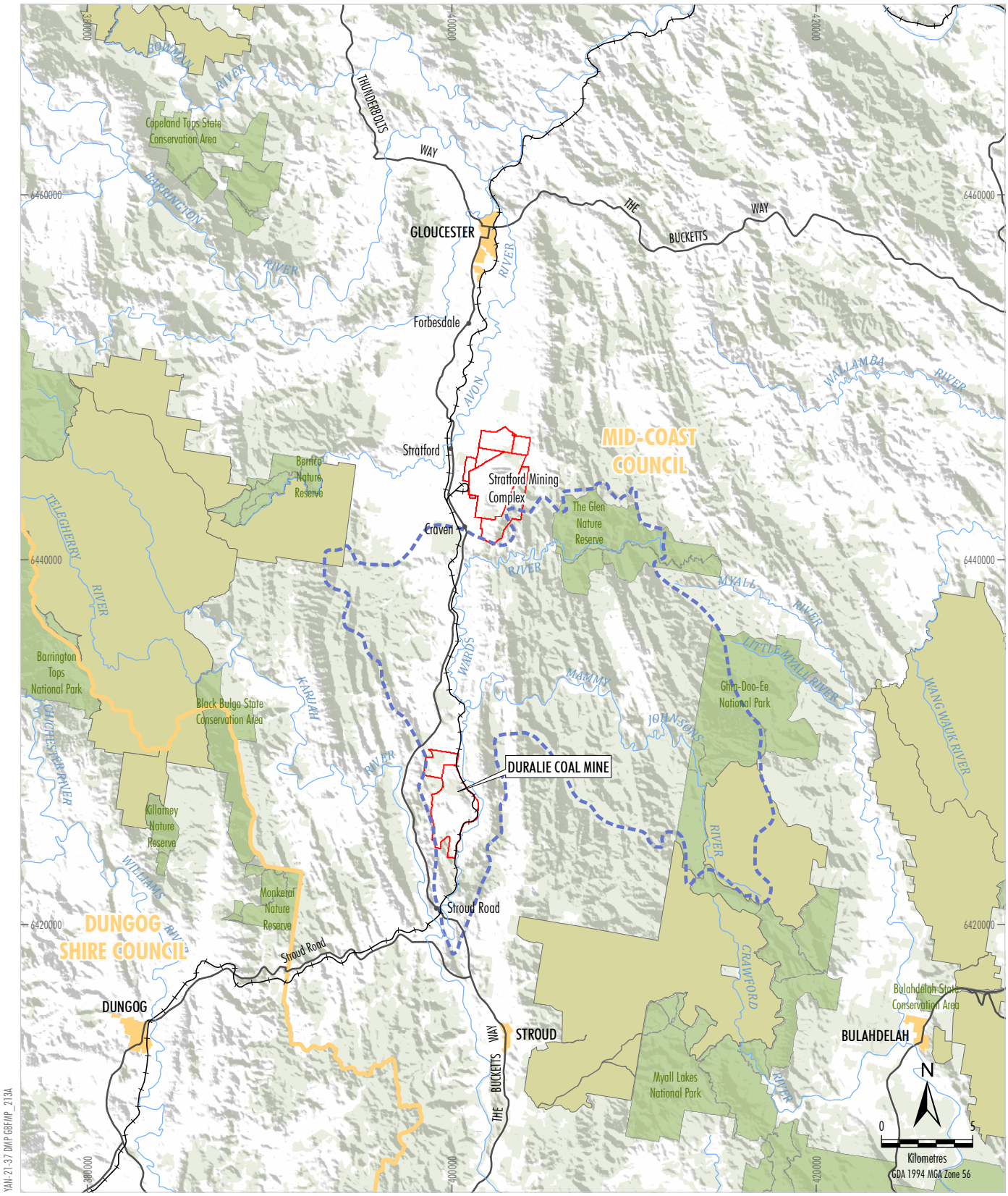
1.5 GIANT BARRED FROG MANAGEMENT PLAN

The GBFMP was predicated on the findings of the Giant Barred Frog Study. Its primary aims were to:

- Establish the detailed baseline data needed for the assessment of potential impacts on the population of Giant Barred Frog in the MJR catchment.
- Establish a monitoring program for the Giant Barred Frog in the MJR catchment.
- Detail the measures and indicators that would be used to assess any potential impacts on the Giant Barred Frog population in the MJR catchment that may have arisen from the DCM;

- Detail the management measures that would be implemented should any impacts be detected; and
- Provide a Contingency Plan to manage any unpredicted impacts and their consequences on the riparian frog fauna.

In 2010, Dr Arthur White and Biosphere Environmental Consultants Pty Ltd were engaged to undertake the monitoring of the Giant Barred Frogs in the MJR catchment as well as to prepare the Giant Barred Frog Study and the GBFMP.



YAN-21-37 DNP GBFMP_213A

LEGEND

- Mining Lease Boundary
- NSW State Forest
- National Park, Nature Reserve or State Conservation Area
- Local Government Area Boundary
- Mammy Johnsons River Catchment Boundary (approximate)

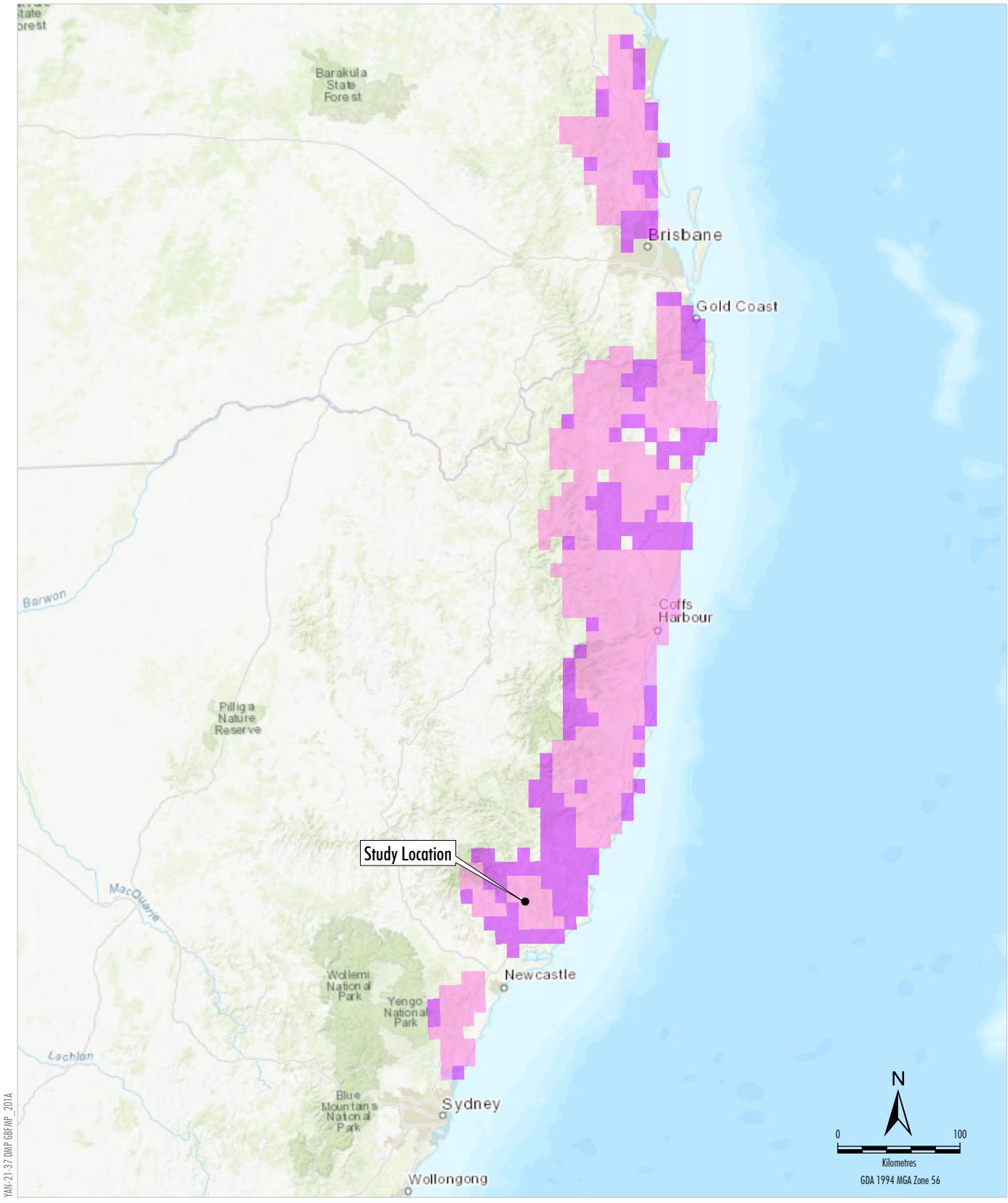
Source: Geoscience Australia (2006);
NSW Department of Planning & Environment (2017)

DURALIECOAL
Part of the Yancoal Australia Group

DURALIE COAL MINE

Regional Location

Figure 1



YAN-21-37 DNP GBFMP_201A

LEGEND

Species or species habitat likely to occur

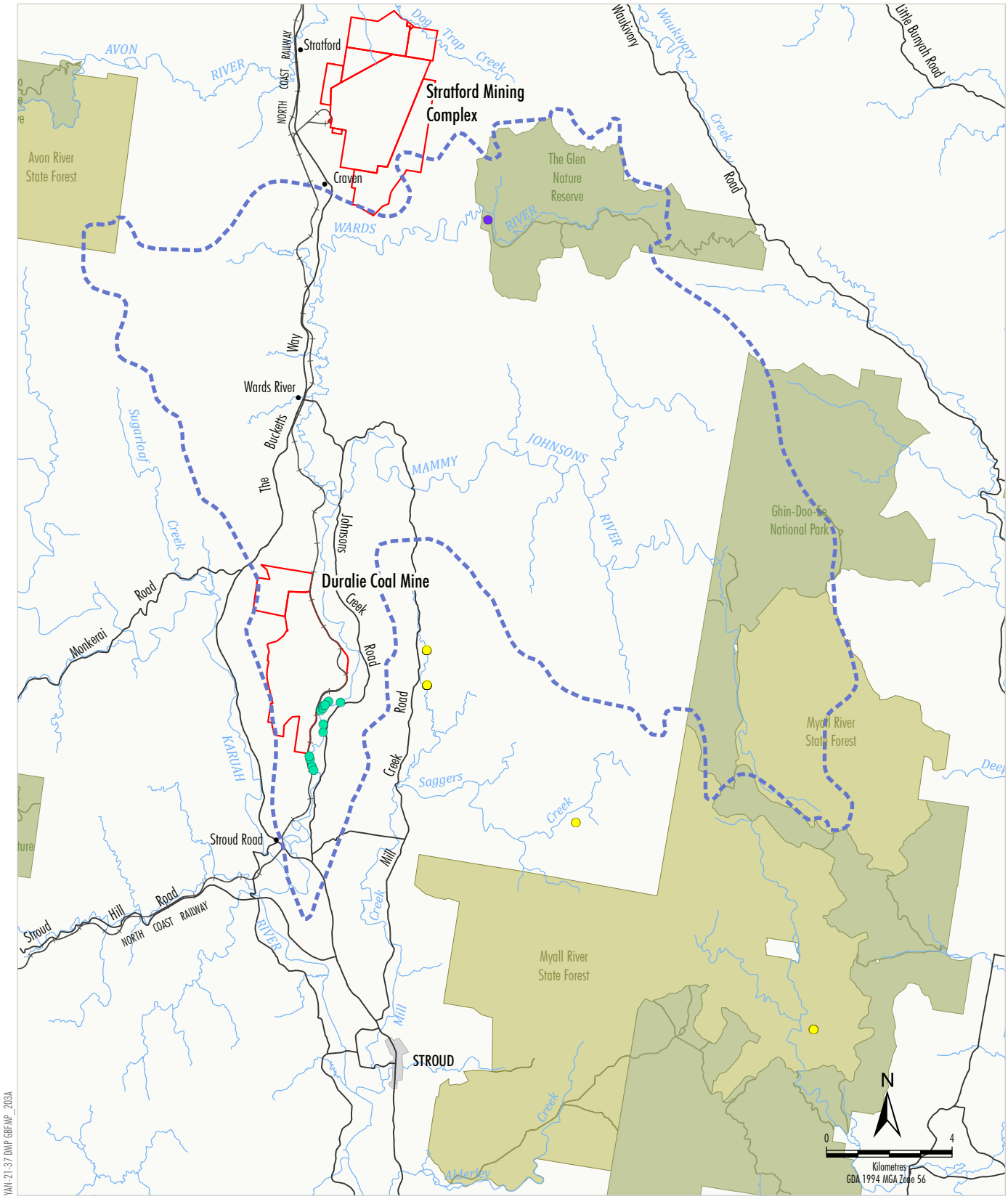
Species or species habitat may occur

Source: SEWPaC (2023); ESRI Base Map (2023)

DURALIE COAL MINE

Giant Barred Frog (*Mixophyes iteratus*)
Distribution Map

Figure 2



YAN-21-37 DMP GBFMP_203A

LEGEND

- Mining Lease Boundary
- National Park, Nature Reserve or State Conservation Area
- NSW State Forest
- Mammy Johnsons River Catchment Boundary (approximate)

No. of Records	Giant Barred Frog Records
(1-20)	Atlas of NSW Wildlife (2012)
(1-20)	Ecobiological (2009)
(1-20)	Ecobiological (2011)

Source: Spatial Services NSW (2022)

DURALIECOAL
Part of the Yancoal Australia Group

DURALIE COAL MINE

Giant Barred Frog Records
Prior to Monitoring

Figure 3

1.6 MAMMY JOHNSONS RIVER CATCHMENT

The MJR has a catchment area of 320 squared kilometres (Gilbert & Associates, 2010). Wards River is the only major tributary of the MJR, and rises in The Glen Nature Reserve. The MJR rises in the Myall River State Forest and Ghin-Doo-Ee National Park.

The upper reaches of the MJR and Wards River are geologically and vegetatively dissimilar to the middle and lower reaches of the MJR and Wards River. Once Wards River and MJR flow west from the headwater reserves, they flow through undulating agricultural land that has been extensively cleared for cattle grazing. For most of the remainder of their courses southwards, the two streams are flanked by a narrow remnant riparian strip of trees often heavily weed infested with privet and lantana. The stream channels also change from being shallow and broad with a rocky base, to narrow and deeply incised in a sedimentary plain.

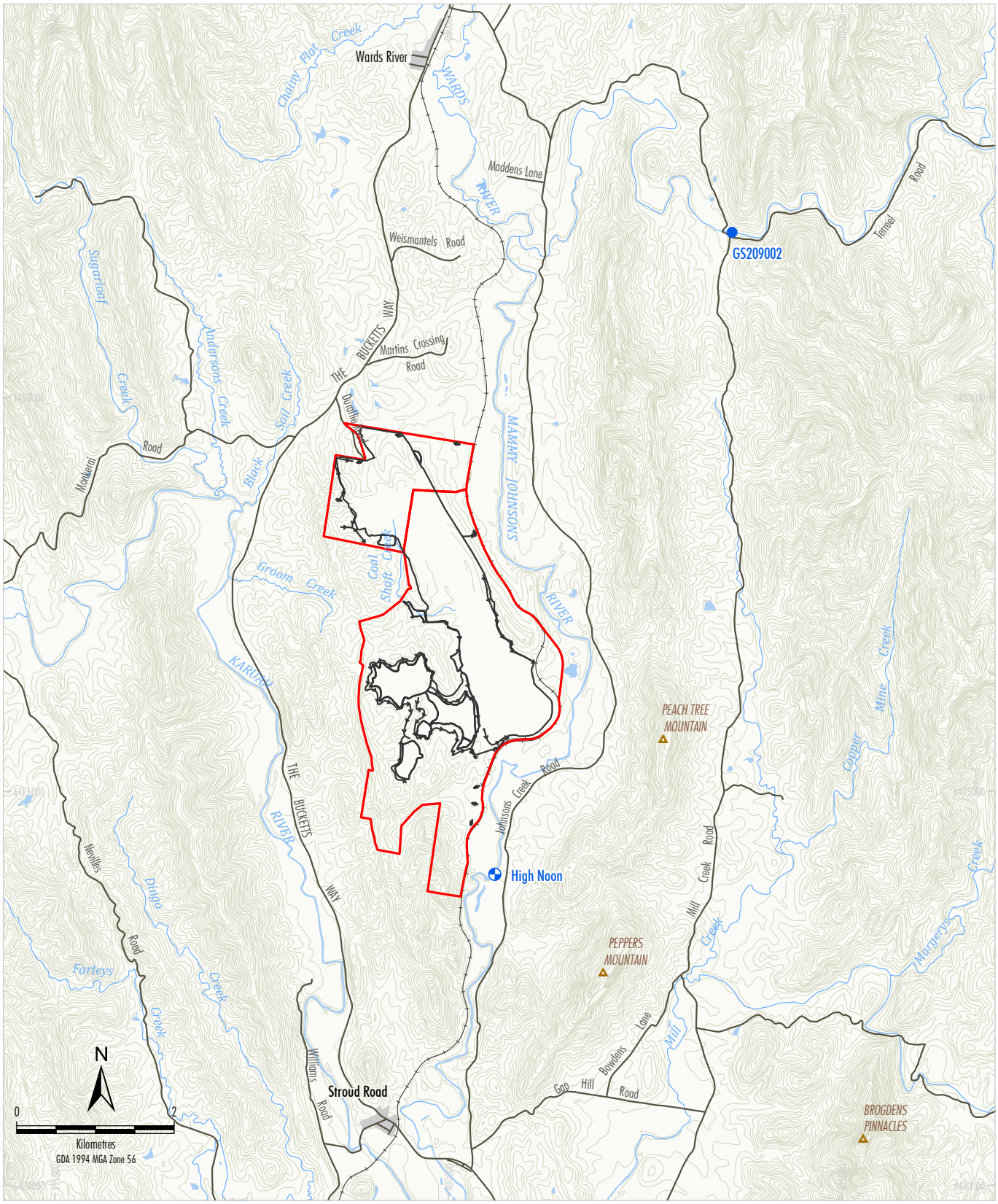
In the lower section of its course, the MJR flows to the east of the DCM. The DCM is situated in the catchment of Coal Shaft Creek and an unnamed minor tributary. Coal Shaft Creek is a small tributary which has been diverted around the DCM workings before rejoining the original Coal Shaft Creek alignment near the DCM rail spur. The confluence of Coal Shaft Creek with the MJR is south of the DCM rail loading infrastructure.

An unnamed minor tributary flows north and east to join the MJR approximately 4 kilometres (km) upstream of the Coal Shaft Creek confluence. Both the Coal Shaft Creek and unnamed minor tributary are ephemeral streams. The MJR continues southwards until it flows into the Karuah River to the south of the town of Stroud Road.

Stream flow data was available from the gauging station located at Pikes Crossing[1] (GS209002) (Figure 4) on the MJR from 1973 onwards. Attachment 2 Chart 1 shows the recorded stream flow hydrograph from 1973 to 2008 for GS209002.

Stream flows are characterised by low to moderate flows for long periods, with periods of higher discharge following heavy rains. Such a rainfall response is typical of small and medium sized upland catchments (Gilbert & Associates, 2010). In terms of low flow persistence, zero flow has been recorded on the MJR on 5.3% of days. Averaged over the full period of available data, stream flow in MJR is estimated to amount to 28% of rainfall (Gilbert & Associates, 2010).

[1]The gauging station site is referred to by Office of Environment and Heritage as Pikes Crossing. Pikes Crossing is known by DCPL as Mavis Tersteeg Crossing.



LEGEND

- Mining Lease Boundary
- Surface Water Monitoring Site
- Gauging Station

Source: © NSW Spatial Services (2020)

DURALIE COAL MINE

Location of Surface Water Monitoring Sites

Figure 4

1.7 GIANT BARRED FROG OVERVIEW

A brief description of the biology, distribution and conservation status of the Giant Barred Frog is provided below.

1.7.1 Habitat

The Giant Barred Frog (Plate 1) inhabits riparian areas associated with permanent flowing watercourses. These can vary from shallow rocky streams in rainforests to slow-moving rivers in lowland open forest (NSW Scientific Committee, 1999). Giant Barred Frogs are usually not found in ponds or ephemeral pools (Mahony et al., 1997). In these riparian areas, Giant Barred Frogs inhabit various vegetation types including rainforest, moist eucalypt forest and nearby dry eucalypt forest (Department of Sustainability, Environment, Water, Population and Communities [SEWPaC], 2012). Populations of the Giant Barred Frog have also been found in disturbed areas including vegetated riparian strips on cattle farms (SEWPaC, 2012). However, deep leaf litter provided by canopy vegetation and/or thick cover is necessary (Mahony et al., 1997).

Plate 1: Adult Giant Barred Frog, MJR, February 2012

White (2008) conducted intensive surveys for the Giant Barred Frog to determine its current distribution in the greater Sydney Basin. The study recorded the Giant Barred Frog in second, third and fourth order streams, all permanent and slow flowing, that ranged in width from 1 metre (m) to 5 m wide (White, 2008). At most of the sites, the riparian corridor of the stream was relatively narrow and varied between 5 m and 25 m away from the banks. Graded banks with undercuts and steep edges are typical of many known Giant Barred Frog sites (Mahony et al., 1997), including sites along the MJR.

Lollback et al. (2020) quantified the use of habitat for this species and found the majority of records were from sites with steep banks (up to 12 m high). Stream pool length was another major habitat use determinant as frogs were much more likely to be present in pools 12 m or more in length.

Giant Barred Frogs do not burrow into the soil like other barred frogs (Lemckert and Brassil, 2000), instead they create shallow depressions underneath leaf litter and hide in these depressions during the day. The leaf litter cover plus their own dorsal patterning provides great camouflage and the frogs are often hard to find during the day (Anstis, 2017). At night the frogs emerge from their hiding places and forage or seek mates. Behavioural surveys indicate that temperature is the most important climatic variable influencing Giant Barred Frog behaviour. During cold conditions (less than 18 degrees Celsius [^{o}C]), males (in particular) secrete themselves under the leaf litter. If it is not too cold, they may remain in a position with their head clearly exposed (Plate 2) (Lemckert and Brassil, 2000; Koch and Hero, 2007). If it is colder again, they will fully retreat under the leaf litter and adopt a compact body position in their hiding place.

Plate 2: Giant Barred Frog with Head Protruding from Under Leaf Litter, MJR, December 2013

1.7.2 Breeding

Giant Barred Frogs are a stream breeding species. Their breeding season is long and quite variable and can extend from mid-spring to the end of summer. Male Giant Barred Frogs usually call throughout spring and summer (Anstis, 2002), but will cease calling if the weather becomes too cold. Calling usually takes places around shallow, flowing, rocky permanent streams where some riparian vegetation is present (DECCW, 2009; Lemckert and Brassil, 2000).

Amplexus (Plate 3) and breeding is associated with local rainfall events. Local rainfall is a trigger for breeding, but stream flow is also an important factor. Giant Barred Frogs do not breed when streams are in full flow. Breeding occurs after water levels have begun to recede and the frogs are able to access the stream banks.

Female Giant Barred Frogs spawn in shallow water close to the creek bank. Once eggs are laid and fertilised, the female uses her hind legs to kick them out of the water, sticking them onto overhanging or steeply sloped banks or rocks. The fertilised eggs remain attached to the overhanging bank until hatching when the tadpoles drop into the stream below (Knowles et al., 2015; Anstis, 2017). The average clutch size is 2000 eggs (Anstis, 2017).

The larval period of the Giant Barred Frog is typically from September to May (Goldingay et al., 1999; Mahony et al., 1997; in SEWPaC, 2012). The Giant Barred Frog has a long tadpole stage that may be as short as five months or last up to eighteen months (White, 2008). Tadpoles that have a long period may overwinter and not metamorphose until the next season (Meyer et al. 2001). Tadpoles are large and can grow to over 100 millimetres (mm) in length (SEWPaC, 2012).

Plate 3: Giant Barred Frogs in Amplexus, MJR, October 2013

Metamorphosis usually occurs anytime from late summer through to autumn (Hines, 2012; Anstis, 2013). Observations of the frogs in the MJR indicates that the metamorphosis of tadpoles is heavily dependent upon the time of egg-laying. If egg-laying occurs in spring, most of the tadpoles will develop and metamorphose before the next winter arrives. If egg-laying occurs in later summer, many tadpoles will not reach metamorphosis before water temperatures begin to fall and winter approaches. These tadpoles will remain as tadpoles throughout winter and will not metamorphose until water temperatures rise in the following spring-summer period. Breeding events are influenced by suitable weather events rather than seasonal factors and so Giant Barred Frog tadpoles may be present all year (Wood, 2017).

Tadpoles are bottom dwellers, grazing over rocks or stream substrate in still or slowly flowing pools, or at the sides of streams. Tadpoles are powerful swimmers and their sectorial disk enables quite firm adherence in flowing water (Anstis, 2017).

1.7.3 Foraging

Giant Barred Frogs are considered to be a generalist feeder, likely to eat a range of potential prey items encountered when foraging. This includes large insects, snails, spiders and frogs (Lemckert and Shoulder, 2007; Office of Environment and Heritage [OEH], 2017) or even small mammals (Madani, 2021). Lemckert and Shoulder (2007) examined the stomach contents of 52 Giant Barred Frogs, which revealed 98% of items eaten to be invertebrates, with insects the dominant prey item (53%). During the study of the Giant Barred Frogs in the MJR catchment, it was observed that some larger prey items were being eaten, including Funnel-Web Spiders (Plate 4) and young rodents (Plate 5).

Tadpoles feed on bottom sediment, algae, detritus, fallen fruit and possibly carrion according to Hines (2012). Wood (2017) suggested a more limited diet, with tadpoles feeding mainly on algae and fallen fruit, whilst the NSW National Parks and Wildlife Service (NPWS) (2000) website, states that Giant Barred Frog tadpoles feed on plant material.

Plate 4: Giant Barred Frog Eating Funnel-web Spider (Image: George Madani)

Plate 5: Giant Barred Frog Eating Juvenile Rat (Image: George Madani)

1.7.4 Movement

Various studies have found Giant Barred Frogs usually remain within approximately 50 m of their habitat (Streatfield, 1999 in SEWPaC, 2012; Lemckert and Brassil, 2000; Koch and Hero, 2007). Streatfield (1999 in SEWPaC, 2012) monitored the spatial movements of four male and four female Giant Barred Frogs at Coomera River in Queensland. Over six weeks, it was found that the individuals moved a maximum distance of 268 m along the stream and 50 m away from the stream.

Lemckert and Brassil (2000) undertook a four-year radio tracking study on the movements and habitat use of Giant Barred Frogs in the Coffs Harbour/Dorrigo area in NSW. The study found that frogs stayed within a 20 m zone either side of the four streams that were monitored. Koch and Hero (2007) radio tracked the Giant Barred Frog and found that males were found on average 7.2 m from the stream (range 0.5 m to 32 m) whereas females were found on average 12.1 m from the stream (range 0 m to 50 m).

While recording the location of Giant Barred Frogs along the MJR, it was similarly found that adult frogs remained (generally) within a 20 m zone either side of the riverbanks, however, there was some variation in this. Where the river had steep banks, the adult frogs were generally less than 10 m from the water's edge. In areas where the river was not deeply incised, adult frogs were more scattered and could be 40 m from the river's edge (Plate 6) and still be foraging or calling. During times of high water flow or localised flooding, Giant Barred Frogs moved further away from the river's edge (into paddocks of exotic pasture grasses). The greatest distance where Giant Barred Frogs were detected from the river's edge was 92 m.

Previous studies have shown that the Giant Barred Frog is not distributed evenly along streams, and cluster/reach highest densities around larger pools with overhanging banks (preferred breeding sites). In contrast, Giant Barred Frogs are generally not found near riffle zones. This pattern also applied for frogs along the MJR where frog densities ranged from 0.3 frogs per 100 m up to 27 frogs per 100 m. The greatest density of frogs recorded was in the Crawford River where at one site there were 38 frogs per 100 m of riverbank.

Adult male frogs are highly territorial (i.e. they defend an area and exclude other males from it). At the Crawford River sites where frog densities were high, Giant Barred Frog males and females were often found foraging alongside each other with minimal aggressive interactions. During the breeding season, or when males were actively calling, males did not tolerate other males within 3 m to 4 m of them.

Plate 6: Giant Barred Frog in Paddock During Period of High Water Flow in River

1.7.5 Distribution

The general distribution of the Giant Barred Frog in Australia extends across the eastern coast and ranges from south-eastern Queensland to the Hawkesbury River in mid-eastern NSW (DECCW, 2009; Hines et al., 1999) (Figure 2).

In Queensland, Giant Barred Frog populations are disparate. For example, the Mary River catchment contains an estimated 65% of the total Giant Barred Frog population in Queensland (Hines, 2012). The species also occurs in various locations south of the Mary River, in the headwaters of the Brisbane River (e.g. Stanley River, Byron Creek) and in coastal streams (e.g. Caboolture River, Burpengary Creek), all north of Brisbane. There is then a break in distribution to a small remnant population in the eastern foothills of the McPherson Range (Canungra and Nixons Creeks, Coomera and Numinbah Rivers) close to the Queensland-NSW border (Hines, 2012).

Giant Barred Frogs are more widely distributed in NSW, although populations have been reduced in some areas.

An indicative distribution map of the Giant Barred Frog is shown on Figure 2.

In NSW, Giant Barred Frogs are relatively abundant in the north-east of the state, particularly in the Coffs Harbour-Dorrigo catchment and Washpool National Park. Giant Barred Frogs are also present in Mebbin National Park, the upper Tweed River catchment, Whian Whian National Park, the Bungawalbyn area, Manning River drainage (DPIE, 1999), and the Watagan area (Anstis, 2017).

Elsewhere in NSW, smaller, disjunct sub-populations occur along the eastern seaboard as far south as the Hawkesbury River. The species did occur further south in sites around the lower Blue Mountains, but these populations have been lost (OEH, 2017).

Declines in both the size and number of subpopulations has occurred over much of the species' known historic range. Most of these declines occurred during the late 1970s and early 1980s. Field observations conducted throughout much of the north-east region and the central coast of NSW found marked population declines (Mahony, 1993). At the same time, surveys in Queensland failed to detect the species and it was not until the 1990s (Lewis and Rohweder, 2005) that the species was redetected in that state. Ingram and McDonald (1993) suggested that species abundance dropped by up to 90% across the geographic range, largely as a result of disease (later identified as chytridiomycosis), together with other threatening processes (Berger et al., 1999; Ingram and McDonald, 1993; Laurance et al., 1996; Lemckert and Brassil, 2000).

In Queensland, Hines (2012) declared the Main Range and the Bunya Mountains subpopulations of Giant Barred Frogs as extinct. However, the subpopulation in the Conondale Range is still extant and appears to be slowly recovering after earlier surveys had failed to find the species (Hines, 2012; Newell, 2018). The number of Giant Barred Frogs in the Mary River catchment (which contains the majority of the total Giant Barred Frog population of Queensland) had declined but numbers now appear to be relatively stable (Mary River Catchment Coordinating Committee, 2016).

In NSW, declines occurred most severely at the southern limit of the range, within the Blue Mountains and along the Central Coast (DPIE, 1999). There have been no recent records south of the Hawkesbury River (OEH, 2017), and in the Blue Mountains, previously large numbers recorded at the Grose River Valley have dramatically declined. The species disappeared from the Watagan Mountains on the central coast of NSW, where a 15-year study (1977 to 1992) failed to record the species after 1984 (Mahony, 1993).

White (2008) located five subpopulations of Giant Barred Frogs in the area south of the Hunter River to the Hawkesbury River in eastern NSW. All of these populations were small and isolated.

In northern NSW, Giant Barred Frogs disappeared from Terania Creek (Nightcap National Park) in the mid-1990s, and were not recorded again until one female frog was observed in 2017 (Newell, 2018). In Bungawalbin, north-eastern NSW, Giant Barred Frogs are now confined to five isolated subpopulations, with varying abundance (Lewis and Rohweder, 2005). There are indications of population recovery in northern NSW, where new subpopulations have been discovered (Newell, 2018).

2. INITIAL INVESTIGATION - JANUARY TO MARCH 2011

The primary purpose of the Giant Barred Frog Study was to gather baseline data prior to irrigation of mine water associated with the Duralie Extension Project. In 2011, an initial investigation into survey areas was undertaken.

2.1 METHODS

Ten survey sites (Figure 5) were randomly chosen from areas of Giant Barred Frog habitat (five upstream of the DCM and five downstream of the mine) and initial scoping frog surveys commenced in January 2011. Each site consisted of a 200 m section of the river course and a team of two frog surveyors surveyed each site (in a different order each night) for two nights. The surveys were repeated four times from January to March 2011 (i.e. a total of eight baseline surveys were conducted at each site).

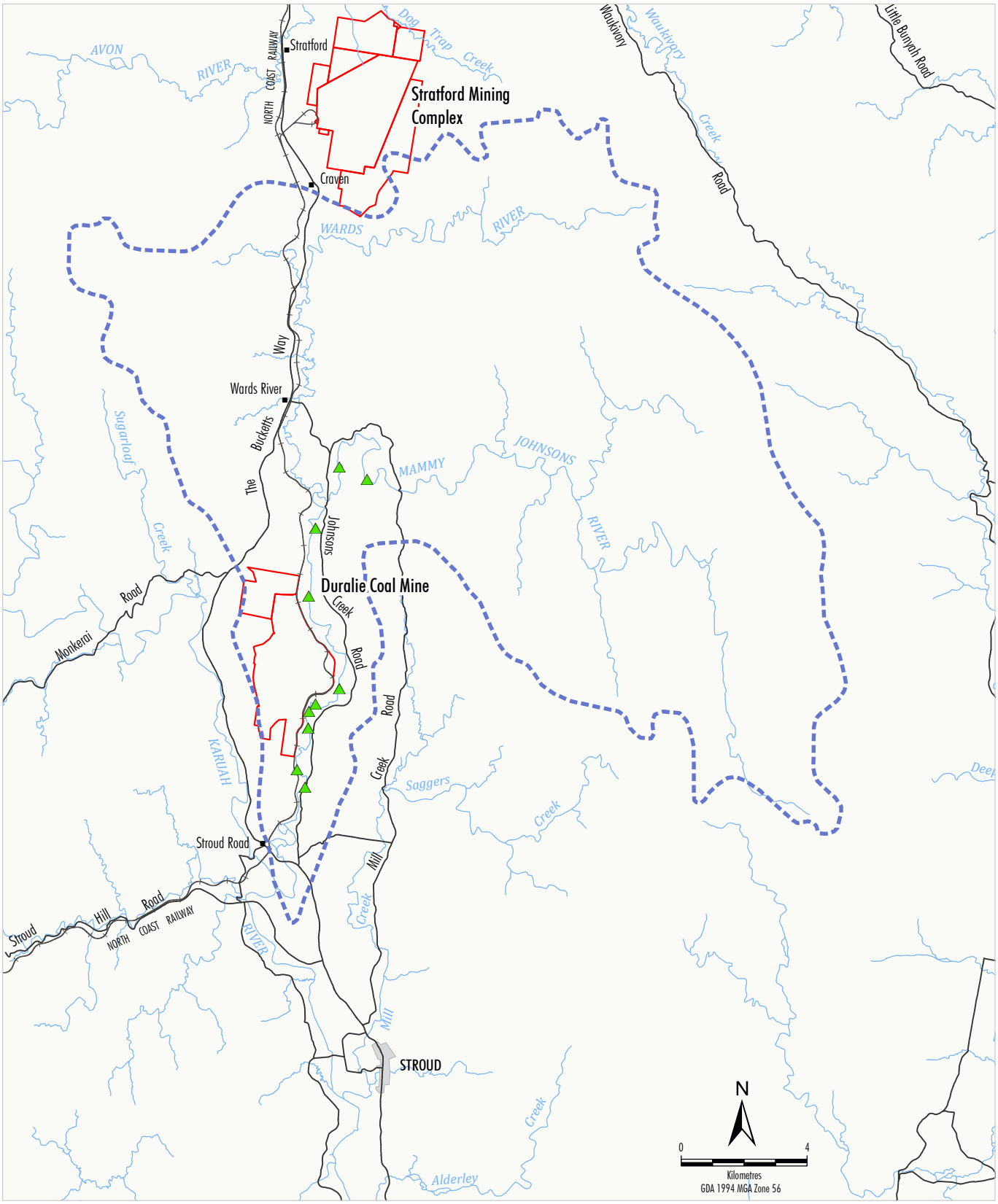
The boundaries of each 200 m stream bank transect were flagged at each location to ensure the same areas were surveyed each time. All frogs encountered were recorded. If Giant Barred Frogs were found, they were caught, weighed, measured, and their sex determined. The frogs were also inspected for signs of injury or disease. Skin swabs were taken and later analysed for the presence of *Batrachochytrium* spores (Frog Chytrid disease). Each frog was implanted with the Passive Induction transponder chip (or microchip) for individual frog identification purposes. The frogs were released at the site of capture.

In addition to the frog surveys, tadpole surveys (Plate 7) were conducted at each site during each survey period. The shallow edges of the river were swept ten times using a long-handled tadpole net. Any tadpoles caught were immediately identified and released.

Habitat assessments were also carried out at each site. A series of qualitative and quantitative descriptors of the structure of the riparian environment were scored. This included the topography, nature of the riverbank, ground and canopy vegetation, leaf litter, soil, water quality parameters, flow data and general hydrological conditions.

For the purposes of this study, flow data from stream gauges at High Noon (in the middle of MJR downstream of the DCM) and Pike's Crossing in the upper catchments section of the MJR was obtained.

Plate 7: Tadpole Netting at Baseline, Site D4



YAN-21-37 DMP GBFMP_212C

Source: Spatial Services NSW (2022)

LEGEND

- Mining Lease Boundary
- Mammy Johnsons River Catchment Boundary (approximate)
- Survey Site

DURALIECOAL
Part of the Yancoal Australia Group

DURALIE COAL MINE

Initial Investigation Survey Sites 2011

Figure 5

2.2 RESULTS

2.2.1 Frog Capture Data

A summary of the frog capture data is provided in Attachment 1. Over the course of the initial survey a total of 83 Giant Barred Frogs were caught, of these, 20 were recaptured and 17 were juvenile (i.e. less than 40 mm snout-vent length) (Plate 8).

Plate 8: Juvenile Giant Barred Frog Being Measured

The recapture rate of Giant Barred Frogs was not particularly high (being about 33%) but was sufficiently high to permit an initial population estimate to be calculated using the Peterson-Lincoln Index. By this method, the ten sites contained approximately 100 adult Giant Barred Frogs. If the frogs were evenly spaced along the riverbank, an adult Giant Barred Frog would be encountered every 20 m.

The sex ratio of the adult frogs caught was skewed towards male frogs (62% of the adult frogs caught were male). This is likely due to the relative ease in locating calling male frogs compared to the non-calling female frogs.

2.2.2 Tadpole Data

Tadpoles of all of the riparian frog species were caught during the surveys, including tadpoles of the Giant Barred Frog. However, Giant Barred Frog tadpoles were netted at lower rates compared to the other frog species, especially the Eastern Stony Creek Frog (*Litoria wilcoxii)* and the Eastern Leaf Green Tree Frog (*Litoria phyllochroa)*. Tadpoles were only found at four sites and the tadpoles were reasonably large (it was estimated that they were between three and four months old).

2.2.3 Habitat Data

Habitat data was specific for each of the sites, but general trends were apparent from the data. It was evident that the MJR has been significantly altered since European settlement. In general, the floodplain fringes of the river have changed as a result of land clearing and agriculture, resulting in the reduction of the floodplain's ability to hold water after flooding. The increased speed of water discharge into the river channel has resulted in rapid changes in river flows causing extensive scouring and bank destruction.

The river channel showed signs of several recent episodes of deep scouring, creating a much deeper main channel (Plate 9). These changes result in overflow frog breeding sites being lost. For the Giant Barred Frogs that breed in the main river channel, the more frequent episodes of high river flow are hazardous. Tadpoles can still survive in several small minor watercourses that feed into the main channel and serve as refuges during times of high river flow, however, many would be swept downstream to their death.

Plate 9: Bank Scouring and Tree Roots Exposed, MJR, Site D27

High river flow has also caused changes to riverbank profiles and the fringing vegetation. The clearing of riparian vegetation in the 1800s has left a permanent scar along the river with old river benches and ancestral river channels now deeply excised by the modern river channel. The removal of trees along the riparian corridor has led to the destabilisation of the banks, bank collapse in places, and the loss of topsoil during periods of high river flow. Exotic weeds, such as privet and lantana have been able to quickly establish on the scoured banks reducing native vegetation.

For Giant Barred Frogs, the changes in vegetation have also been problematic. Giant Barred Frogs rely on fringing vegetation for protection and cover. In addition, they utilise the leaf litter as superficial cover during seasons when the frogs are particularly active. The loss of vegetation and the replacement with exotic weeds means some sections of the river are no longer suitable as habitat for the frogs.

Water quality along the MJR changes markedly from site to site. In general, water quality is good immediately following periods of high water flow, but during times of low-flow, pockets of saline water concentrate in the pools rendering them unsuitable for frogs (and freshwater fish and invertebrates). The salt leaches from some of the siltstones and shales that form the rocky floor of the valley and the deepening of the river channel has cut into a number of salt-bearing geological strata. During times of low river flow, nutrient build-up is also evident. The nutrients appear to be derived from cattle that free range along the riparian corridor and from agricultural run-off. At times of sustained low river flow, sections of the river become unsuitable for frog and tadpole survival.

3. FIRST MONITORING SEASON (2011-2012)

3.1 INTRODUCTION

With the initial survey data established in early 2011 (Section 2), the survey was broadened to cover the entire length of the MJR catchment and hence determine the distributional range of Giant Barred Frogs in this system (Biosphere Environmental Consultants, 2012). Furthermore, the number of monitoring sites above and below the DCM were able to be extended. Two suitable control sites were found, one inside of the MJR catchment (Mill Creek) and one outside of the MJR catchment (Crawford River). The control sites were close enough to the DCM to experience the same weather and hydrological conditions as the MJR.

3.2 SURVEY SITES

Survey teams were sent to survey along as much of the MJR as possible. The survey teams were able to visit sites that cover over 70% of the total length of the river, starting in Ghin-Doo-Ee National Park in the Myall Ranges, to the junction of the MJR with the Karuah River just south of the township of Stroud Road. The MJR has two main arms, a northern arm referred to as Wards River and an eastern arm which is the continuation of MJR in to Ghin-Doo-Ee National Park.

In order to select suitable sites, the MJR catchment was divided into 200 m sections for its entire length. Sections of the river that do not appear to contain habitat for the Giant Barred Frog were discarded whereas 200 m sections that contained habitat for the Giant Barred Frog were retained for the study. As all of these sites could not be sampled within the time frame of the study, sub-sets of the 200 m sites were chosen at random from the remaining sections. Complete randomisation was not possible because of unavailable land access to some sites and long-term land ownership issues. Baseline data indicated that there was no necessity to keep the 200 m transects a set distance apart and so consecutive transect sites along a portion of the river was permissible.

Seven survey areas comprising 70 monitoring sites were eventually established, 50 of these were within the catchment of the MJR (Figure 6):

- Impact Areas within the MJR catchment: Areas 1, 2 and 3 (20 Sites).
- Impact Control Areas within the MJR catchment: Areas 4 and 5 (30 Sites); and
- Control Areas outside the MJR catchment: Areas 6 and 7 (20 Sites).

Figure 6 shows the survey areas within the MJR catchment and Mill Creek. Note: Area 7 is located approximately 25 km east of the MJR. These monitoring sites include the 10 sites established to collect initial data during January to March 2011 surveys.

Originally it was hoped that additional sites could be established in the Ghin-Doo-Ee National Park (Area 8[2]) and along the section of Wards River immediately upstream of the confluence with MJR. Both of these parts of the catchment proved to have too few Giant Barred Frogs to make the continuance of monitoring in the areas useful. Table 1 lists the location of the final survey areas and number of sites within each and Figure 6 shows their approximate locations.

These sites were largely adopted as a basis for subsequent monitoring seasons.

[2]Survey Area 8 was surveyed in the 2011-2012 monitoring period but these sites were only visited once in the 2012-2013 monitoring period. Survey Area 8 was discontinued as the number of Giant Barred Frogs found in them was too low to be of statistical use.

Table 1
Survey Areas and Monitoring Sites 2012-2013

Survey Area (Figure 6)	Location	Number of Monitoring Sites (Figure 6)
1	Lower MJR, downstream of confluence with Coal Shaft Creek	10 (11, 12, 15, 16, 18, 21, 24, 25, 27, 31)
2	Lower MJR, between Coal Shaft Creek and unnamed minor tributary	10 (29, 33, 35, 36, 38, 39, 40, 46, 54, 59)
3	Lower MJR upstream of unnamed minor tributary to confluence with Wards River	10 (61, 62, 66, 67, 68, 70, 73, 74, 81/-273, 96/-286)
4	Lower Wards River, from confluence with MJR to the first ford on Glen Road.	10 (282, 285, 287, 83, 85, 87, 95, 98, 118, 121)
5	Upper Wards River, from first ford to Craven Trig Road Crossing, The Glen Nature Reserve	10 (390, 391, 395, 398, 400, 405, 406, 411, 413, 414)
6	Mill Creek	10 (MC 8, MC 17, MC 18, MC 19, MC 37, MC 38, MC 46, MC 47, MC 66, MC 67)
7	Crawford River	10 (232, 233, 239, 240, 242, 243, 248, 249, 250, 253)

Note: Some areas proposed by the GBFMP were discarded or adapted due to land access and/or absence of Giant Barred Frogs. Areas 8 and 9 were discarded due to low numbers of Giant Barred Frogs. Areas 6 and 7 were adjusted to a more suitable and easily accessible area.

3.3 TIMING

The survey method required that each site be surveyed for three nights during six survey periods during the period from late August to the start of April each year. The survey dates for the 2011-2012 sampling season are presented in Table 2. Note: the February 2012 survey was cancelled due to dangerous flood conditions within the catchment.

Table 2
Survey Dates 2011-2012

Survey Period	Dates	Survey Team	Number of Sites Surveyed	Notes
1	23-28 September 2011	3 teams of 2 people	17	River recovering after July floods.
2	26-31 October 2011	6 teams of 2 people	43	River surging through regular rainfall in catchment.
3	23-28 November 2011	8 teams of 2 people	43	Regular rainfall continuing.
4	11-16 January 2012	8 teams of 2 people	55	River levels low.
5	February 2012	N/A	N/A	Survey abandoned. Flooding.
6	14-19 March 2012	8 teams of 2 people	57	Periodic heavy rain causing river surges.

3.4 METHODS

The survey methods that were used for the Giant Barred Frog monitoring program are consistent with the Department of the Environment, Water, Heritage and the Arts (2010) *Survey Guidelines for Australia's Threatened Frogs* and DECC (2009) *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna - Amphibians*. The work was carried out under Scientific Licence (S) 1000038.

The monitoring program included survey methods as described below.

3.4.1 Nocturnal Frog Surveys

Each 200 m transect was surveyed by two personnel. The survey included 30 minutes per 200 m length (i.e. the total search time per site was 1 person hour).

Upon arrival at each transect, the surveyors listened for three minutes and recorded all calling frogs. The surveyors then moved slowly through the transect area using headlamps to detect calling and non-calling Giant Barred Frogs. Call imitations were used at the start, near the middle, and at the end of each transect to try to elicit calling by male Giant Barred Frogs.

Any Giant Barred Frogs detected were caught when possible. Captured frogs were:

- sexed (i.e. male or female);
- if female, examined to determine if she is gravid;
- classified as adult, sub-adult or juvenile;
- weighed (using spring balances);
- measured for snout-vent length (using dial callipers) and classified using growth index (Table 3);
- micro-chipped[3];
- visually inspected for signs of injury or disease;
- swabbed for Chytrid testing; and
- released at the site of capture.

The growth rate of frogs is not constant and is altered by environmental conditions such as food availability, temperature and other factors. The snout-vent lengths of Giant Barred Frogs were grouped into indexes (Table 3).

Table 3
Growth Index for Giant Barred Frog Juveniles and Adults

Growth Index Category	Snout-Vent Length Ranges (cm)
E	3-5
F	>5-7
G	>7-9
H	>9

Observations of behaviours including amplexus, oviposition and egg masses were also noted. In addition, each survey recorded an estimate of the number of calling males at each site (both banks).

[3]Only individuals classified as adults or sub-adults are micro-chipped.

Other species of non-target riparian frogs were also recorded including an estimate of the number of individuals of each species.

3.4.2 Diurnal Tadpole Surveys

Diurnal tadpole surveys were also undertaken at each Giant Barred Frog monitoring site. Ten sweeps using a long-handled net were used to sample the water along the stream bank for tadpoles. Tadpoles caught in the sweeps were:

- measured for snout-vent length (using dial callipers);
- classified using a growth index (Table 4);
- visually inspected for external signs of injury (e.g. from fish or bird attack); and
- inspected using a magnifying glass to assess the condition of their buccal disc and denticles, including the possible early stages of Chytrid infection.

Tadpoles caught during the surveys were classified using a growth index (Table 4). Each tadpole was assigned to a growth index category (A, B, C or D) based on the growth stage of the tadpole. The index is a simplified grouping of tadpole growth stages into categories that can be easily recognised in the field.

Table 4
Growth Index for Giant Barred Frog Tadpoles

Growth Index Category	Growth Stages	External Features	Age (Approximate Only)
A	1-23	Cornea transparent; external gills present	1-10 days
B	24-25	Cornea pigmented, no limb buds	10-20 days
C	26-42	Hind limbs present	20-120 days
D	43-46	Fore limbs present	80-300 days

All tadpoles were released at the site of capture. During the diurnal surveys, observations were also made of other aspects of the natural history of the Giant Barred Frog, such as evidence of oviposition or amplexus, and the location of any observed egg masses.

3.4.3 Hydrological Conditions

The hydrological conditions of the MJR were documented prior to and during the Giant Barred Frog monitoring surveys. In summary, this included:

- rainfall, maximum and minimum temperature and relative humidity data obtained from the on-site weather stations located at the DCM and Stratford Mining Complex;
- a description of the weather and stream flow conditions experienced during each survey;
- stream flow monitoring data from GS209002 and at the High Noon site on the MJR (Figure 4);
- surface water quality data for the MJR, Karuah River, Coal Shaft Creek and other tributaries of the MJR including data from continuous EC sensors/loggers on MJR and on tributaries of the MJR;
- the measurement of turbidity, dissolved oxygen content, percent oxygen saturation, oxidation-reduction potential, pH, salinity, conductivity and water temperature at the Giant Barred Frog monitoring sites using a Yeo-Kal portable water meter during the tadpole surveys; and
- the measurement of water temperature during the nocturnal Giant Barred Frog monitoring surveys.

Stream characteristics recorded at each site included:

- river depth;
- river width;
- flow rate;
- presence of pools;
- presence of riffles;
- water quality observations (e.g. clarity and presence of algae);
- stream bank characteristics (e.g. profile, composition, vegetation cover and litter depth);
- water temperature; and
- observations of changes to bank conditions and observed impacts.

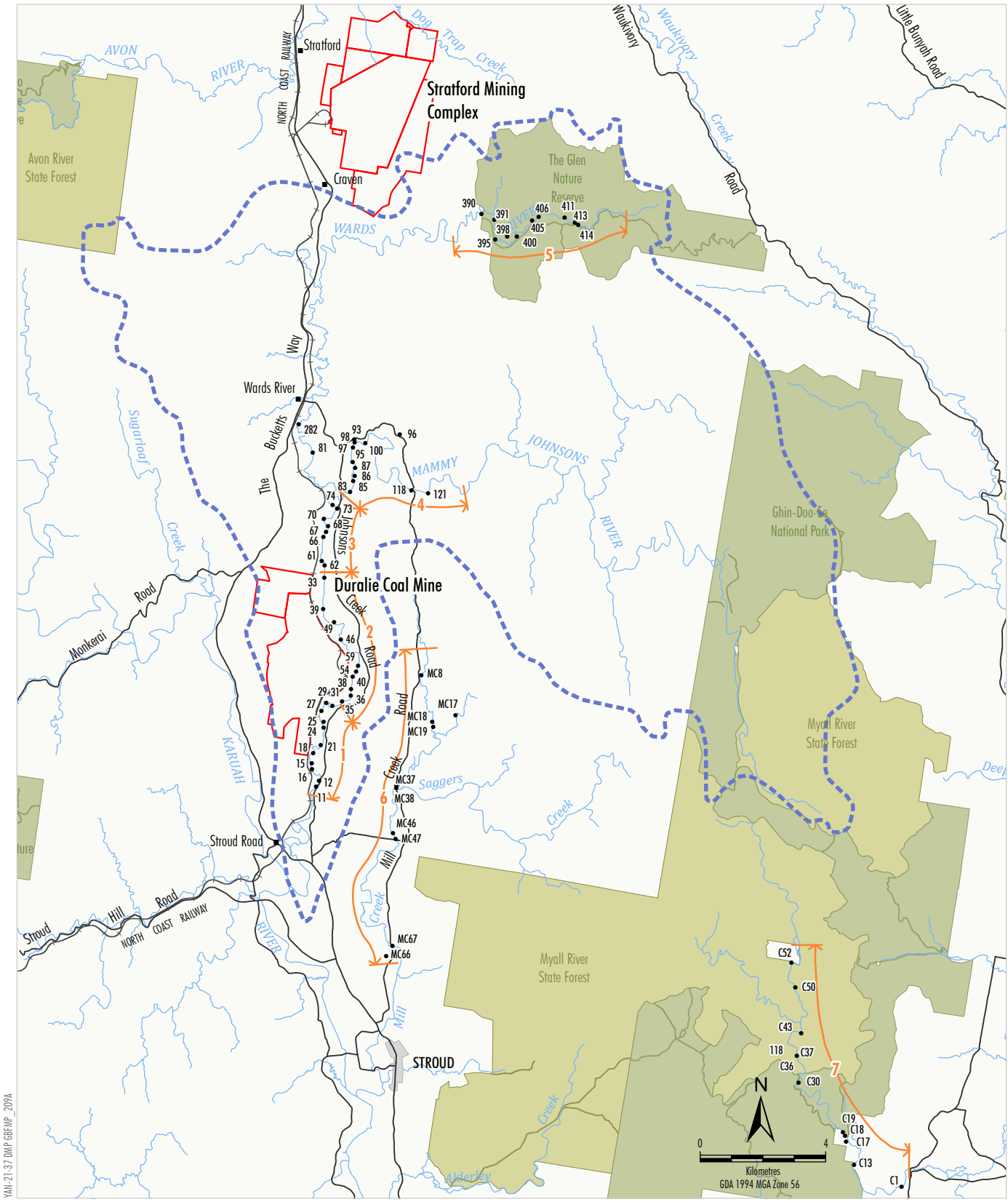
Stream flow data was also available for the gauging station located at Pikes Crossing (GS209002) (Attachment 2 Chart 1). The location of the gauging station and surface water quality monitoring sites is shown on Figure 4.

3.4.4 Chytrid Fungus

Skin swabs from captured Giant Barred Frogs were taken in the field in accordance with the NPWS *Hygiene Protocol for the Control of Disease in Frogs 2001*. Samples were forwarded to the Newcastle University for analysis.

3.4.5 Condition of the Giant Barred Frog Habitat

The habitat assessment results for each Giant Barred Frog monitoring site were used to assess changes in habitat during each survey period. Vegetation, topography, land use and other site features were recorded using the proforma in Attachment 1. Habitat assessment sites are shown on Figure 7.



YAN-21-37 DNP GBFMP_209A

LEGEND

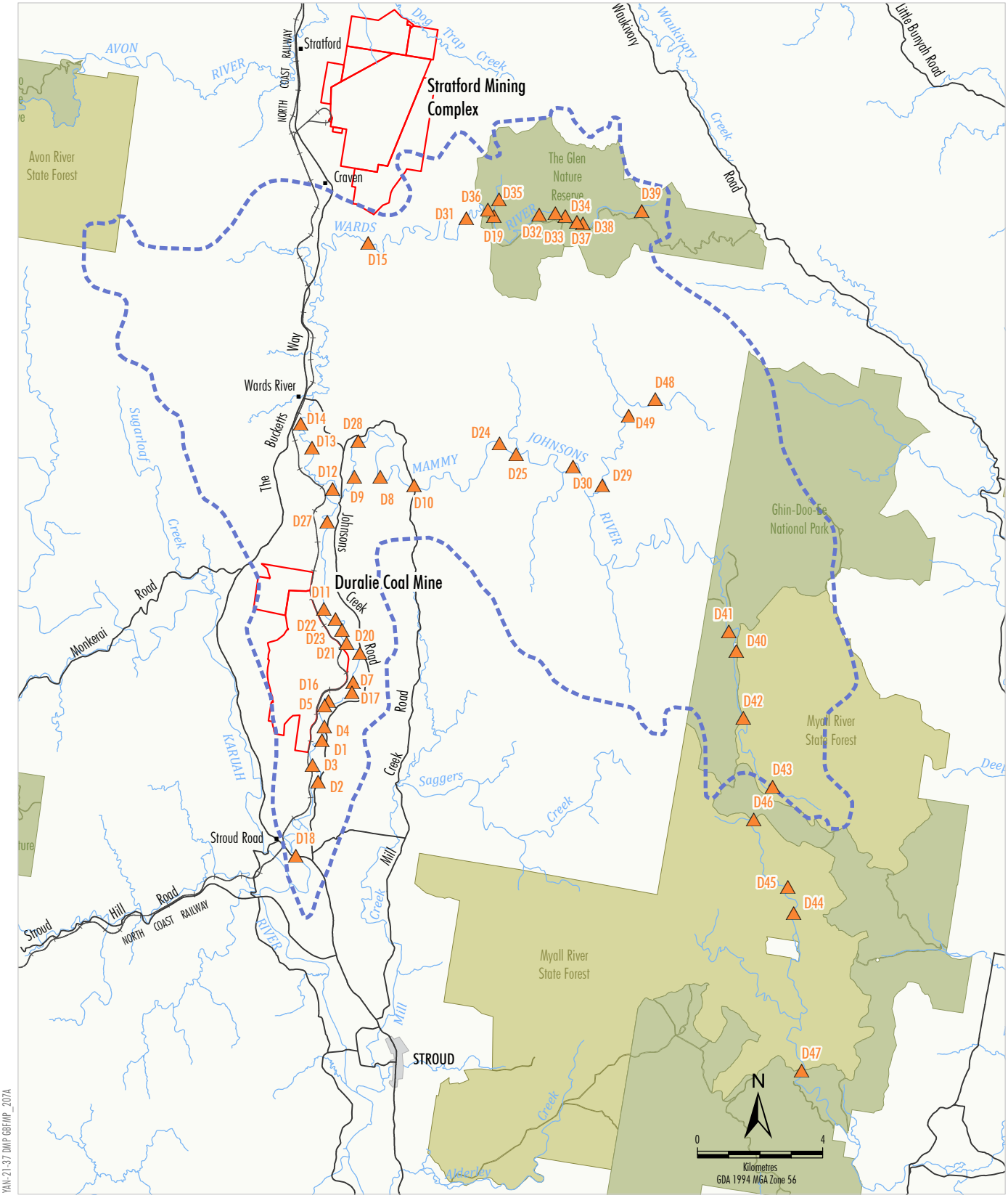
- Mining Lease Boundary
- National Park, Nature Reserve or State Conservation Area
- NSW State Forest
- Mammy Johnsons River Catchment Boundary (approximate)
- Monitoring Area
- Monitoring Site

Source: Spatial Services NSW (2022)

DURALIE COAL MINE

Giant Barred Frog Survey Areas and Monitoring Sites (2011-2013 Monitoring Seasons)

Figure 6



YAN-21-37 DMP GBFMP_207A

LEGEND

- Mining Lease Boundary
- National Park, Nature Reserve or State Conservation Area
- NSW State Forest
- Mammy Johnsons River Catchment Boundary (approximate)
- Existing Habitat Assessment Site

Source: Spatial Services NSW (2022)

DURALIE COAL MINE

Habitat Assessment Sites

Figure 7

3.5 RESULTS

3.5.1 Giant Barred Frog Captures

Frog captures in each survey area of the catchment are presented in Figure 8.

3.5.2 Population Structure

An approximation of the population structure of each area was determined by plotting the percentage of individuals in each size class against frequency. The data for areas 1, 2, 3, 4, 6 and 7 is presented in Tables 5 and 6 (Area 5 had too few frog captures to provide useful data for a population analysis).

Table 5
Size Class Frequency Data for Tadpoles 2011-2012

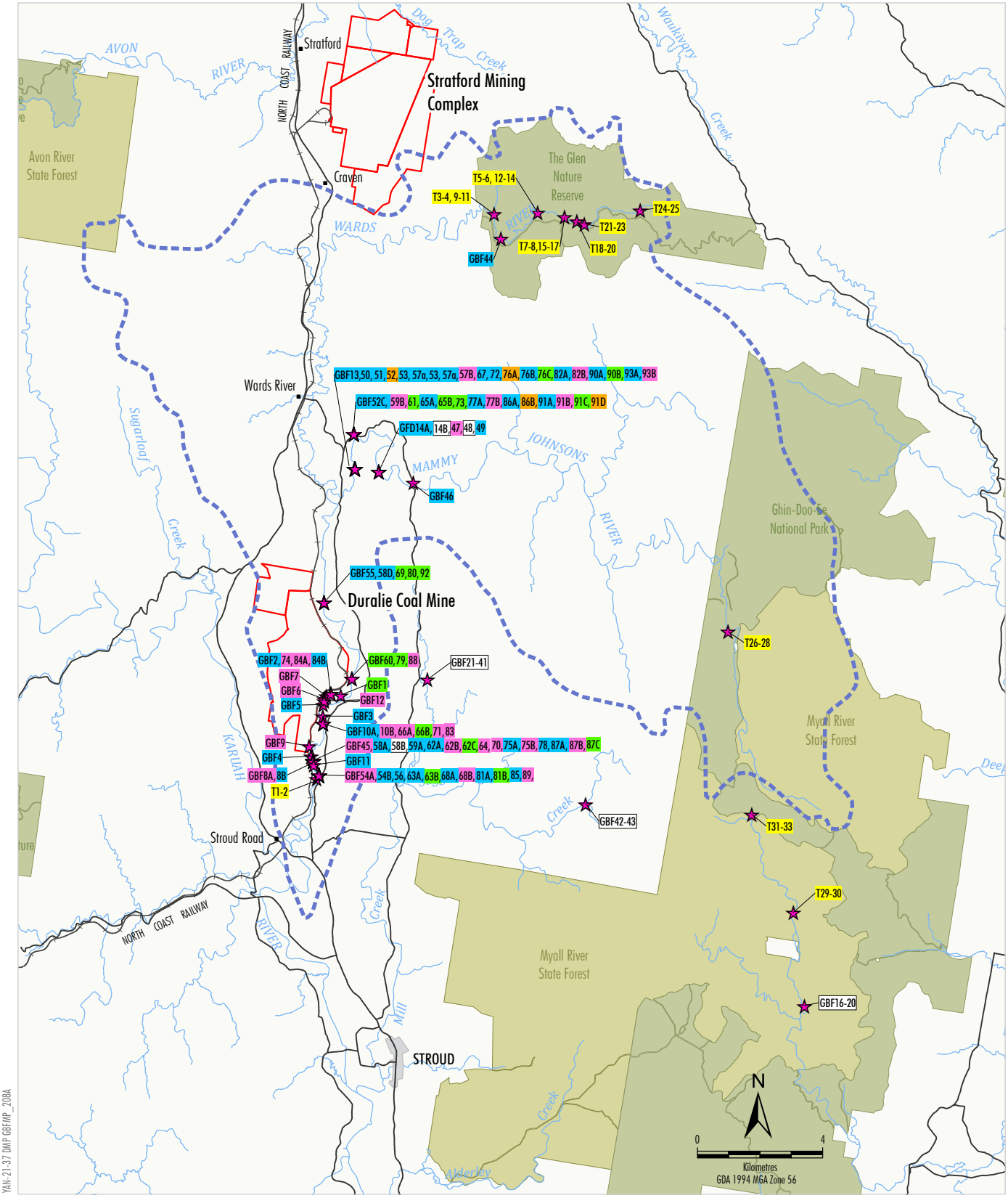
Area	% Tadpoles (Stages 1-23)	% Tadpoles (Stages 24-25)	% Tadpoles (Stages 26-42	% Tadpoles (Stages 43-46)
Growth Index Category	A	B	C	D
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	50	50
5	50	34	16	0
6	0	0	0	0
7	22	72	6	0

Table 6
Size Class Frequency Data for Frogs 2011-2012

Area	% Juveniles (less than 40 mm SVL)	% 40-65 mm SVL	% 65-85 mm SVL	% Greater than 85 mm SVL
Growth Index Category	D	E	F	G
1	40	22	28	10
2	62	24	13	1
3	21	55	20	4
4	39	32	25	4
5	13	50	37	0
6	23	56	19	2
7	17	30	40	13

SVL = snout-vent length.

The age structure of the Giant Barred Frog population, based on growth rate classifications of tadpoles (Table 4) and the snout-vent length measurements of captured Giant Barred Frogs, is presented in Attachment 2 Chart 2.



YAN-21-37 DMP GBFMP_208A

LEGEND

- Mining Lease Boundary
- National Park, Nature Reserve or State Conservation Area
- NSW State Forest
- Mammy Johnsons River Catchment Boundary (approximate)
- Known Giant Barred Frog Location (approximate)
- Male Adult(s)
- Female Adults(s)
- Sub-Adults(s)
- Juveniles(s)
- Tadpole(s)
- Undetermined (e.g. spotted by eye shine or not specified in record)

Note: Each star represents a general location at which *Mixophyes iteratus* has been recorded (by call, sighting and/or capture) rather than the number recorded.

Source: Spatial Services NSW (2022)

DURALIECOAL
Part of the Yancoal Australia Group

DURALIE COAL MINE

Giant Barred Frog Capture Locations
2011-2012 Monitoring Season

Figure 8

3.5.3 Estimated Population Size

Based on the recapture data, an initial population estimate was calculated for each area (note that the error in performing these estimates on individual areas becomes larger compared to estimates of the total population in the MJR catchment) (Table 7). The area population estimates were calculated as it gives an indication of the number of frogs in each section of the catchment. The population size determined from the recapture data was calculated using the Mark Recapture technique (MARK). For the purposes of easy comparison, the figures have been rounded to the nearest whole number, and the size of the error has been expressed as a number of frogs (rather than a proportion of the average).

Table 7
Survey Area Population Estimates 2011-2012

Area	Population Estimate
1	53 - 148
2	16 - 95
3	32 - 71
4	87 - 153
5	1 - 3
6	14 - 19
7	119 - 235

If the data for the areas within the MJR catchment is pooled, the population estimate for Giant Barred Frogs in the catchment area is approximately 310 adult frogs (Areas 6 and 7 are not part of the MJR catchment).

3.5.4 Condition of the Giant Barred Frog Habitat

The results of habitat assessments conducted at a number of sites indicated that despite the impacts of previous land clearing and ongoing agricultural impacts, most of the study sites along the MJR contained some suitable habitat for the Giant Barred Frog. Habitat suitability was tightly correlated with the extent of canopy and ground cover vegetation. Sites that had lost either their ground cover or had reduced canopy cover had far fewer frogs than neighbouring sites where the vegetation was more intact.

Hydrological Conditions

Stream flow data from Pikes Crossing (GS209002) on MJR from 1973 onwards is presented in Attachment 2 Chart 1. Stream flows were characterised by low to moderate flows for long periods, with periods of higher discharge following heavy rains. Such a rainfall response is typical of small to medium sized upland catchments (Gilbert & Associates, 2010). In terms of low flow persistence, zero flow has been recorded on the MJR on 5.3% of days. Averaged over the full period of available data, stream flow in MJR is estimated to amount to some 28% of rainfall (Gilbert & Associates, 2010).

3.5.5 Chytrid Fungus

During the 2010-2011 monitoring period, approximately 50% of Giant Barred Frogs tested were Chytrid-positive, but most had relatively low infection titres. Approximately 64% of Eastern Stony Creek Frogs (*Litoria wilcoxii)* tested were Chytrid-positive, and approximately 45% of Eastern Leaf Green Tree Frogs (*Litoria phyllochroa*) tested were positive. The location of Chytrid-positive Giant Barred Frogs was dispersed widely from the lower and middle parts of the MJR catchment. The prevalence of Chytrid declined significantly in the upper catchment.

3.6 DISCUSSION

3.6.1 Distribution

Frog surveys carried out prior to the 2011-2012 monitoring period established the limits of distribution of Giant Barred Frogs in the MJR catchment. Based on population estimates (Table 7), the frogs are not distributed evenly throughout the catchment but occur in discrete areas. In general, Giant Barred Frogs are mostly present in the lower section of the catchment, but notable clusters of frogs were found in several parts of the middle section of the river. Giant Barred Frog numbers were very low in the upper sections of the river (in Ghin-Doo-Ee National Park).

There were discrete areas where the frogs are absent in the catchment; including the lower section of Wards River from its junction with the MJR through pastureland northwards until it approaches the Glen Nature Reserve. The frogs are also absent from the entire Terreel Valley portion of the MJR tributary (Figure 8).

These significant gaps in the distribution of the Giant Barred Frog are due to loss of habitat. The lower sections of the Wards River have undergone a radical loss of riparian vegetation resulting in the establishment of dense privet groves within the riverbanks. In the Terreel Valley, not only has the riparian vegetation been cleared, but the surrounding land has been cleared over most of the valley.

It was not clear if the groups of Giant Barred Frog present in the upstream sections of the Wards River and MJR contribute to the populations of Giant Barred Frog further downstream. The large sections of river corridor that lack habitat for these frogs may isolate the frog communities from each other. It is possible that some tadpoles may occasionally be washed down from the upstream sites and manage to survive in the lower parts of the catchment.

The greatest number of Giant Barred Frogs found was in the Crawford River catchment (Area 7) where the numbers and densities of Giant Barred Frogs greatly exceed the numbers found in the MJR catchment (Areas 1 to 5). The Giant Barred Frogs in the Mill Creek catchment more closely approximate the numbers and densities found in the MJR catchment. Mill Creek Valley has been impacted by land clearing and agriculture in a similar way to the MJR valley. The Crawford River area has scarcely been impacted by agriculture but has been impacted by forestry activities.

3.6.2 Population Size and Structure

The MJR supports a viable population of Giant Barred Frog. The frogs are not evenly distributed across the catchment and there are sections where they are absent or low in density. It is evident from the 2011-2012 capture data (Biosphere Environmental Consultants, 2012) that the lower parts of the MJR (Areas 1 and 2) contain far fewer Giant Barred Frogs than equivalent areas further upstream (Areas 3 and 4). Based on the initial investigation's sample data alone, it was not possible to determine if the lower density of Giant Barred Frogs in the lower sections of the river was due solely to habitat degradation, or impact associated with the presence or operation of the DCM.

The frog densities recorded along the Crawford River were in keeping with Giant Barred Frog densities recorded by Newell (pers. com) in his study of Giant Barred Frog in northern NSW on land also unaffected by agriculture.

3.6.3 Population Dynamics

Most of the subgroups of Giant Barred Frog along the MJR show a relatively high proportion of young animals (i.e. between 1-3 years). This suggests that breeding had been more successful in the MJR in the last few years compared to the years immediately before. This response may be a direct result of the changes in rainfall patterns over the past two years with greater and more regular rainfall being experienced in the MJR catchment (DCM data). Some sub-populations (e.g. Giant Barred Frogs in Areas 1 and 3) have relatively few older animals in the population, again indicative of years of low or no recruitment.

3.6.4 Habitat Assessment

Habitat variables have been recorded for all survey sites, and for a number of other non-survey sites in the MJR catchment. The variables include measurements of the nature and extent of the fringing vegetation, the nature and extent of the riparian tree line, water flow, stream dimensions, presence or absence of pools and riffles, and indicators of disturbance to the sites (e.g. by cattle trampling, recent floods or agricultural activity).

General Habitat Description

The riparian vegetation along all of the lower and middle sections of the MJR and Wards River has been greatly reduced or removed in places. Most of the removal of this vegetation occurred decades ago when the valley was being opened up to dairy farming. Trees were removed up to the creek banks, or in some cases, they were removed from inside the creek banks as well. The extent of tree removal has been responsible for extensive erosion of the lower and middle sections of the MJR. Another consequence was the widespread occurrence of invasive weeds (especially privet and lantana) in areas previously occupied by riparian vegetation (Plate 10).

The only areas where relatively intact riparian vegetation was found was in the headwaters of the MJR where habitat for the Giant Barred Frog is mostly absent. In these areas another species of Barred River Frog (*Mixophyes balbus*) occurred. This species is more suited to the rockier terrain.

The deep scoring of the middle and lower sections of the MJR has removed pool and backwaters from the water course creating a single, deep channel that is prone to sudden rises and drops in water level. The surging nature of the river under these conditions makes the survival of *Mixophyes barbus* tadpoles in the lower and middle MJR very difficult.

Impacts on Giant Barred Frogs

The observable impacts on the Giant Barred Frogs are varied and include habitat loss through land clearing, current or past agricultural practices, changes to river flow patterns, changes in the frequency of flash flooding, cattle trampling of riparian ground cover vegetation (Plate 11), cattle trampling of frogs, and addition of agricultural chemicals to the river. Allied with many of these impacts is the subsequent replacement of native riparian vegetation with invasive weeds and predatory feral species (such as foxes and pigs).

Plate 10: Extensive Privet Infestation Lower Wards River

3.6.5 Chytrid Fungus

The rates of Chytrid infection in captured frogs (approximately half) during this monitoring period indicate past infections in the MJR catchment and immediate surrounds. The resilience of the Giant Barred Frog population despite infection attests to their previous exposure and implies some degree of heightened immunity. It is likely that the disease will become prevalent whenever the frogs are stressed, such as during winter. To test this hypothesis, skin swabbing during the 2011-2012 monitoring period was undertaken during early spring so as to get a better indication of likely infection activity levels, and possibly a measure of mortality rates.

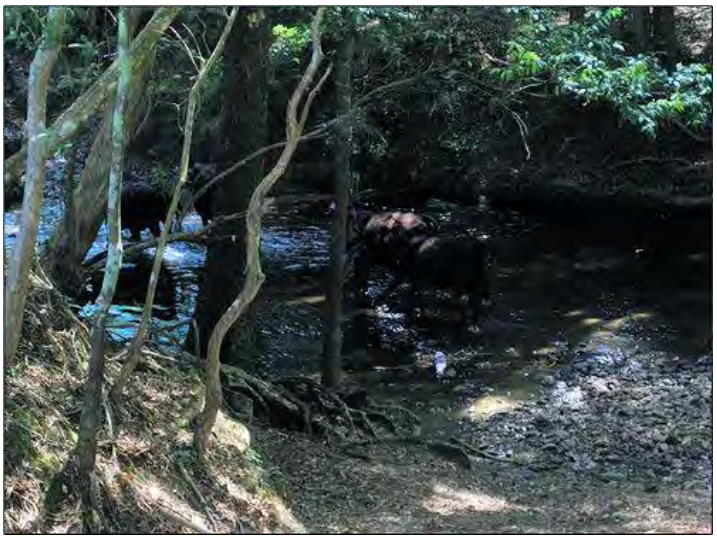


Plate 11: Cattle Frequent the Unfenced Sections of the MJR

4. SECOND MONITORING SEASON (2012-2013)

4.1 INTRODUCTION

The first full monitoring season was carried out between September 2011 and March 2012 (Section 3). This monitoring period, while successful, was handicapped by difficulties in establishing long-term access to sites and the complete loss of one sampling session due to extensive localised flooding. Despite these problems, the first comprehensive population survey was completed and detailed information was collected about the numbers and distribution of Giant Barred Frogs in the MJR catchment and in nearby control sites.

The second monitoring season was carried out between September 2012 and February 2013 (Biosphere Environmental Consultants, 2013). This season did not have the same site availability issues that dogged the previous survey season, and no survey periods were lost due to flooding or bad weather. Biosphere Environmental Consultants again undertook the surveys for the Giant Barred Frog and the results were integrated into the DCM Giant Barred Frog Study report.

4.2 SURVEY SITES

Survey areas were nominated at the first monitoring season (Section 3.2) and these sites were adopted as a basis for the second monitoring season with the exception of Survey Area 5 which had too few frog records (Figure 6). The survey areas and monitoring sites are listed in Table 1.

The survey areas surveyed between September 2012 – March 2013 can be classified as:

- Potential impact sites within the MJR catchment survey: Survey Areas 1 and 2 (20 Sites);
- Upstream ‘control’ sites within the MJR catchment: Survey Areas 3, 4 and 5 (18 Sites); and
- Study Areas outside the MJR catchment: Survey Areas 6 and 7 (20 sites).

4.3 TIMING

Survey timing is as described in Section 3.3. The survey dates for the 2012-2013 sampling season are presented in Table 8.

Table 8
Survey Dates 2012-2013

Survey Period	Dates	Survey Team	Survey Areas	Number of Sites Surveyed	Notes
1	21-26 September 2012	8 teams of 2 people	1-4, 6 and 7	58 (3 times each)	River levels low.
2	18-23 October 2012	8 teams of 2 people	1-4, 6 and 7	58 (3 times each)	River levels low.
3	15-20 November 2012	8 teams of 2 people	1-4, 6 and 7	58 (3 times each)	River levels low.
4	13-18 December 2012	8 teams of 2 people	1-4, 6 and 7	58 (3 times each)	River levels low.
			5	10 (once each)	
5	17-22 January 2013	8 teams of 2 people	1-4, 6 and 7	58 (3 times each)	River levels increasing.
6	14-19 February 2013	8 teams of 2 people	1-4, 6 and 7	58 (3 times each)	River in recovery phase after earlier high flows.
			5	10 (once each)	

4.4 METHODS

Details of monitoring methods are described in Section 3.4.

For this monitoring period and monitoring periods that follow, frog capture data was analysed by Dr Ian Lenane using MARK. Using this program, population estimates were calculated for each night, month and survey area, considering each sampling session (three nights of visits) as a closed population study. In addition:

1. For each session visit, the marked frogs in the area were considered to be the ones encountered on the other two nights of the session and the other collected were regarded as unmarked.
2. The hypergeometric probability distribution (HPD) has been used to estimate the number of frogs present on each night of the session. A standard maximum likelihood estimate (MLE) formula of the total number of frogs in the area have been used, based on that probability distribution.
3. 5% upper and lower confidence bounds have been calculated for the population present on each night (using standard calculations for the HPD). A 50th percentile (median value) has also been calculated for the estimated population sizes. The median is a good estimate of the population size and can be calculated in cases where the MLE does not exist (i.e. where all the frogs collected on the night in question were not encountered on the other 2 nights).
4. The estimates for the individual visits are independent of each other. They can be combined through a number of standard formulas to allow one population estimate to be provided for each monitoring session.

4.5 RESULTS

4.5.1 Nocturnal Frog Surveys

Frogs were present in all areas, though some areas had noticeably fewer frogs than others. From these records it is estimated that Area 5 has the smallest population, while Area 7 has the largest. Initial estimates on the Giant Barred Frog population structure and population size are presented in Sections 3.5.2 and 3.5.3, respectively. Giant Barred Frog records within the MJR catchment and immediate surrounds is shown on Figure 9.

Injured

Injured frogs were recorded within Areas 2, 3 and 4. One individual was recorded in each of these areas. All of the frogs suffered limb damage and were most likely injured by being trodden on by cattle while hiding in the grassy areas adjacent to the riverbanks.

Gravid

During surveys, eight female Giant Barred Frogs were found to be gravid. Of these, seven were recorded within Area 7, while the other gravid female was found in Area 1.

4.5.2 Diurnal Tadpole Surveys

Tadpoles were recorded rarely. Of all sites visited over six survey periods, 143 tadpoles were recorded, 73 of which were Giant Barred Frogs (*Mixophyes iteratus*). The remaining tadpole species were from Wilcox's Frog (*Litoria wilcoxii*), Eastern Leaf Green Tree Frog, Tusked Frog (*Adelotus brevis*) and Peron's Tree Frog (*Litoria peronii*).

4.5.3 Population Structure

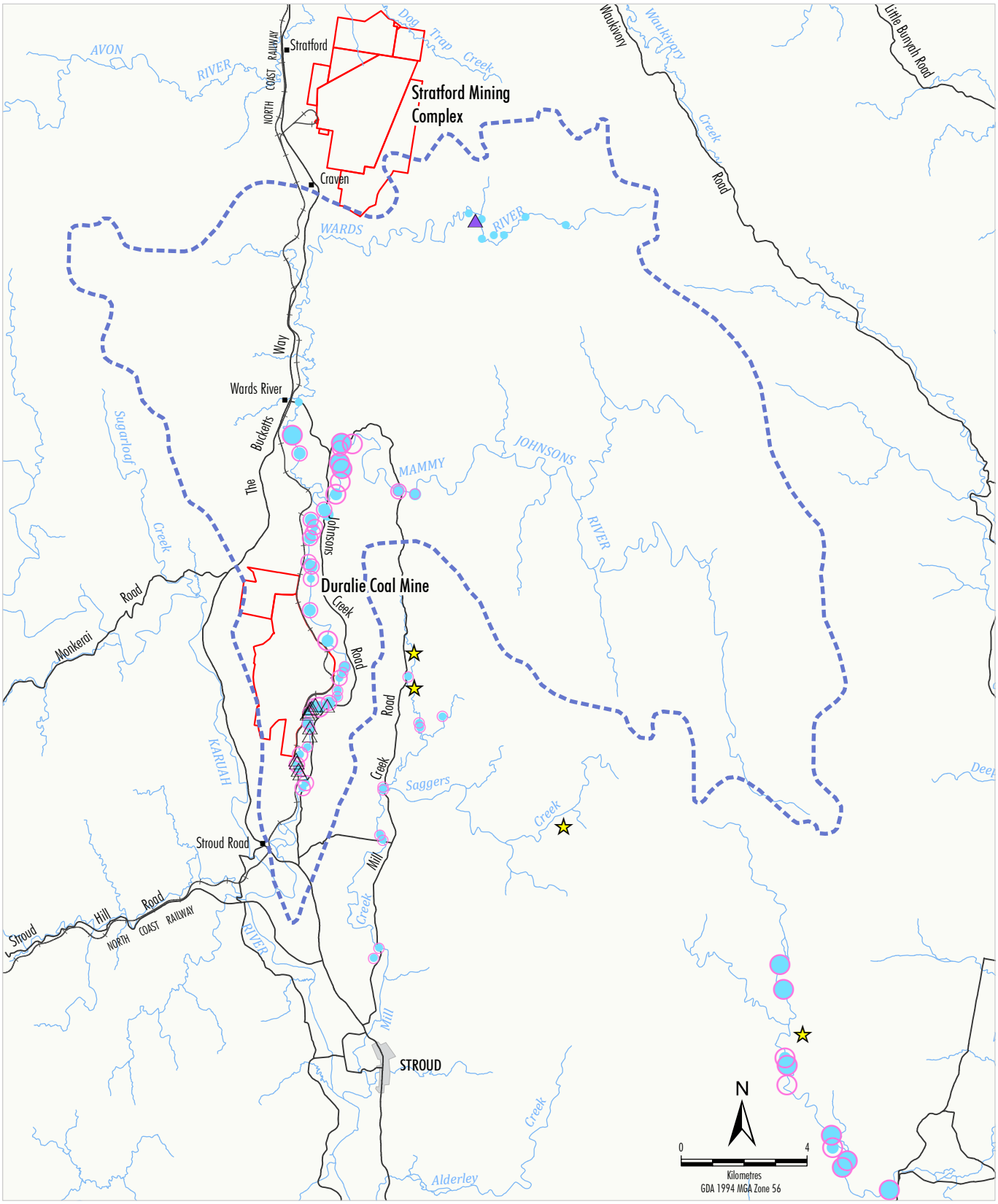
An approximation of the age structure of the Giant Barred Frogs present in each area was determined by plotting the percentage of individuals in each size class (tadpoles [Table 9] and frogs [Table 10]) against frequency. The data for Areas 1, 2, 3, 4, 6 and 7 is presented in Tables 9 and 10 (Area 5 had too few frog captures to provide useful data for analysis). The data for age classes for each frog or tadpole captured in areas 1 to 7 is reproduced graphically in Attachment 2 Chart 3.

Tadpoles

Tadpoles of all frog species along the MJR, including the Giant Barred Frog, were relatively uncommon during this survey period. For all sites visited over six survey periods, only 143 tadpoles were recorded, 73 of which were Giant Barred Frogs. No tadpoles were recorded within Areas 2, 3 or 6. The majority of tadpoles were recorded as growth index B (17), the least in growth index D (4).

Adults

Adult Giant Barred Frogs (i.e. those in growth indexes E to H) were still present in all areas along the river foreshore. Area 7 contained significantly more individual adult frogs than other areas. Areas 1, 2 and 4 showed a decreasing trend in individual frog numbers with increasing growth index, whilst the reverse was true for Area 7 up to growth stage G.



YAN-21-37 DMP GBFMP_211A

LEGEND

Mining Lease Boundary

Mammy Johnsons River Catchment Boundary (approximate)

No. of Records	Source
(1-20)	Atlas of NSW Wildlife (2013)
(1-20)	Biosphere Environmental Consultants (2012-2013)
(21-50)	Biosphere Environmental Consultants (2012-2013)
(51+)	Biosphere Environmental Consultants (2012-2013)
(1-20)	Biosphere Environmental Consultants (2010-2012)
(21-50)	Biosphere Environmental Consultants (2010-2012)
(51+)	Biosphere Environmental Consultants (2010-2012)
(1-20)	Ecobiological (2011)
(1-20)	Ecobiological (2009)

Source: Spatial Services NSW (2022)

DURALIECOAL
Part of the Yancoal Australia Group

DURALIE COAL MINE

Giant Barred Frog Records
from the 2012-2013 Monitoring Season

Figure 9

Table 9
Size Class Frequency Data for Tadpoles 2012-2013

Area (Figure 9)	% Tadpoles (Stages 1-23)	% Tadpoles (Stages 24-25)	% Tadpoles (Stages 26-42)	% Tadpoles (Stages 43-46)
Growth Index Category*	**A**	**B**	**C**	**D**
1	0	100	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	50	50
6	0	0	0	0
7	22	72	6	0

*Growth Index categories are provided in Table 4

Table 10
Size Class Frequency Data for Frogs 2012-2013

Area (Figure 9)	% Juveniles (< 40 mm SVL)	% 40-65 mm SVL	% 65-85 mm SVL	% Greater than 85 mm SVL
Growth Index Category	**E**	**F**	**G**	**H**
1	3	6	11	23
2	5	12	17	2
3	13	23	11	6
4	52	37	16	4
6	4	6	6	9
7	27	16	39	56

mm = millimetre

Potential impact survey areas within the MJR catchment (i.e. Areas 1 and 2) contained mostly (approximately 85%) growth stages G and H. This is very different from the previous season's data where significantly greater numbers of smaller frogs (i.e. size class E and F) were found. This suggests that the 2012-2013 season did not greatly add to the local populations in sites along the lower parts of the MJR catchment.

Upstream 'control' sites within the MJR catchment (i.e. Areas 3, 4 and 5) contained approximately 3% of individuals of growth class H. Growth classes E, F and G for these areas had a relatively even spread of individuals (40%, 32% and 25%, respectively). This may indicate a younger-aged population, however it is expected that this interpretation is a more accurate reflection of the population age dynamics within Area 4. Area 5 contained very few individuals and so the sample is more likely to be skewed towards older frogs.

Study Areas outside the MJR catchment (i.e. Areas 6 and 7) contained approximately 70% of individuals of growth classes F and G with approximately 17% and 13% of growth classes E and H, respectively. The low levels of adolescent (growth class E) and full adults (growth class H) may indicate that full adults move on after reproducing and that there are low levels of recruitment.

Whilst the number of individuals within each survey area differed, the distribution pattern of individuals per growth class between the Impact Areas and Control Areas within the MJR catchment were similar (i.e. decreasing number of individuals as growth class progressed).

The Control Areas outside the MJR catchment showed the reverse trend through growth classes E to G, then dropping in numbers for growth class H.

4.5.4 Estimated Population Size

Based on the recapture data, a population estimate was calculated for each area (note that the error in performing these estimates on individual areas becomes larger compared to estimates of the total population in the MJR catchment) (Table 11). This calculation was performed as it gives an indication of the number of frogs in each area. The population size determined from the recapture data was calculated using MARK. For the purposes of easy comparison, the figures have been rounded to the nearest whole number, and the size of the error has been expressed as a number of frogs (rather than a proportion of the average).

Table 11
Survey Area Population Estimates 2012-2013

Survey Area	Estimate of Population Size in Each Study Area
1	53 – 148
2	16 – 95
3	32 – 71
4	87 – 153
5	1 – 3
6	14 – 19
7	119 – 235

4.5.5 Condition of the Giant Barred Frog Habitat

A summary of quantitative habitat data is presented in Table 12.

Table 12
Quantitative Habitat Assessment Data 2012-2013

Survey Area	Stream								Flow (m/s)	
	Width Max (m)	Width Min (m)	Depth Max (m)	Depth Min (m)	Vegetation (%)	Rock (%)	Leaf (%)	Bare (%)	Max	Min
1	14.5	7.5	1.4	0.5	51.2	6.0	25.9	16.9	0.4	0.2
2	13.6	6.4	1.6	0.6	37.6	8.0	45.2	8.4	0.3	0.1
3	11.7	5.7	1.3	0.6	38.1	8.6	33.6	19.4	0.4	0.2
4	9.2	4.5	1.0	0.4	38.1	2.0	42.5	17.2	0.6	0.3
5	4.1	1.9	0.6	0.2	60.5	19.0	13.2	7.3	0.4	0.2
6	6.8	3.6	0.9	0.4	54.0	22.0	21.5	2.5	0.2	0.1
7	11.1	6.1	1.3	0.5	32.4	13.0	38.9	15.2	0.4	0.2

m/s = metres per second

Damage from cattle was evident in all survey areas with the exception of Area 5 (The Glen Nature Reserve). Areas 1 to 4 showed much evidence of vegetation clearance, Areas 6 and 7 varied in presence of vegetation clearance and Area 5 had no evidence of vegetation clearance.

Areas 4, 5 and 6, all upstream locations, generally had narrower and shallower streams. Areas 1, 5 and 6 had over 50% vegetation cover on average. Area 7 had the lowest vegetation cover with 32.4%. Areas 5 and 6 also had a higher percentage cover of rocks, with Area 4 having the lowest. Areas 2, 4 and 7 had the highest percentage of leaf cover. Area 4 had the highest flow rate at 0.6 metres per second (m/s).

4.5.6 Hydrological Conditions

The DCM and Stratford Mining Complex have an on-site weather station which documents a number of climate conditions, including maximum and minimum temperature and relative humidity data. The climate factors for the 2011-2012 monitoring period is provided in Table 13.

Table 13
Climate Data 2011-2012

	Survey Period	1	2	3	4	5	6
		23-28 September 2011	26-31 October 2011	23-28 November 2011	11-16 January 2012	8-13 February 2012	14-19 March 2012
Temperature (°C)	**Max**	28.6	28.5	29.7	29.9	26.9	30.6
	Min	6.7	13.1	14.4	11.9	15.7	13.7
Relative Humidity (%)		72.3	72.3	77.4	77.3	61.2	77.8

Source: DCPL on-site weather station

Stream flow data for the survey period from gauging station GS209002 (Figure 4) is provided in Attachment 2 Chart 4. Minor flooding prior to the February survey period (14-19 February 2013) provided the first flush of the river in six months but a larger flooding event was to occur after the last survey in March 2013 (Attachment 2 Chart 4). Water level and electrical conductivity data from the High Noon gauging station is presented in Attachment 2 Chart 5-10.

4.5.7 Chytrid Fungus/Health of Tadpoles

During the 2010-2011 initial investigation period, approximately 50% of Giant Barred Frogs tested were Chytrid-positive, but most had relatively low infection titres. Approximately 64% of Eastern Stony-Creek Frogs tested were positive, and approximately 45% of Leaf-Green Tree Frog (*Litoria phyllochroa*) tested were positive. The location of positive Giant Barred Frogs was dispersed widely from the lower and middle parts of the MJR catchment.

Three individuals from the 2010-2011 period were swabbed again during the 2011-2012 surveys. Of these twice swabbed frogs, two were not found to be infected during the 2011-2012 period. One frog displayed low levels of infection during the 2010-2011 monitoring period, however was found to be clear during the 2011-2012 monitoring period.

Results from the 2012-2013 monitoring period indicated that, of the 247 swab samples taken, 103 (approximately 42%) were Chytrid-positive. However, most frogs had very low infection levels and only four frogs from the entire sample were regarded as being impacted by the pathogen. Infected frogs were present in all areas sampled and there was no pattern to the location of frogs with higher than average numbers of Chytrid zoospores.

4.6 DISCUSSION

4.6.1 Distribution

The records of Giant Barred Frog in the MJR catchment are shown on Figure 9. Based on population estimates during the 2012-2013 monitoring period (Table 11), the frogs are not distributed evenly throughout the catchment but occur in discrete areas. In general, Giant Barred Frogs are mostly present in the lower section and parts of the middle section of the catchments. There are discrete areas where the frogs are absent in the catchment, including in the lower sections of Wards River (from its junction with the MJR through pastureland north until it approaches The Glen Nature Reserve) and from the entire Terreel Valley portion of the MJR tributary.

Similar to the first monitoring season from 2011-2012, these significant gaps in the distribution of the Giant Barred Frog are likely to be due to loss of habitat. It is not clear at this stage if the groups of Giant Barred Frogs present in the upstream sections of the Wards River and MJR contribute to the populations of Giant Barred Frogs further downstream (and separated by the sections of river that no longer contain habitat for the frogs). It is possible that some tadpoles are washed down from the higher sites and manage to survive in the lower parts of the catchment.

The greatest number of Giant Barred Frogs found was at Area 7 (in the Crawford River catchment) where the numbers and densities of Giant Barred Frog greatly exceed the numbers found in the MJR catchment (Areas 1 to 4). The Giant Barred Frogs in the Mill Creek catchment more closely approximate the numbers and densities found in the very lower end of the MJR catchment (an area also severely impacted by agriculture and land clearing).

4.6.2 Population Size and Structure

The MJR supports a viable population of Giant Barred Frog. The frogs are not evenly distributed across the catchment and are absent in sections or in low densities in other sections. It is evident from Table 11 that the lower parts of the MJR (Areas 1, 2 and 3) contain fewer Giant Barred Frogs than equivalent areas further upstream (Area 4). Area 7 (Crawford River) supports a high number of Giant Barred Frogs at densities almost equivalent to those found in Area 4 on the MJR. The frog densities recorded in Areas 4 and 7 are in keeping with Giant Barred Frog densities recorded by Newell (pers. com) in his study of the Giant Barred Frog in northern NSW conducted on land also unaffected by agriculture.

As no detectable impacts from the DCM can be found, the differences in frog densities along the MJR are most likely due to differences in habitat quality. Area 4 and Area 7 (Crawford River) have the highest quality of habitat available in the study area.

4.6.3 Population Dynamics

The 2012-2013 data demonstrates that most of the subgroups of Giant Barred Frog along the MJR have a relatively high proportion of young animals (Attachment 2 Chart 3). This suggests that breeding had again been successful in the MJR, as it had been for the past three years.

Repeated breeding success is likely to be linked to the favourable rainfall and river flow conditions experienced over the past three years during the breeding seasons and may not be a true indicator of breeding success in the long-term. Rainfall patterns over the past three years in the MJR catchment (DCM data) has resulted in more regular rain and more frequent rises in river levels.

Should weather patterns change in the future and rainfall become less regular, successful breeding may not be possible in areas with poorer habitat (especially Areas 1 and 2) and these sub-populations may only survive through immigration of frogs from further upstream sites.

4.6.4 Habitat Assessment

Habitat variables have been recorded for all survey sites, and for a number of other non-survey sites in the MJR catchment. The variables include measurements of the nature and extent of the fringing vegetation, the nature and extent of the riparian tree line, water flow, stream dimensions, presence or absence of pools and riffles and indicators of disturbance to the sites (e.g. by cattle trampling, recent floods, or agricultural activity).

General Habitat Description

The riparian vegetation along all of the lower and middle sections of the MJR and Wards River have been greatly reduced or removed in places. Most of the removal of this vegetation occurred decades ago when the valley was being opened up to dairy farming.

Trees were removed up to the creek banks, or in some cases, they were removed from inside the creek banks as well. The extent of tree removal has been responsible for extensive erosion of the lower and middle sections of the MJR. Another consequence is the widespread occurrence of invasive weeds (especially privet and lantana) in areas previously occupied by riparian vegetation.

The lower sections of the Wards River have undergone a radical loss of riparian vegetation with the establishment of dense privet groves within the riverbanks (Plate 10). In the Terreel Valley, not only has the riparian vegetation been cleared, but the surrounding land had been cleared over most of the area of the valley.

Mill Creek Valley had been impacted by land clearing and agriculture in a similar way to the MJR valley. Cattle frequent these areas and damage in-stream and riparian habitat (Plate 11). The Crawford River area had scarcely been impacted by agriculture but had been impacted in some areas by forestry activities.

The only areas where relatively intact riparian vegetation was found were in the headwaters of the MJR where habitat for the Giant Barred Frog is mostly absent. In these areas another species of Barred River Frog (*Mixophyes balbus*) is more suited to the rockier terrain.

The deep scoring of the middle and lower sections of the MJR has removed pool and backwaters from the water course creating a single, deep channel that is prone to sudden rises and drops in water level. The surging nature of the river under these conditions makes the survival of Giant Barred Frog tadpoles in the lower and middle MJR very difficult.

Notable Impacts on Giant Barred Frogs in the Wider Catchment

The observable impacts on the Giant Barred Frogs are varied and include habitat loss through land clearing, current or past agricultural practices, changes to river flow patterns and changes in the frequency of flash flooding, cattle trampling of riparian ground cover vegetation, cattle trampling of frogs, and addition of agricultural chemicals to the river. Allied with many of these impacts is the subsequent replacement of native riparian vegetation with invasive weeds and predatory feral species (such as foxes and pigs).

4.6.5 Hydrological Conditions

During surveys, hydrological conditions regarding surface water quality, temperature, stream flow, and weather conditions were recorded. Chart 4 of Attachment 2 displays the stream flow data from Pikes Crossing Gauging Station (GS209002) within the six survey periods. Rainfall data is consistently concurrent with stream flow rates. Similarly, electrical conductivity closely followed water level trends observed at the High Noon gauging station (Attachment 2 Chart 5-10). One exception to this trend is shown on Chart 7, (during Survey Period 3 [November 2012]) during which the electrical conductivity fell as water levels rose, and vice versa.

Survey period 1 (September 2012) began during a relatively dry period. The last significant rainfall event was in June 2012. The MJR was running at low levels with increasing solute levels throughout spring (Attachment 2 Charts 5-7). Rainfall continued to be very light throughout spring and so the river remained low in early summer, but the electro-conductivity levels steadily rose from 300 to 600 microgram per centimetre (ug/cm) (Attachment 2 Chart 5-10). It was not until after the January 2013 survey that significant rain fell. Solute levels fell dramatically as the river system was flushed out (Chart 9-10). Another major rainfall and minor flooding event occurred after the February 2013 survey and again the increase in river flow quickly removed the salt build-up in the catchment.

Average stream flow during the first four months of the survey (i.e. September to December 2012) was approximately 30 megalitres per day (ML/day), well below the mean annual flow of approximately 149 ML/day. Only on a few brief occasions in December 2012 did the flow actually exceed the mean level (Chart 8). This meant that solutes released by salt-bearing shales in the MJR catchment accumulated in the river making parts of the river unsuitable for frogs and other aquatic life.

Despite the poor water conditions of the river and the drier nature of the riparian vegetation, Giant Barred Frogs were regularly found foraging along the banks or in nearby pastureland. However, breeding was not possible in some sections of the MJR with such high salt levels in the water, whereas breeding was possible in the nearby Crawford River.

The high saline conditions continued until late January 2013 when the first major flushing event took place (Chart 9). Survey period 6 (February 2013) was thus the only survey that was carried out when river flows were moderate and salt levels were relatively low (Chart 10). The lack of repeated high flows and minor flooding events in the 2012-2013 season had one positive benefit as it allowed the ground cover vegetation and leaf litter on the riverbanks to build up again and provide ample cover for frogs moving within the riparian strip.

There is a very strong correlation between stream flow changes as a result of rainfall and numbers of Giant Barred Frogs found. During the drier periods, when stream levels are low, fewer frogs are out on any given night foraging and fewer frogs are calling. The recapture rates changed dramatically in the February 2013 survey when frogs were caught on successive nights when the rainfall and river levels were restored.

Flood events appear to be the main factors that determine breeding success on the MJR but local factors also come into play. For example, both the Crawford River and MJR experienced low rainfall and falling water levels from July 2012 to January 2013 but the breeding response of the Giant Barred Frogs in those catchments was quite different. Few tadpoles were found in the MJR in the first five surveys but tadpoles were found in the Crawford River every survey. Even within the Crawford River, there was patchiness in the location of breeding sites. Areas C37, C50 and C52 (Figure 6) had tadpoles present at every survey whereas other areas up and down the Crawford River did not have evidence of breeding until the last survey in February 2013.

No major floods occurred during the 2012-2013 season. Minor flooding occurred in January and February 2013 (Chart 10) but this did not cause inundation of the surrounding pastureland (as occurred in 2010 and 2011). This meant that less erosional damage was done to the riverbanks and the vegetation had an opportunity to restore itself in areas previously scoured out by earlier floods. All of the data so far recorded indicates that receding water levels after flooding are the strongest stimulus for breeding in Giant Barred Frogs.

4.6.6 Chytrid Fungus

The rates of Chytrid infection in captured frogs during the 2012-2013 monitoring period was approximately 42%. This was almost identical to levels detected the previous year (Biosphere Environmental Consultants, 2012). This means that Chytrid is widespread within the MJR catchment and immediate surrounds.

The number of zoospores in each frog tested was generally quite low. The significance of this may be critical. It implies that a large number of frogs in the MJR catchment have been exposed to Chytrid and are potential carriers of the disease. However, few frogs are becoming infected to the point of being disabled by the disease. This implies that the frogs have some resilience (possibly immunity as a result of previous exposure to the pathogen).

To date, the Giant Barred Frogs in the MJR catchment had only been sampled under benign environmental conditions. It was likely that the disease will become more prevalent whenever the frogs are stressed, such as during particularly cold and dry winters.

To date, all sampling has included frogs collected in September (i.e. early spring) and there is no evidence of increased frog mortality over winter under the present climatic conditions.

As Professor Mahony (1997) pointed out, the frog study in the MJR catchment had the potential to resolve many of the issues relating to the long-term interaction between the Chytrid pathogen and its frog hosts.

5. THIRD MONITORING SEASON (2013-2014)

5.1 INTRODUCTION

This section summarises the results of the third monitoring season (October 2013 - January 2014) (Biosphere Environmental Consultants, 2014). The third monitoring season differed from the previous two in that only four monthly surveys were conducted (instead of six) and Areas 5 and 6 were no longer included in the survey.

The third monitoring season also differed from the previous survey seasons by the prevailing rainfall and weather conditions. The first two survey seasons were carried out during times of regular, ample rainfall with the MJR surging three or four times each year. Conditions during 2013 were much drier with the river remaining very low from June to November (where rainfall in mid-November produced a short-lived rise in the river levels). Apart from low river levels and the lack of rain, many survey sites had reduced ground vegetation cover and very little calling by the Giant Barred Frogs was noted across the catchment.

5.2 SURVEY SITES

Survey areas were nominated at the first monitoring season (Section 3.2). During the third monitoring season, Areas 5 and 6 were not surveyed due to of lack of frog numbers. The survey areas and monitoring sites are listed in Table 14 and shown on Figure 10.

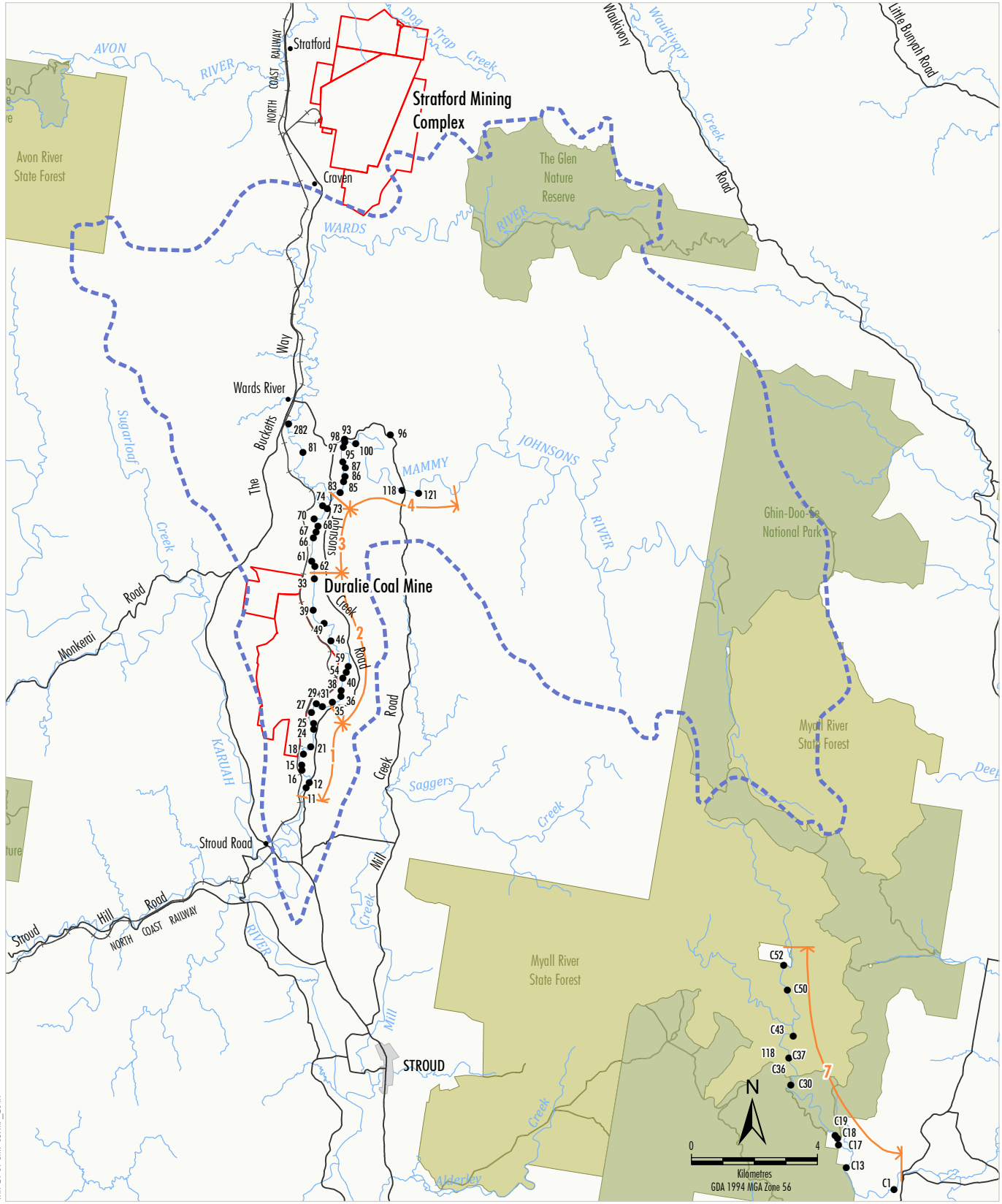
The areas surveyed between October 2013 - January 2014 can be classified as:

- Potential impact sites within the MJR catchment: Survey Areas 1 and 2 (20 sites);
- Upstream ‘control’ sites within the MJR catchment: Survey Areas 3 and 4 (21 sites); and
- Study Areas outside the MJR catchment: Survey Area 7 (11 sites).

Table 14
Survey Areas and Monitoring Sites 2013-2014

Survey Area	Location	Number of Monitoring Sites	Survey Area Type	Sampling
1	Located on the MJR, downstream of the confluence with Coal Shaft Creek (i.e. downstream of the DCM).	11 (11, 12, 15, 16, 18, 21, 24, 25, 27, 29, 31)	Potential impact survey area.	First, second and third monitoring period.
2	Located on MJR, upstream of the confluence with Coal Shaft Creek and downstream of an unnamed minor tributary.	9 (33, 35, 36, 38, 39, 40, 46, 54, 59)	Potential impact survey area.	First, second and third monitoring period.
3	Located on the MJR, upstream of the unnamed minor tributary to the confluence with Wards River.	8 (61, 62, 66, 67, 68, 70, 73, 74)	Upstream 'control' survey area.	First, second and third monitoring period.
4	Located on the MJR, upstream of the confluence with Wards River.	10 (282, 83, 85, 86, 87, 95, 98, 100, 118, 121)	Upstream 'control' survey area.	First, second and third monitoring period.
7	Located on the Crawford River, outside of the MJR Catchment.	10 (C1, C13, C17, C18, C19, C30, C36, C37, C50, C52)	Survey Area 7 was established to provide comparative data to authenticate (or disprove) climatic impacts on frog populations.	First, second and third monitoring period.

*Note: Ian Lenane has advised that Study Areas 5 and 6 do not warrant further monitoring. A comparatively low number of Giant Barred Frogs have been recorded in these study areas and data from Study Area 6 would not be able to be statistically analysed in the way that was originally intended (i.e. to be able to measure and attribute the impact of agriculture to any changes in Giant Barred Frog numbers).



YAN-21-37 DMP GBFMP_204A

Source: Spatial Services NSW (2022)

LEGEND

- Mining Lease Boundary
- National Park, Nature Reserve or State Conservation Area
- NSW State Forest
- Mammy Johnsons River Catchment Boundary (approximate)
- Monitoring Area
- Monitoring Site

DURALIECOAL
Part of the Yancoal Australia Group

DURALIE COAL MINE

Giant Barred Frog Survey Areas and Monitoring Sites (2013-2015 Monitoring Seasons)

Figure 10

5.3 TIMING

Survey timing is as described in Section 3.3. The survey dates for the 2013-2014 sampling season are presented in Table 15.

Table 15
Survey Dates 2013-2014

Survey Period	Dates	Survey Team	Survey Areas	Number of Sites Surveyed	Notes
1	17-24 October 2013	7 teams of 2 people	3, 4, and 7	30 (3 times each)	River levels low.
			1 and 2	20 (4 times each)	
2	14-21 November 2013	7 teams of 2 people	3, 4, and 7	30 (3 times each)	River levels low. Rain during survey.
			1 and 2	20 (4 times each)	
3	12-19 December 2013	7 teams of 2 people	3,4, and 7	30 (3 times each)	River levels low.
			1 and 2	20 (4 times each)	
4	16-23 January 2014	7 teams of 2 people	3,4 and 7	30 (3 times each)	River levels low.
			1 and 2	20 (4 times each)	

5.4 METHODS

Details of monitoring methods are described in Section 3.4.

During this monitoring season, other species of non-target riparian frogs (Plates 12 and 13) were also recorded, including an estimate of the number of individuals of each species.

Statistical analysis was undertaken consistent with the program described in Section 4.4.

No population estimates were carried out for Survey Areas 5 and 6 as frog numbers were too low to provide statistical value.

Plate 12: Male and Female Stony Creek Frog in Amplexus, MJR, Site 39

Plate 13: Leaf-Green Tree Frog, MJR

5.5 RESULTS

All known Giant Barred Frog records within the MJR catchment and immediate surrounds from the 2013-2014 monitoring period are shown on Figure 11.

This section reports on the results from the 2013-2014 monitoring period.

5.5.1 Nocturnal Frog Surveys

Giant Barred Frog records for 2013 – 2014 in each survey area of the catchment is represented on Figure 11. Note, not all frogs were able to be sexed and only those large enough were micro chipped.[4]

Frogs were present in all Survey Areas, though some had noticeably fewer than others. From these records it is estimated that Survey Area 5 has the smallest population, while Survey Area 7 has the largest. Initial estimates on the Giant Barred Frog population structure and population size are presented in Sections 3.5.2 and 3.5.3, respectively.

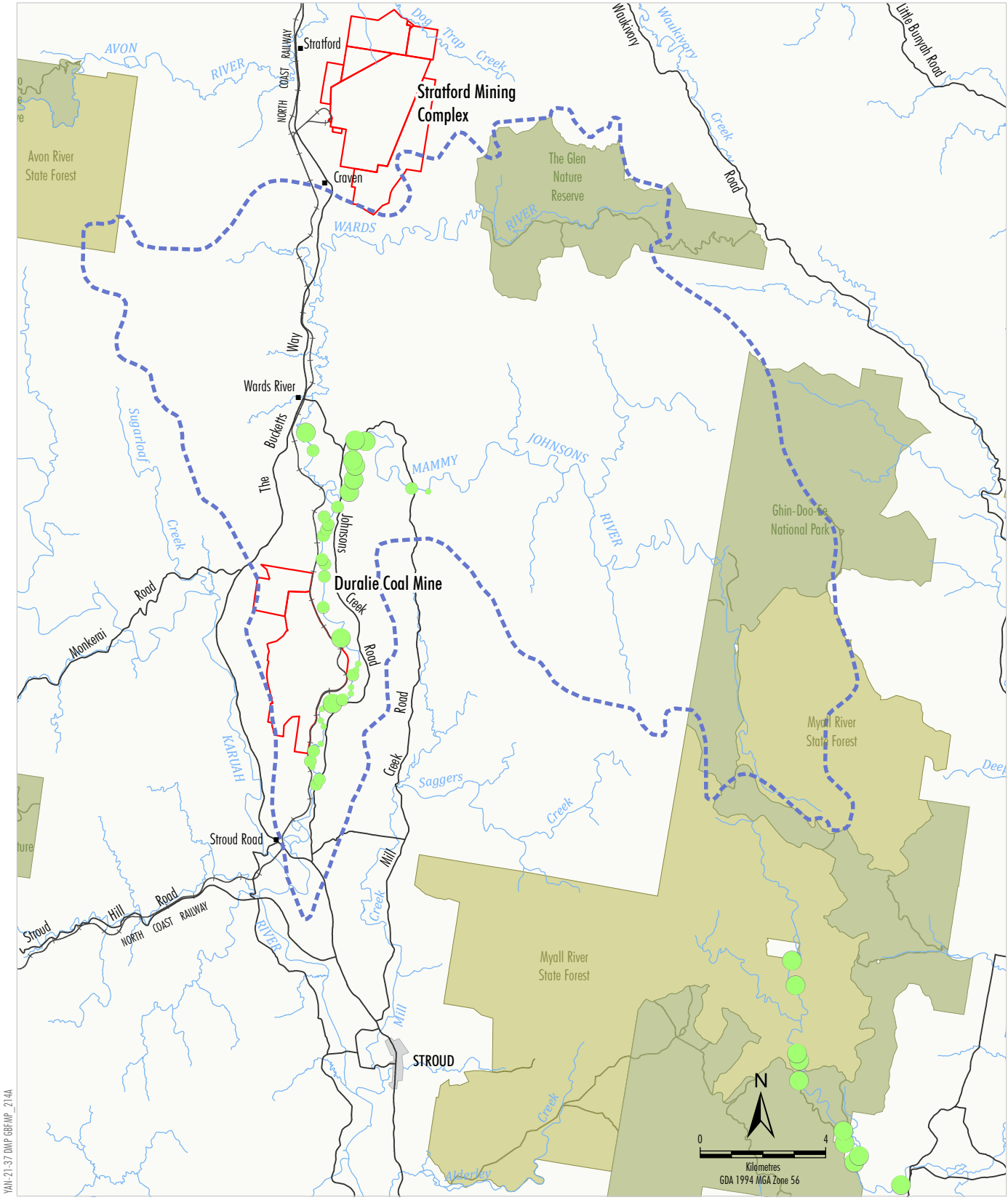
Injured

Injured frogs were recorded within Survey Areas 3 and 4. Two individuals were recorded in each of these Survey Areas. Three of the frogs suffered limb damage and were most likely injured by being trodden on by cattle while hiding in the grassy areas adjacent to the riverbanks. The fourth frog had a split abdomen, again the likely result of being trodden upon by cattle.

Calling Males

Calling by male Giant Barred Frog was related to air temperature and time since last rainfall. In general, calling was detected on most nights when the air temperature was above 20°C, however, if rain had not fallen for more than three weeks calling would not occur regardless of the air temperature. At most sites, less than 10% of the known male population was detected calling on any given night.

[4]Only individuals classified as adults or sub-adults were micro-chipped.



YAN-21-37 DMP GBFMP_214A

LEGEND

- Mining Lease Boundary
- National Park, Nature Reserve or State Conservation Area
- NSW State Forest
- Mammy Johnsons River Catchment Boundary (approximate)

No. of Records	Source
(1-20)	Biosphere Environmental Consultants (2013-2014)
(21-50)	Biosphere Environmental Consultants (2013-2014)
(51+)	Biosphere Environmental Consultants (2013-2014)

Source: Spatial Services NSW (2022)

DURALIE COAL MINE

Giant Barred Frog Records
from the 2013-2014 Monitoring Season

Figure 11

Amplexus

Amplexus was rarely observed during the 2013-2014 survey season. Amplexus appears to be tightly associated with falling river levels (i.e. post-flood events). Amplexus was only observed in Survey Area 7 in November and December 2013.

Gravid

During the 2013-2014 monitoring period, nine gravid female Giant Barred Frogs were found. Of these, four were from Area 1, two from Area 3, one from Area 4 and two from Survey Area 7.

Egg Masses

No egg masses were found during the 2013-2014 monitoring period.

5.5.2 Diurnal Tadpole Surveys

Tadpole Numbers

Tadpoles were not recorded in Areas 1, 2 and 3 during the 2013-2014 monitoring period. Juvenile frogs were found in Survey Areas 1,2,3,4 and 7. The low number of tadpoles implies that breeding was not as successful during the early breeding season but the number of emerging juvenile frogs towards the end of the season implies that later breeding events were more successful.

Of all sites visited over four survey periods, 156 tadpoles were recorded, 56 of which were Giant Barred Frogs. The remaining tadpole species were from Wilcox's Frog, Eastern Leaf Green Tree Frog, Tusked Frog and Peron's Tree Frog.

Tadpole Health

All of the tadpoles captured appeared to be healthy. There were no signs of deterioration of the denticles associated with chytrid.

5.5.3 Population Structure

An approximation of the age structure of the Giant Barred Frogs present in each area was determined by plotting the percentage of individuals in each size class (tadpoles [Table 16] and frogs [Table 17]) against frequency. The 2013-2014 monitoring period data for Survey Areas 1, 2, 3, 4 and 7 is presented in Tables 18 and 19. The data for age classes for each frog or tadpole captured in Areas 1 to 6 is reproduced graphically in Attachment 2 Chart 11.

Table 16
Size Class Frequency Data for Tadpoles 2013-2014

Survey Area (Figure 10)^	% Tadpoles (Stages 1-23)	% Tadpoles (Stages 24-25)	% Tadpoles (Stages 26-42)	% Tadpoles (Stages 43-46)
Growth Index Category*	**A**	**B**	**C**	**D**
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	40	60	0
7	7	28	65	0

^ Survey Areas had too few frog captures to provide useful data for analysis.

* Growth Index categories are provided in Table 4.

Table 17
Size Class Frequency Data for Frogs 2013-2014

Survey Area	% Juveniles (< 40 mm SVL)	% 40-65 mm SVL	% 65-85 mm SVL	% Greater than 85 mm SVL
Growth Index Category	**E**	**F**	**G**	**H**
1	12	9	22	18
2	8	15	16	5
3	21	21	22	18
4	37	31	16	15
7	22	24	24	44

^ Survey Areas 5 and 8 had too few frog captures to provide useful data for analysis.

mm = millimetre.

The sex ratio of the Giant Barred Frogs collected was about 50:50 and this was consistent across the different survey areas.

Tadpoles

Tadpoles were only regularly found in Area 7 and most were recorded as growth index C (65%), the least in growth index D (0%) (Table 16).

Adults

Survey Area 7 contained significantly more individual adult frogs (i.e. those in growth indexes E to H) than present in other survey areas (Table 17). All survey areas had a reasonably consistent number of frogs in each age class which is rather different from previous seasons where the number of frogs in each stage decreased from stages E to growth stage G.

Potential impact survey areas within the MJR catchment (i.e. Survey Areas 1 and 2) contained mostly adult frogs in (approximately 59%) growth stages G and H (Table 3). This was again different from the previous season's data where significantly greater numbers of smaller frogs (i.e. size classes E and F) were found (Biosphere Environmental Consultants, 2013). This suggested that the 2013-2014 season had not greatly added to the local populations in sites along the lower parts of the MJR catchment.

Upstream 'control' sites within the MJR catchment (i.e. Survey Areas 3 and 4) contained approximately 16% of large individuals of growth class H (Table 18). Growth classes E, F and G for these areas had a relatively even spread of individuals (31%, 33% and 20%, respectively). This may indicate that the populations in these upstream areas are more stable than the downstream areas where age classes are not as evenly consigned in the population.

Study areas outside the MJR catchment (i.e. Survey Area 7) contained approximately 5 % of individuals of growth classes F and G with approximately 26% and 24% of growth classes E and H, respectively (Table 17). These levels indicated that adolescent frogs (growth class E) either don't remain in the area or move on after metamorphosing and that there were low (but steady) levels of recruitment in-situ.

Whilst the number of individuals within each Survey Area differed, the distribution pattern of individuals per growth class between the potential impact Survey Areas and other Study Areas within the MJR catchment were similar (i.e. decreasing number of individuals as growth class progressed).

5.5.4 Estimated Population Size

A population estimate was calculated for each Survey Area based on the recapture data (note that the error in performing these estimates on individual areas becomes larger compared to estimates of the total population in the MJR catchment) (Table 18). This calculation was performed as it gives an indication of the number of frogs in each area. The population size determined from the recapture data was calculated using MARK. For the purposes of easy comparison, the figures have been rounded to the nearest whole number, and the size of the error has been expressed as a number of frogs (rather than a proportion of the average).

Table 18
Survey Area Population Estimates 2013-2014

Survey Area	Estimate of Population Size in Each Survey Area
1	35.5 (29 – 46)
2	43.8 (22 – 59)
3	66.8 (51 – 94)
4	87.8 (75 – 119)
7	177.5 (153 – 195)

As found in the previous season's survey (Biosphere Environmental Consultants, 2013), Giant Barred Frogs are not distributed evenly throughout the MJR catchment. Their abundance varies considerably within the catchment. They are notably absent from the lower sections of Wards River and the Terreel Valley portion of the MJR tributary. The frogs are in highest concentrations in the middle sections of the MJR catchment (in Survey Areas 3 and 4).

A summary of the Giant Barred Frog population estimates in each Survey Area is presented in Table 19. The sum of the population estimates of Giant Barred Frogs in each Survey Area during the 2013-2014 monitoring period was 411 adult Giant Barred Frogs (compared with a total of 316 based on the 2011-2012 monitoring period estimates [Biosphere Environmental Consultants, 2013]), the largest populations being in Survey Areas 3 and 4.

Table 19
Giant Barred Frog Population Estimates Between Survey Periods 2013-2014*

Survey Period	Survey Area 1	Survey Area 2	Survey Area 3	Survey Area 4	Survey Area 7
2011-2012	53(2)	95(4)	68(5)	87(4)	202(4)
2012-2013	44(6)	58(6)	107(6)	107 (6)	140 (6)
2013-2014	35 (4)	44 (4)	67 (4)	88 (4)	178 (4)

* Population estimate values were not included for periods when no recaptures had been made. The number in brackets refers to the number of estimates used in deriving the final population number.

Of some concern was the apparent decline in Giant Barred Frogs in Area 2 (all other areas appear to be reasonably stable). This decline cannot be attributed to mine-related activities as it is upstream of the current irrigation water release site. No cause for this decline is apparent.

5.5.5 Condition of Giant Barred Frog Habitat

Habitat Data

A summary of quantitative habitat data from the 2013-2014 monitoring period is presented in Table 20.

Table 20
Quantitative Habitat Assessment Data 2013-2014

Survey Area	Stream								Flow (m/s)	
	Width Max (m)	Width Min (m)	Depth Max (m)	Depth Min (m)	Vegetation (%)	Rock (%)	Leaf (%)	Bare (%)	Max	Min
1	14.5	7.4	1.4	0.2	44.6	6.1	28.6	20.7	0.4	0.1
2	13.6	6.4	1.6	0.3	33.7	8.0	47.4	10.9	0.3	0.1
3	11.7	5.7	1.3	0.2	34.1	8.6	36.1	21.2	0.3	0.1
4	9.0	4.3	1.0	0.0	29.8	2.2	45.0	22.0	0.5	0.1
7	11.1	6.1	1.3	0.4	32.6	13.0	40.7	13.7	0.4	0.2

Damage from cattle was evident in all survey areas in the MJR catchment. Survey Areas 1 to 4 showed evidence of vegetation clearance as a result of cattle damage as well as reduced streamside vegetation growth due to the drier condition (Plate 14). Survey Area 7 was not affected by cattle but did have some reduction in streamside vegetation presumably also due to the drier conditions.

The MJR becomes increasingly shallower and narrower as you proceed upstream. Survey Area 4 (the most upstream of the survey areas) often had large bare section of river base and isolated pools during this survey period (Table 20).

Survey Area 4 had the lowest vegetation cover with 29.8% (Table 20). Survey Area 7 had the highest rock cover. Survey Areas 2 and 4 had the highest percentage of leaf cover. Survey Area 4 had the highest flow rate at 0.5 m/s and this was recorded in November 2013 following local rainfall.

Plate 14: Cattle Damage in Unfenced Sections of MJR, February 2013

Hydrological Conditions

The DCM and Stratford Mining Complex have an on-site weather station which documents a number of climate conditions, including maximum and minimum temperature and relative humidity data. The climate factors for the 2013-2014 monitoring period is provided in Table 21.

Table 21
Climate Data 2013-2014

	Survey Period	1	2	3	4
		17-24 Oct 2013	14-21 Nov 2013	12-19 Dec 2013	16-23 Jan 2014
Temperature (°C)	Max	35.4	27.8	36.1	32.4
	Min	14.4	14.9	18.2	19.8
Relative Humidity (%)		55.8	71.1	67.3	69.6

Source: DCPL on-site weather station.

Stream flow data for the survey period from gauging station GS209002 is provided in Attachment 2 Chart 12. Minor flooding occurred for one day during the second survey period (15 November 2013) and this was the first flush of the river since July 2013 (Attachment 2 Chart 12). Water level and EC data from the High Noon gauging station is presented in Attachment 2 Chart 13-16.

Attachment 2 Chart 12 displays the stream flow data from Pikes Crossing gauging station (GS209002) within the four survey periods. Rainfall data is concurrent with stream flow rates demonstrating how quickly the MJR rises after rainfall in the catchment. Comparatively, EC and the trends of water level observed at the High Noon gauging station have an inverse relationship (Attachment 2 Chart 14 and 16).

Survey period 1 (October 2013) began during an extended dry period. The last significant rainfall event was in July 2013. The MJR was running at low levels with increasing solute levels throughout spring (Chart 13-15). Rainfall continued to be very light throughout spring with only one significant rainfall event in mid-November 2013. The river remained low in early summer but the electrical conductivity levels steadily rose from 300 to 600 µg/cm (Chart 13-16). It was not until after the surveys had finished that significant and sustained rainfall fell (March 2014).

Average stream flow during the survey (i.e. October 2013 to January 2014) was approximately 23 ML/day, well below the mean annual flow of approximately 149 ML/day. Only in November 2013 did the flow actually exceed the mean level. This meant that solutes released by salt-bearing shales in the MJR catchment accumulated in the river, making parts of the river unsuitable for frogs and other aquatic life.

5.5.6 Chytrid Fungus/Health of Tadpoles

Analysis of skin swabs from frogs in the MJR catchment over the past three years indicates Chytrid is widespread in the catchment and was present in all frog species tested to date. The level of infection varied greatly from year to year with the current season's infection rates being the lowest so far.

In the 2010-2011 monitoring period, approximately 50% of Giant Barred Frogs tested were Chytrid-positive, but most had relatively low infection titres. Infection rates in the 2011-2012 season were slightly lower and in the 2012-2013 monitoring period, 42% of skin swabs taken were Chytrid-positive. Again, most frogs had very low infection level and only a few frogs from the entire sample were regarded as being impacted by the pathogen.

In the 2013-2014 season, the infection rate fell to approximately 3%. This dramatic decline in infection is due to environmental changes, namely the prolonged hot and dry conditions experienced prior to sample collection. It appears that under these conditions, Giant Barred Frogs (and presumably other frogs as well) were able to purge themselves of Chytrid spores. How this is achieved is likely to be a combination of processes including chytrid spores dying at temperatures of 30 ^{o}C or more (especially if it is also dry) (Berger *et al*. 1999). In addition, the salinity of the MJR was elevated due to lack of flow and the high salt levels probably also assisted with the removal and death of chytrid spores.

Infected frogs were present in all areas sampled and there was no pattern to the location of frogs with higher-than-average numbers of Chytrid zoospores.

5.6 DISCUSSION

5.6.1 Distribution

All known Giant Barred Frog records within the MJR catchment and immediate surrounds (from various sources including the 2013-2014 monitoring period) are shown on Figure 11.

As described earlier, the frogs are not distributed evenly throughout the catchment but occur in discrete areas. In general, Giant Barred Frogs are mostly present in the lower section and parts of the middle section of the catchment. There are discrete areas where the frogs are absent in the catchment; including in the lower sections of Wards River (from its junction with the MJR through pastureland north until it approaches The Glen Nature Reserve) and from the entire Terreel Valley portion of the MJR tributary.

These significant gaps in the distribution of the Giant Barred Frog are likely due to loss of habitat. It is not clear at this stage if the groups of Giant Barred Frogs present in the upstream sections of Wards River and MJR contribute to the populations of Giant Barred Frog further downstream (and separated by the sections of river that no longer contains habitat for the frogs). It is possible that some tadpoles are washed down from the higher sites and manage to survive in the lower parts of the catchment.

The greatest number of Giant Barred Frogs found was at Survey Area 7 (in the Crawford River catchment) where the numbers and densities of Giant Barred Frog greatly exceed the numbers found in the MJR catchment (Survey Areas 1 to 4).

5.6.2 Population Size and Structure

The MJR supports a viable population of Giant Barred Frogs. The frogs are not evenly distributed across the catchment and are absent in sections or in low densities in other sections. It is evident from Table 18 that lower parts of the MJR River (Survey Areas 1, 2 and 3) contain fewer Giant Barred Frogs than equivalent areas further upstream (Survey Area 4). Survey Area 7 (Crawford River) supports a higher number of Giant Barred Frogs at densities almost equivalent to those found in Survey Area 4 on the MJR. The frog densities recorded in Survey Areas 4 and 7 are consistent with Giant Barred Frog densities recorded by Newell (pers. com) in his study of the Giant Barred Frog in northern NSW on land unaffected by agriculture (similar to Survey Area 7).

While more male frogs were caught than female frogs, the recapture data makes it clear that the two sexes are approximately equal in numbers in each of the survey areas. Male frogs are caught more often as they appear to be active on more nights and are more easily captured when they are calling. Female frogs are less active and do not call.

5.6.3 Population Dynamics

The preliminary monitoring data from the 2011 to the present time made it clear that Giant Barred Frogs along the MJR had a reasonably stable population size, and recruitment by juvenile frogs occurred each season during this study. The 2013-2014 breeding season has not been as successful as previous breeding seasons and this is presumably due to the low rainfall and low river flow conditions that occurred from mid-2013 until the first significant rains in November 2013. Sex ratios were approximately 50:50 in each survey area implying that there were no selection pressures favouring the survival of one sex over the other.

Repeated breeding success was likely to be linked to the favourable rainfall and river flow conditions experienced over the past three years during the breeding seasons. Rainfall patterns over the past three years in the MJR catchment resulted in more regular rain and more frequent rises in river levels. The period from July to early November 2013 was exceptionally dry with no significant rainfall events and breeding events declined as a result.

Based on the number of new frogs at each site it appears that the successful recruitment rate in 2013-2014 was about 5% in Areas 1, 2 and 3 but closer to 10% in Areas 4 and 7. The number of young frogs caught (too small to be micro-chipped) was higher than 10% for each survey area's sub-population but it is likely that there is a high death rate amongst these small frogs. Many of the juvenile frogs caught were underweight, another consequence of the lower rainfall conditions experienced during the survey.

The 2013-2014 season was the first where rainfall has been sporadic and river levels had been consistently low. No significant changes occurred with frog numbers but if conditions remain dry and recruitment falls, this may change.

5.6.4 Habitat Assessment

The Giant Barred Frog population in the MJR catchment is subject to a range of impacts unrelated to the DCM, many arising from past and current agricultural uses of the river and surrounding land. The observable impacts on the Giant Barred Frogs are varied and include habitat loss through land clearing, current or past agricultural practices, changes to river flow patterns and changes in the frequency of flash flooding, cattle trampling of riparian ground cover vegetation, cattle trampling of frogs, and the addition of agricultural chemicals to the river. Allied with many of these impacts is the subsequent replacement of native riparian vegetation with invasive weeds and predatory feral species (such as foxes and pigs).

It is clear that habitat quality varies greatly within the catchment. Some areas, such as the lower and middle sections of the Wards River arm of the MJR catchment and the Terreel Valley section of the MJR, are devoid of habitat for the frog.

The riparian vegetation along all of the lower and middle sections of the MJR and Wards River have been greatly reduced or removed in places through earlier vegetation clearing and timber felling, and more recent degradation due to cattle grazing and agricultural activity. Most of the removal of this vegetation occurred decades ago when the valley was being opened up to dairy farming.

These activities have denuded the riverbanks of native vegetation in many areas. Ongoing cattle damage is resulting in accelerated erosion of the banks and the widespread use of agricultural sprays and chemicals is likely to be impacting on water quality in the river. Trees were removed from the creek banks, and the extent of tree removal has been responsible for extensive erosion of the lower and middle sections of the MJR. Another consequence is the widespread occurrence of invasive weeds (especially privet and lantana) in areas previously occupied by riparian vegetation.

The lower sections of the Wards River (e.g. Survey Area 4) have undergone a radical loss of riparian vegetation with the establishment of dense privet groves within the riverbanks (Plate 10).

In the Terreel Valley (not a survey area), not only has the riparian vegetation been cleared, but the surrounding land has been cleared over most of the area of the valley.

Mill Creek Valley (previously included in Survey Area 6) has been impacted by land clearing and agriculture in a similar way to the MJR Valley. Cattle frequent these areas and damage in-stream and riparian habitat (Plate 11). The Crawford River area has scarcely been impacted by agriculture but has been impacted by forestry activities.

The only areas where relatively intact riparian vegetation still remained was in the headwaters of the MJR (The Glen Nature Reserve, previously Survey Area 5) where habitat for the Giant Barred Frog is mostly absent. In these areas another species of Barred River Frog is more suited due to the rockier terrain.

The deep scoring of the middle and lower sections of the MJR (Survey Areas 1, 2 and 3) has removed pool and backwaters from the water course creating a single, deep channel that is prone to sudden rises and drops in water level. The surging nature of the river under these conditions makes the survival of Giant Barred Frog tadpoles in the lower and middle MJR (including Survey Areas 1 and 2, near the DCM) very difficult.

Some high-quality habitat areas survive where the riparian vegetation is either completely or partially intact, where cattle have been fenced out of the river and where agricultural activity is minimal. The Crawford River (Survey Area 7) was selected as a control site (outside of the MJR catchment) as it is minimally impacted by agriculture and has not suffered loss of riparian vegetation. In the areas where the riparian vegetation is intact and agriculture is minimal, Giant Barred Frog numbers are much higher.

5.6.5 Hydrological Conditions

Despite the prolonged low flow conditions of the MJR, and the drier nature of the riparian vegetation, Giant Barred Frogs were regularly found foraging along the banks or in the nearby pastureland. However, breeding was not evident in some sections of the MJR with high salt levels in the water (e.g. Survey Areas 1 and 2), whereas breeding had occurred in the nearby Crawford River (Survey Area 7).

Low river flows means that salt levels build up in the remaining water. Salt levels continued to slowly increase until mid-November 2013 when the first major flushing event took place (Chart 12 and 15). Survey period 2 (November 2013) was thus the only survey that was carried out when river flows were moderate and salt levels relatively low (Attachment 2 Chart 14). The lack of repeated high flows and minor flooding events in the 2013-2014 monitoring period had one positive benefit as it allowed the ground cover vegetation and leaf litter on the riverbanks to build up again and provide ample cover for frogs moving within the riparian strip.

There is a very strong correlation between stream flow changes as a result of rainfall and numbers of Giant Barred Frogs found. During the drier periods, when stream levels are low, fewer frogs are out on any given night foraging and fewer frogs are calling. The recapture rates changed dramatically in the November 2013 survey when frogs were caught on successive nights when the rainfall and river levels were restored.

Flood events appear to be the main factors that determine breeding success on the MJR but local factors also come into play. For example, both the Crawford River and MJR experienced low rainfall and falling water levels from July 2013 to January 2014 but the breeding response of the Giant Barred Frogs in those catchments was quite different. Few tadpoles were found in MJR in the first three survey periods whereas tadpoles were found every time in the Crawford River.

No major floods occurred during the 2013-2014 monitoring period. Minor flooding occurred in January 2014 (Attachment 2 Chart 16) but this did not cause inundation of the surrounding pastureland (as occurred in 2010 and 2011 [Biosphere Environmental Consultants, 2012]). This meant that less erosional damage was done to the riverbanks and the vegetation had an opportunity to restore itself in areas previously scoured out by earlier floods. All of the data recorded indicates that receding water levels after flooding are the strongest stimulus for breeding in Giant Barred Frogs.

5.6.6 Chytrid Fungus

The unprecedented hot and dry conditions experienced during the survey season had an unexpected benefit for the Giant Barred Frogs in the MJR catchment. The hot, dry conditions, combined with the sustained saline conditions of the river resulted in a dramatic decline in the survival of Chytrid spores in the area; infection rates fell from an average (during the wetter times) of between 40% and 50% to 3%. The infected frogs found in the 2013-2014 season had low Chytrid loads and no frogs were found that exhibited symptoms of Chytrid infection.

These events imply that periodic, sustained dry periods may be critical for suppressing infectious pathogens (such as Chytrid) and may have a long-term beneficial effect on the frog population (despite frog breeding rates also being suppressed by the dry conditions).

6. FOURTH MONITORING SEASON (2014-2015)

6.1 INTRODUCTION

This chapter summarises the results of the fourth monitoring season (October 2014 – February 2015) (Biosphere Environmental Consultants, 2015).

Although surveys were seasonal and conducted during spring and summer, weather conditions before and during the surveys were quite varied. For example, the first survey season had regular rainfall throughout whereas the second and third survey seasons were drier. The fourth survey period was quite different. The 2014-2015 frog season had long, hot and dry periods followed by short, torrential rainfall events. The frogs had also benefitted from a particularly benign winter that resulted in relatively few deaths among the younger frogs and metamorphosing tadpoles. This resulted in a fresh cohort of juvenile frogs being on hand when the first survey was commenced in October 2014, before the normal breeding season would commence.

The weather conditions throughout the survey further assisted the survival of spawns and tadpoles, resulting in another wave of juvenile frogs entering the population by early summer. Juvenile frogs of the two cohorts were to dominate the number of frog captures throughout the entire fourth survey period.

The overall size of the adult frog population remained relatively stable and the influx of juvenile frogs had yet to have an impact on adult frog numbers.

6.2 SURVEY SITES

Survey areas for the fourth monitoring season (October 2014 – February 2015) were identical to the third monitoring season (October 2013 - January 2014) (Section 5.2). The survey areas and monitoring sites are listed in Table 22 and shown on Figure 10.

The survey areas surveyed between October 2014 – February 2015 can be classified as:

- Potential impact sites within the MJR catchment: Survey Areas 1 and 2 (20 sites);
- Upstream ‘control’ sites within the MJR catchment: Survey Areas 3 and 4 (20 sites); and
- Study Areas outside the MJR catchment: Survey Area 7 (10 sites).

Table 22
Survey Areas and Monitoring Sites 2014-2015

Survey Area (Figure 6)	Location	Number of Monitoring Sites	Survey Area Type	Sampling
1	Located on the MJR, downstream of the confluence with Coal Shaft Creek (i.e. downstream of the DCM).	11 (11, 12, 15, 16, 18, 21, 24, 25, 27, 29, 31)	Potential impact survey area.	All monitoring periods.
2	Located on the MJR, upstream of the confluence with Coal Shaft Creek and downstream of an unnamed minor tributary.	9 (33, 35, 36, 38, 39, 40, 46, 54, 59)	Potential impact survey area.	All monitoring periods.
3	Located on the MJR, upstream of the unnamed minor tributary to the confluence with Wards River.	8 (61, 62, 66, 67, 68, 70, 73, 74)	Upstream 'control' survey area.	All monitoring periods.
4	Located on the MJR, upstream of the confluence with Wards River.	10 (282, 83, 85, 86, 87, 95, 98, 100, 118, 121)	Upstream 'control' survey area.	All monitoring periods.
7	Located on the Crawford River, outside of the MJR Catchment.	10 (C1, C13, C17, C18, C19, C30, C36, C37, C50, C52)	Survey Area 7 was established to provide comparative data to authenticate (or disprove) climatic impacts on frog populations.	All monitoring periods.

6.3 TIMING

Survey timing is as described in Section 3.3. The survey dates for the 2014–2015 sampling season are presented in Table 23.

Table 23
Survey Dates 2014-2015

Survey Period	Dates	Survey Team	Survey Areas	Number of Sites Surveyed	Notes
1	16-21 October 2014	7 teams of 2 people	1-4, and 7	50 (3 times each)	River levels low.
2	13-18 November 2014	7 teams of 2 people	1-4, and 7	50 (3 times each)	River levels low. Rain during survey.
3	11-16 December 2014	7 teams of 2 people	1-4, and 7	50 (3 times each)	River levels low.
4	14-19 January 2015	7 teams of 2 people	1-4, and 7	50 (3 times each)	River levels low.
5	12-17 February 2015	3 teams of 2 people	1, 2 and 3.	30 (3 times each)	River levels low.

6.4 METHODS

Details of monitoring methods are described in Section 3.4

In addition to previous monitoring, the distance that the frog was found from the water's edge was recorded during nocturnal frog surveys.

No population estimates were carried out for Survey Areas 5 and 6 as frog numbers were too low to provide statistical value.

Statistical analysis was undertaken consistent with the program described in Section 4.4 with the addition of an analysis based on Pollocks' Robust design. The robust design model is a combination of the Cormack-Jolly-Seber (CJS) live recapture model and the closed capture models. The model was described in detail by Kendall et al. (1995, 1997). The key difference from the CJS model is that instead of just one capture occasion between survival intervals, multiple (ie. more than one) capture occasions are used. These occasions must be close together in time to allow the assumption that no mortality or emigration occurs during these short time intervals. The closed encounter occasions which occur each month during the survey period are termed "trapping sessions", and each trapping session can be viewed as a closed capture survey.

The power of this model is derived from the fact that the probability that an animal is captured at least once in a trapping session can be estimated from just the data collected during the session using capture-recapture models developed for closed populations. The longer intervals between trapping sessions allows estimation of survival, temporary emigration from the trapping area, and immigration of marked animals back to the trapping area. Kendall et al. (1995, 1997) term the intervals between trapping sessions the primary sampling periods, where population gains (through birth and immigration) and losses (through deaths and emigration) occur. The shorter intervals during each intense survey session are referred to as a secondary sampling period. These are the times when the population is effectively closed.

6.5 RESULTS

All known Giant Barred Frog records within the MJR catchment and immediate surrounds from the 2014-2015 monitoring period are shown on Figure 12.

This section reports on the results from the 2014-2015 monitoring period.

6.5.1 Nocturnal Frog Surveys

Frogs were present in all Survey Areas. From these records it is estimated that Survey Area 2 had the smallest population, while Survey Area 7 had the largest. Initial estimates on the Giant Barred Frog population structure and population size are presented in Sections 3.5.2 and 3.5.3, respectively.

Injured

Injured frogs were recorded within Survey Areas 2, 3 and 4. Three individuals were found to be suffering damage to limbs. In one case, the damage was not recent and the injured arm had withered to a stump. Two frogs were found dead. Both were crushed. The injuries to all of these frogs were consistent with being trodden on by cattle while hiding in the grassy areas adjacent to the riverbanks.

Calling Males

Calling by male Giant Barred Frog was strongly correlated with air temperature and time since last rainfall. In general, calling was detected on most nights when the air temperature was above 20°C, however, if rain had not fallen for more than three weeks calling would not occur regardless of the air temperature. At most sites, less than 10% of the known male population was detected calling on any given night.

Amplexus

Amplexus was only occasionally observed. During the 2014-2015 survey season, only five amplexed pairs were found. Four of the five amplexed pairs found were in Survey Area 7.

Gravid

During the 2014-2015 monitoring period, 19 Giant Barred Frogs were determined to be gravid. Of these, four were from Area 1, one from Area 3, three from Area 4 and 11from Survey Area 7.

Egg Masses

No egg masses were found during the 2014-2015 monitoring period.

6.5.2 Diurnal Tadpole Surveys

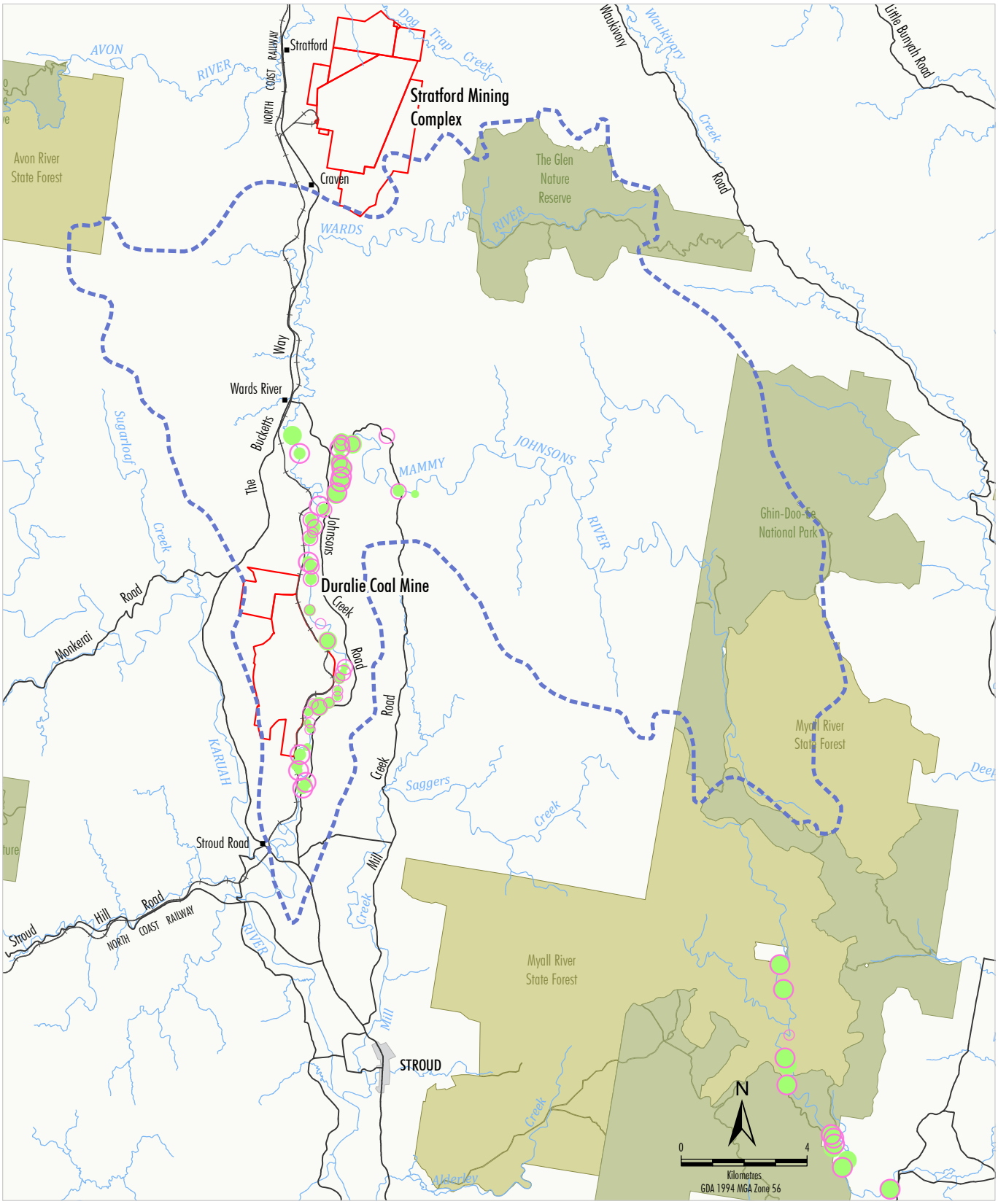
Tadpole Numbers

Tadpoles were rarely found during the 2014-2015 monitoring period and no tadpoles were found in Area 3 despite the presence of newly-emerged juvenile frogs. Large numbers of juvenile frogs were found in all survey areas with distinct pulses of new juvenile frogs being detected in October 2014 and January 2015. The inability to repeatedly capture Giant Barred Frog tadpoles in these open river systems diminished the value of the tadpole data as it does not reflect the breeding intensity at each site. The number of juvenile frogs captured proved to be a much better indicator of breeding success.

For all sites surveyed over the entire monitoring period, only 68 tadpoles were captured. This was the least number of tadpoles caught since the surveys commenced and indicates that the netting techniques being used were equally poor at catching other species of riparian tadpoles. The other tadpole species captured were from Wilcox's Frog, Eastern Leaf Green Tree Frog and the Tusked Frog.

Tadpole Health

All of the tadpoles captured appeared to be healthy. There were no signs of deterioration of the denticles associated with Chytrid.



YAN-21-37 DNP GBFMP_210A

LEGEND

- Mining Lease Boundary
- National Park, Nature Reserve or State Conservation Area
- NSW State Forest
- Mammy Johnsons River Catchment Boundary (approximate)

No. of Records	Source
(1-20)	Biosphere Environmental Consultants (2014-2015)
(21-50)	Biosphere Environmental Consultants (2014-2015)
(51+)	Biosphere Environmental Consultants (2014-2015)
(1-20)	Biosphere Environmental Consultants (2013-2014)
(21-50)	Biosphere Environmental Consultants (2013-2014)
(51+)	Biosphere Environmental Consultants (2013-2014)

Source: Spatial Services NSW (2022)

DURALIECOAL
Part of the Yancoal Australia Group

DURALIE COAL MINE

Giant Barred Frog Records from the 2014-2015 Monitoring Season

Figure 12

6.5.3 Population Structure

An approximation of the age structure of the Giant Barred Frogs present in each area was determined by plotting the percentage of individuals in each size class (tadpoles [Table 24] and frogs [Table 25]) against frequency. The 2014-2015 monitoring period data for Survey Areas 1, 2, 3, 4 and 7 is presented in Tables 26 and 27. The data for age classes for each frog or tadpole captured in Survey Areas 1 to 7 is reproduced graphically in Attachment 2 Chart 17.

Table 24
Size Class Frequency Data for Tadpoles 2014-2015

Survey Area	% Tadpoles (Stages 1-23)	% Tadpoles (Stages 24-25)	% Tadpoles (Stages 26-42)	% Tadpoles (Stages 43-46)
Growth Index Category*	**A**	**B**	**C**	**D**
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	2	0	0	0
7	0	16	0	0

* Growth Index categories are provided in Table 4

Table 25
Size Class Frequency Data for Frogs 2014-2015*

Survey Area	% Juveniles (< 40 mm SVL)	% 40-65 mm SVL	% 65-85 mm SVL	% Greater than 85 mm SVL
Growth Index Category	**E**	**F**	**G**	**H**
1	250	149	62	43
2	27	94	65	18
3	94	271	65	32
4	283	370	123	19
7	195	463	437	150

mm = millimetre.

* This data applies to newly caught frogs or frogs caught for the first time during the survey period .e. it does not include recapture data.

The sex ratio of the Giant Barred Frogs collected was about 50:50 and this was consistent across the different survey areas.

Tadpoles

Tadpoles were only regularly found in Area 7 and most were recorded as growth index A or B (50% respectively), the least in growth indexes C and D (Table 24).

Adults

Frogs with a snout-vent length of 40 mm or more are considered adults (growth indexes F,.G, and H) despite the fact that their sex may not be determinable until they grow larger. A significantly greater number of adult frogs (i.e. those in growth indexes F to H) were caught in Survey Area 7 compared to other sites along the MJR. The large and highly re-catchable Giant Barred Frog population along the Crawford River were remarkably stable and fluctuated far less than the smaller populations along the MJR. This population also had the highest proportion of very large adults (i.e. > 85 mm SVL) (Table 25).

Potential impact Survey Areas within the MJR catchment (i.e. Survey Areas 1 and 2) had fewer frogs but the age classes were skewed by the large number of juvenile frogs (especially in Area 1); the ratio of the other age classes (i.e. F, G and H) were very similar to that of Area 7 (Table 26). This is a positive feature of these smaller populations as it implies that they are behaving in a relatively similar manner to the un-impacted control population along the Crawford River (Area 7).

The age class distributions for the upstream 'control' sites within the MJR catchment (i.e. Survey Areas 3 and 4) were also distorted by the high influx of juvenile frogs (Attachment 2 Chart 17). However, if the juvenile numbers were removed from the data set, both Areas 3 and 4 had a higher proportion of young adult frogs than Area 7. This suggested that these populations had successfully recruited a higher proportion of new frogs from the previous year's breeding event. It is not known why Areas 3 and 4 had a higher proportion of young adult frogs but it augured well for both areas.

The massive pulse of juvenile frogs that distorted the age class distributions for the populations along the MJR did not have the same impact in Area 7. The detection of tadpoles in the Crawford River combined with the appearance of a large numbers of juvenile frogs suggested that there may be a higher mortality of juvenile frogs in the Crawford River catchment. This was not due to lack of habitat as the Crawford River sites consistently scored better than those in the MJR catchment. It was most likely that there was a higher predation rate of juvenile frogs (possibly by the resident large adult Giant Barred Frogs). In the MJR catchment, the adult frog population was lower and more patchily distributed, the predation rates of juvenile frogs was likely to be lower than for the Crawford River population. In the MJR sites, juvenile deaths were more likely to be attributed to starvation rather than predation due to limited habitat.

While there were differences in the age class structure of the various populations, the relatively high number of young adult frogs in each population indicated that they were all viable and had a regular turnover of individuals.

6.5.4 Estimated Population Size

A population estimate was calculated for each Survey Area based on the recapture data (note that the error in performing these estimates on individual areas becomes larger compared to estimates of the total population in the MJR catchment) (Table 26). This calculation was performed as it gives an indication of the number of frogs in each area. The population size determined from the recapture data was calculated using MARK. For the purposes of easy comparison, the figures have been rounded to the nearest whole number, and the size of the error has been expressed as a number of frogs (rather than a proportion of the average).

Table 26
Survey Area Population Estimates 2014-2015

Survey Area	Average of Population Size in Each Survey Area
1	39 (26 – 52)
2	26 (11 – 38)
3	78 (60 – 97)
4	128 (106 – 155)
7	267 (238 – 338)

As found in the previous season's survey (Biosphere Environmental Consultants, 2014), Giant Barred Frogs were not distributed evenly throughout the MJR catchment. Their abundance varied considerably within the catchment. They were notably absent from the lower sections of Wards River and the Terreel Valley portion of the MJR tributary. The frogs were in highest concentrations in the middle sections of the MJR catchment (in Survey Areas 3 and 4).

A summary of the Giant Barred Frog population estimates is presented in Table 27. The sum of the population estimates of Giant Barred Frogs in each Survey Area during the 2014-2015 monitoring period in the MJR catchment was 271 adult Giant Barred Frogs. This was a slight increase in the total numbers and perhaps represented a recovery in the population after the drought conditions experienced during 2013-2014 (Biosphere Environmental Consultants, 2013).

Table 27
Giant Barred Frog Population Estimates Between Survey Periods

Monitoring Period	Survey Area 1	Survey Area 2	Survey Area 3	Survey Area 4	Total MJR Catchment	Survey Area 7
2011-2012	51(2)	53(3)	96(4)	110(4)	310	202(4)
2012-2013	50(5)	67(5)	75(5)	125 (5)	317	140 (6)
2013-2014	30 (4)	44 (4)	67 (4)	88 (4)	229	178 (4)
2014-2015	39(4)	26(5)	78(4)	128(4)	271	267(4)

Population estimate values were not included for the period when no recaptures had been made. The number in brackets refers to the number of estimates used in deriving the final population number. In 2014-2015, the population estimates were affected by the high number of juvenile frogs that were reaching taggable size during the study periods (this affects the confidence intervals as new frogs suddenly appeared in the population that may have been recorded before as juveniles). This disturbance to the estimates was most apparent with the February 2015 data set. For that reason, the population estimates were based on the first four survey periods only (i.e. October 2014 to January 2015).

The Giant Barred Frog population in the MJR catchment and along the Crawford River increased in numbers with the breaking of the drought. The 2013-2014 survey period saw populations in all areas decline to their lowest numbers since monitoring began. The Giant Barred Frog population in the MJR catchment increased by 15% compared to the last year's numbers whereas the frogs in the Crawford River increased by 33%. Amplecting pairs of frogs and tadpoles were always more numerous in the Crawford River catchment and the frogs in that area were able to recover from the impacts of the drought much faster.

The slow decline in Giant Barred Frog numbers in Area 2 (all other areas appeared to be reasonably stable) was of some concern. This decline could not be attributed to mine-related activities as it was upstream of the irrigation water release site. Habitat areas did not appear to have altered greatly (although there was a loss of ground cover vegetation during the 2013-2014 drought). No cause for this decline was apparent.

6.5.5 Condition of Giant Barred Frog Habitat

Habitat Data

A summary of quantitative habitat data from the 2014-2015 monitoring period is presented in Table 28.

Table 28
Quantitative Habitat Assessment Data 2014-2015

Survey Area	Stream								Flow (m/s)	
	Width Max (m)	Width Min (m)	Depth Max (m)	Depth Min (m)	Vegetation (%)	Rock (%)	Leaf (%)	Bare (%)	Max	Min
1	14.5	4.4	1.4	0.2	42.3	6.1	30.5	15.1	0.4	0.1
2	13.6	6.4	1.6	0.3	38.0	9.3	27.4	25.3	0.3	0.05
3	11.7	5.7	1.4	0.2	37.7	7.3	38.1	16.9	0.2	0.05
4	9.0	4.3	1.5	0.1	35.5	3.6	43.6	17.3	0.4	0.05
7	11.1	6.1	1.9	0.4	44.3	8.8	38.7	7.2	0.4	0.2

Damage from cattle was evident in all survey areas in the MJR catchment. Survey Areas 1 to 4 showed evidence of vegetation clearance as a result of cattle damage, with some sites showing significant bank-side erosion due to the collapse of cattle paths. Survey Area 7 was not affected by cattle and the riparian vegetation was more extensive close to the edges of the flowing water.

MJR becomes increasingly shallower and narrower as you proceed upstream. Survey Area 4, the most upstream of the survey areas being surveyed, has many riffle areas separating large pools of water. The lower sections of the river (such as in Areas 1 and 2) comprise wider and generally deeper river sections that are occasionally interrupted by rocky bars crossing the riverbed.

Survey Area 7 had the highest vegetation cover (44.3%) while Areas 2, 3 and 4 had lower but similar amounts of cover (38.0%, 37.7% and 35.5% respectively) (Table 28). Survey Areas 4 and 7 had the highest percentage of leaf cover. Survey Area 2 had the highest amount of bare ground as well as the highest percentage of exposed rock.

Hydrological Conditions

Conditions during spring were warm and dry. In summer, periodic thunderstorms added much needed rainfall to otherwise hot weather conditions. The climate factors for the 2014-2015 monitoring period is provided in Table 29. Rainfall is shown graphically in Attachment 2 Chart 17.

Table 29
Climate Data 2014-2015

	Survey Period	1	2	3	4	5
		16-21 Oct 2014	13-18 Nov 2014	11-16 Dec 2014	15-20 Jan 2015	12-17 Feb 2015
Temperature (°C)	Max	27.4	39.8	31.0	36.5	31.6
	Min	6.9	11.8	13.2	16.0	17.5
Rainfall (mm)		8.2	0.0	49.2	5.2	60.0

Source: Temperature data Maitland Met Station 61388; Rainfall Stroud PO 61071.

Stream flow data for the survey period from gauging station GS209002 is provided in Attachment 2 Chart 18.

No floods were recorded during the 2014-2015 monitoring period. River levels rose and fell quickly after local rain but were generally between 0.6 m and 0.8 m at Pikes Crossing for most of the survey period. The only notable change in river level occurred before the first survey period following late August rainfall but this also did not result in any flooding (Attachment 2 Chart 18). Water level and EC data from the High Noon gauging station is presented in Chart 18-23.

As noted previously, the EC of the river water was greatly influenced by local rainfall events. Immediately following rain, the river rises quickly and solutes in the water are dispersed and diluted resulting in a decline in EC. During dry periods when river flow is low, solutes leeching from the ground slowly accumulate in the river water and rise until the next river surge when the solutes are flushed down stream (Attachment 2 Chart 18-23).

Survey period 1 (October 2014) followed a very mild winter and had regular rainfall throughout early spring. This meant that riparian vegetation was comparatively dense in places at the start of the season. The warm and humid conditions during October ensured that insects were abundant and the frogs caught were well fed and in good condition.

Average stream flow during the survey period October 2014 to February 2015 was approximately 72 ML/day which was much higher than the mean flow level of 23 ML/day recorded during the 2013-2014 season, but below the annual mean of 149 ML/day. Only in late August 2014 and April 2015 did the river flow actually exceed the mean level. While flows were below-average, the small flow surges were sufficient to prevent solute build-up in the pools in the river.

6.5.6 Chytrid Fungus/Health of Tadpoles

Analysis of skin swabs from frogs in the MJR catchment over the past four years indicates that Chytrid was widespread in the catchment and was present in all frog species tested. The level of infection varied greatly from year to year with the infection rates dropping to their lowest levels during the drought years of 2013-2014.

In the 2010-2011 monitoring period, approximately 50% of Giant Barred Frogs tested were Chytrid-positive, but most had relatively low infection titres. Infection rates in the 2011-2012 season were slightly lower and in the 2012-2013 monitoring period 42% of skin swabs taken were Chytrid-positive. Again, most frogs had very low infection level and only a few frogs from the entire sample were regarded as being impacted by the pathogen.

In the 2013-2014 season, the infection rate fell to approximately 3%. This dramatic decline in infection is due to environmental changes, namely the prolonged hot and dry conditions experienced prior to sample collection. It appears that under these conditions Giant Barred Frogs (and presumably other frogs as well) are able to purge themselves of Chytrid spores. How this is achieved is likely to be a combination of processes including Chytrid spores dying at temperatures of 30^{o}C or more (especially if it is also dry) (Berger *et al*. 1999). In addition, the salinity of the MJR was elevated due to lack of flow and the high salt levels may have also assisted with the removal and death of chytrid spores.

In the 2014-2015 monitoring season, infection rates rose again with the wetter weather conditions. The infection rate was 19% and infected frogs were present in all areas sampled. There was no pattern to the location of frogs with higher than average numbers of Chytrid zoospores.

6.6 DISCUSSION

6.6.1 Distribution

All known Giant Barred Frog records within the MJR catchment and immediate surrounds (from various sources including the 2014-2015 monitoring period) are shown on Figure 12.

The frogs were not distributed evenly throughout the catchment but occurred in discrete areas. In general, Giant Barred Frogs were mostly present in the lower section and parts of the middle section of the catchment. There were discrete areas where the frogs were absent in the catchment including in the lower sections of Wards River (from its junction with the MJR through pastureland north until it approaches The Glen Nature Reserve) and absent from the entire Terreel Valley portion of the MJR tributary.

These significant gaps in the distribution of the Giant Barred Frog were likely due to loss of habitat. It was not clear if the groups of Giant Barred Frogs present in the upstream sections of the Wards River and MJR supplemented the populations of Giant Barred Frogs further downstream (and separated by the sections of river that no longer contains habitat for the frogs). It was possible that some tadpoles are washed down from the higher sites and managed to survive in the lower parts of the catchment.

The greatest number of Giant Barred Frogs found was at Survey Area 7 (in the Crawford River catchment) where the numbers and densities of Giant Barred Frog greatly exceeded the numbers found in the MJR catchment (Survey Areas 1 to 4).

6.6.2 Population Size and Structure

The MJR supported a viable population of Giant Barred Frogs. The frogs were not evenly distributed across the catchment; they were absent in some sections or were in low to medium densities in other sections. It was evident from Table 26 that the lower parts of the MJR (Survey Areas 1 and 2) contained fewer Giant Barred Frogs than equivalent areas further upstream (Survey Areas 3 and 4). Survey Area 7 (Crawford River) supported a higher number of Giant Barred Frogs at densities almost equivalent to those found in Survey Area 4 on the MJR. The frog densities recorded in Survey Areas 4 and 7 were consistent with Giant Barred Frog densities recorded by Newell (pers. com) in his study of the Giant Barred Frog in northern NSW on land unaffected by agriculture similar to Survey Area 7.

While more male frogs were caught than female frogs, the recapture data makes it clear that the two sexes are approximately equal in numbers in each of the survey areas. Male frogs were caught more often as they appeared to be active on more nights and are more easily detected when they were calling. Female frogs do not call and often foraged away from the riverbanks.

6.6.3 Population Dynamics

Monitoring data since 2011 indicates that Giant Barred Frogs along the MJR had a reasonably stable population and recruitment by juvenile frogs occurred each season during this study. The 2013-2014 season was the least successful but this did not result in a significant decline in frog numbers. To date, the surveys have not spanned a dry period of more than seven months and so the frog population may not have been severely tested yet. The 2014-2015 monitoring season saw an increase in frog numbers after the decline measured during the previous season.

Sex ratios are approximately 50:50 in each survey area implying that there were no selection pressures favouring the survival of one sex over the other.

Breeding success was likely to be linked to the favourable rainfall and river flow conditions. However, the 2014-2015 monitoring season recorded an unprecedented number of juvenile frogs in both the MJR and Crawford River catchments. The big influx of new frogs was due to the higher-than-normal survivorship of over-wintering tadpoles. Benign winter conditions allowed for the tadpoles to survive and then metamorphose at the onset of spring.

Based on the number of new frogs at each site, it appeared that the successful recruitment rate in 2014-2015 was about 8% in Areas 1, 2 and 3 but closer to 12% in Areas 4 and 7. The number of young frogs caught (too small to be micro-chipped) was higher than 30% for each survey area.

The 2014-2015 monitoring season had the highest survivorship of juvenile frogs over winter and the greatest numbers of juvenile frogs entering the population at the start of spring. The later breeding events in late spring and summer added even more young frogs to the populations in the catchments of the MJR and Crawford River. Based on the average number of adult frogs recorded, it appears that many of these young frogs cannot survive (either there is not enough food to sustain such a high number of frogs, or competition and cannibalism by the large resident frogs will reduce the numbers of smaller frogs).

6.6.4 Habitat Assessment

Habitat availability and quality is quite variable within the MJR catchment. The variations in habitat availability are directly related to the extent of land clearing in the river corridor. Along the lower and middle sections of the MJR and Wards River the riparian vegetation was totally removed in places where there were broad river flats. The initial timber cutters in the district removed most of the taller trees and cleared smaller areas for log dumps and for snig tracks. The dairy farmers who later moved into the Stroud-Gloucester Valley removed most of the shrub and low tree cover to create grazing lands. Unfortunately, they also removed many of the trees along the banks of the river resulting in bank destabilisation and loss of topsoil.

Today, the riparian corridor is peppered areas that have either remained relatively bare (due to the loss of top soil) or have become overgrown by invasive weeds (especially privet and lantana). Where these invasive weeds have become densely established, the native ground cover plants have been lost through over-shadowing and over-crowding and the ground surfaces are relatively bare of herbs and grasses.

Current agricultural practices in the valley are still impacting on the riparian vegetation and on habitat that could otherwise be used by the Giant Barred Frogs. The extensive clearing of vegetation across the river flats accelerated surface run-off after rain. This is in part responsible for the sudden rises and falls in river levels following rainfall. The sudden river surges also accelerate the erosion of the riverbanks which in turn has changed the riverbank profiles. The main channel of the MJR is now deeply incised and has much steeper banks than before the arrival of the early settlers. There is no data available to know exactly how the water surges affect the Giant Barred Frogs and their tadpoles but compared to other locations (where these Frogs occur) sudden changes in river levels are not a feature of the "typical habitat" (Mahony et al. 1997). One possible advantage of the sudden changes in river level might be that it also reduces the number of fish that can feed in the river (and this may reduce the predation of tadpoles by fish).

Other impacts on habitats for the Giant Barred Frog arise as a result of the trampling of the riparian vegetation by cattle (Plate 11) and predation by exotic species (such as foxes and pigs).

The effect of the impacts described above has created a discontinuous habitat area along the riparian strip. Some areas, such as the lower and middle sections of the Wards River arm of the MJR catchment and the Terreel Valley section of the MJR are now devoid of habitat for the Giant Barred Frog.

The lower sections of the Wards River (e.g. Survey Area 4) have undergone a radical loss of riparian vegetation with the establishment of dense privet groves within the riverbanks (Plate 15).

In the Terreel Valley (not a survey area), not only has the riparian vegetation been cleared, but the surrounding land has been cleared over most of the area of the valley.

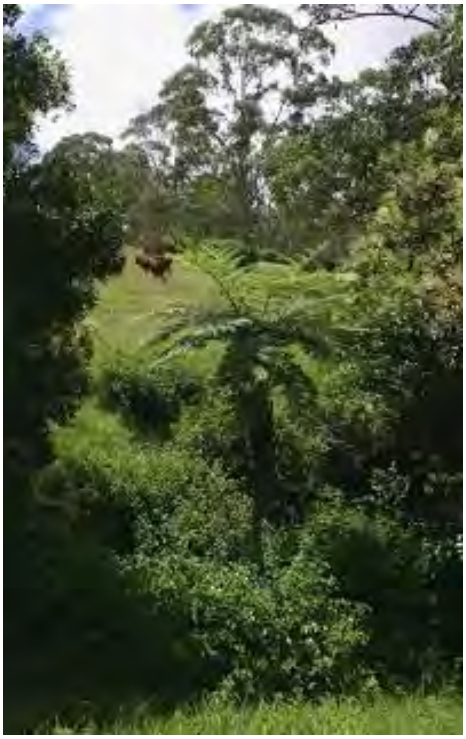


Plate 15: Lower Wards River – Extensive Privet Infestation

The Crawford River area was chosen as a mining and agriculturally-impacted control site because of the relatively intact nature of the habitat areas along the river corridor. Selective logging occurred within the catchments and some areas close to the riverbanks still retained the old stumps of large trees that had been removed. However, this area was not cleared for dairy farming and most of the original ground cover vegetation still remains. In addition, the upper catchment of the Crawford River lies in protected lands and the river does not show signs of significant changes to flow regimes that are apparent in the MJR.

The deep scouring of the river channel in the middle and lower sections of the MJR (Survey Areas 1, 2 and 3) has removed pools and backwaters from the water course creating a single, deep channel that is prone to sudden rises and drops in water level. The surging nature of the river under these conditions makes the survival of Giant Barred Frog tadpoles in the lower and middle MJR (including Survey Areas 1 and 2, near the DCM) very difficult.

6.6.5 Hydrological Conditions

Despite the lower-than-average flow conditions of the MJR, Giant Barred Frogs were regularly found foraging along the banks or in the nearby pastureland. Breeding, as evidenced by the emergence of juvenile frogs, was evident in all sections of the MJR and Crawford River (Survey Area 7).

The regular rainfall periods meant that salt levels did not rise to a point where they were a problem for the tadpoles and frogs in the river. Salt levels remained moderately low throughout the survey period (Chart 18-23).

There is a strong correlation between stream flow changes and the number of Giant Barred Frogs found. During periods of rising water levels, frog captures declined markedly in the riparian corridor and more frog sightings were made in the nearby pastureland. During high flow periods, few Giant Barred Frogs were found. However, a few days after the fall in river levels, Giant Barred Frog numbers rapidly rose and many frogs were observed to be actively foraging.

Changing water levels not only determined frog activity and abundance but also influenced readiness for breeding in the Giant Barred Frog. For example, in December 2014, January and February 2015, surveys were conducted when river levels were falling. During this time, frog calling was high and amplexed animals were found. As spawn masses are hard to find, it was not possible to demonstrate spawning success at these times. However, frog behaviour certainly indicated active breeding, and tadpoles or young frogs were later found in these areas.

6.6.6 Chytrid Fungus

Of the 200 skin swabs taken, DNA of the Chytrid pathogen was successfully extracted from 35 of these. In a few cases the laboratory was unable to amplify DNA. It appears that the amplification of the DNA was inhibited by the presence of other DNA (most likely bacterial DNA).

A 19% infection rate was a considerable increase from 3% levels recorded during the drought of 2013-2014. Clearly, Chytrid was able to thrive under the more mesic conditions experienced this season and more frogs were likely to succumb to Chytrid infections during the winter period.

7. INCIDENTAL SURVEYS (BETWEEN 2015 AND 2018)

Between 2015 and 2018, a few opportunistic and less formal Giant Barred Frog surveys took place. These surveys were much shorter in duration (usually 4 days on site) and included a small sub-set of survey sites. These surveys are further described below.

7.1 OCTOBER 2015 SURVEY

In April 2015, a major low-pressure system formed along the east coast of Australia (referred to as an East Coast Low). The system produced intense rainfall, high winds and damaging waves. Widespread heavy rain occurred across the Upper Hunter Region from the 20th of April to the 22nd of April 2015. The most intense falls occurred on the morning of the 21st of April 2015. On that day the town of Dungog received 188 mm of rain, Patterson 242 mm of rain, and Stroud (on the MJR) received 164 mm of rain (Bureau of Meteorology; Stroud Post office Met station).

The sudden deluge caused many of the local waterways to rise quickly and burst their banks. Swiftly moving flood waters swirled through Stroud, Dungog, Maitland and Patterson. Flooding in Dungog washed away five houses, significantly damaged another 80 homes, drowned livestock, flattened fences and caused extensive erosion of river channels. Human fatalities also occurred in the wake of the floods.

Near Stroud, MJR and Mill Creek both broke their banks. Floodwater surged across all low-lying parts of the town, especially in the areas around the Stroud Showground and close to Mill Creek. Houses were lost and many more damaged. The flood was short-lived and by the 26th of April 2015 river levels had dropped below the level of the banks.

The impact of the storm and the resultant sudden flooding was not only a disaster for the towns people and the farmers in the valley, but also for the wildlife that depend on the river corridor. Our previous work on the Giant Barred Frogs had shown that they move away from the riverbanks during times of rising waters and so can avoid the danger of being washed away during flood events. But this flood was so rapid, it seemed unlikely that any riparian species would have had sufficient time to escape the turbulent floodwaters.

In order to assess the impact of the April 2015 flood on the Giant Barred Frog population in the MJR catchment, two field staff returned to Stroud and surveyed 10 sites scattered across Areas 2, 3 and 4. The survey method was the same as previous monitoring seasons (i.e. night transects of 200 m lengths of the riverbanks for 30 minutes each site). The biggest change in method was that no untagged frogs were micro-chipped. The aim of the exercise was to determine the survival rates of the frogs after the flood, not to increase the number of tagged frogs.

Deep scouring had occurred to the river channel in many places while sand bars and flood debris blocked other sections of the channel. Depressions and old ox-bows in the nearby peneplain were still full of water six months after the April flood.

Giant Barred Frogs were present in all of the sites surveyed. Giant Barred Frog captures were reasonably high and frog densities had not changed significantly since the previous season. Although Giant Barred Frogs do not construct burrows, they can somehow avoid fast flowing flood water. Tadpole numbers were down, as they do not have the same capacity to escape fast flowing water as frogs.

The October 2015 survey indicates that, despite the destruction of habitats along the riverbanks and surrounds (Plate 16), Giant Barred Frog numbers were relatively unaffected.

Plate 16: Deep Scouring of the Riverbanks Exposes Tree Roots, MJR, Site 37

7.2 FEBRUARY 2018 SURVEY

Another informal survey was carried out in February 2018. The purpose was to gain some information about the natural attrition rate of Giant Barred Frogs. Giant Barred Frogs had been tagged once they reached a snout-vent length of 40 mm of more. Giant Barred Frogs reach a size of 40 mm within the first year after metamorphosis. Some frogs will die through predation, disease or misadventure, while others will die of old age. By examining the “drop-off” rate of tagged frogs it is possible to extrapolate backwards and determine an average life expectancy for Giant Barred Frogs.

Two survey staff visited 10 sites in Areas 2, 3 and 4 in February 2018. Giant Barred Frogs were captured, but less than 20% of them had been micro-chipped. The last time that Giant Barred Frogs were microchipped was in March 2015, so in the two and a half years since the micro-chipping program was ended, 80% of the tagged Barred Frogs were no longer in the population. About 30% of the frogs that were tagged were 1 year old, the others were older. Plate 1 shows one of the adult recorded Giant Barred Frogs.

This rate of turnover of adult frogs provides useful information about the life expectancy of Giant Barred Frogs. Assuming that most of the Giant Barred Frogs that had been tagged survived to sexual maturity and that predation or disease of adults was not the major cause of death, the life expectancy of male Giant Barred Frogs is between 5 and 6 years, and between 6 and 7 years for female Giant Barred Frogs.

8. KEY FINDINGS

8.1 DISTRIBUTION

Prior to the commencement of the assessments and surveys implemented for the DCM, Giant Barred Frogs were scarcely recorded within the MJR catchment. With more than 8 years of surveys completed between 2010 to 2018, it is now known that Giant Barred Frogs are widely distributed throughout the MJR catchment. Giant Barred Frogs were not present in the lower reaches of the MJR (i.e. from north of Stroud to the junction with the Karuah River) and were not present in the uppermost sections of the catchment (in the higher parts of Ghin-Doo-Eee National Park). The frogs were present in the lower Wards River section of the catchments but were conspicuously absent in the Terreel Valley (Figure 12).

While the frogs occupy the majority of the length of the catchment, their abundances varied greatly. In general, Giant Barred Frogs were in high abundance in areas where the riparian ground and canopy vegetation was intact and where water quality was not compromised by agricultural or sustained salt influxes from surrounding geology. The frogs were most common along the middle sections of the MJR, from north of Stroud to the Mavis Tersteeg Crossing (i.e. Survey Areas 3 and 4).

Giant Barred Frogs were also found in reasonable numbers in Mill Creek, and Saggers Creek, close to the MJR. They were present in exceptionally high numbers along the lower and middle sections of Crawford River.

8.2 ABUNDANCE

A summary of the Giant Barred Frog population estimates is presented below in Table 30. The sum of the population estimates of Giant Barred Frogs in each survey area in the 2014-2015 monitoring period is 271 adult Giant Barred Frogs in the MJR catchment (Survey Areas 1-4) (compared with 310, 317 and 229 frogs from the previous three monitoring seasons respectively). The largest sub-populations of Giant Barred Frogs being in Survey 4.

Table 30
Giant Barred Frog Population Estimates Between Survey Periods 2011-2015*

Monitoring Period	Survey Area 1	Survey Area 2	Survey Area 3	Survey Area 4	Survey Area 7
2011-2012	52(2)	53(3)	96(4)	110(4)	202(4)
2012-2013	50(5)	67(5)	75(5)	125 (5)	140 (6)
2013-2014	30 (4)	44 (4)	67 (4)	88 (4)	178 (4)
2014-2015	39(4)	26(5)	78(4)	128(4)	267(4)

*Population estimate values were not included for period when no recaptures had been made. The number in brackets refers to the number of estimates used in deriving the final population number.

Most of the Giant Barred Frog populations in each survey area are relatively stable (although they all vary from year to year). Only Area 2 showed any noticeable trend where frog numbers slowly declined since the start of the monitoring. This decline is not attributable to mine-related activities and appears to be the results of habitat deterioration along the lower parts of the MJR. The DCM did not commence irrigation in areas approved under the Duralie Extension Project.

Frog population data indicated that the Giant Barred Frogs in the MJR and Crawford River catchments fluctuate according to climatic conditions but overall, they are reasonably stable. No effect of the existing irrigation or mining activities at the DCM is evident on the frog numbers downstream of the Coal Shaft Creek confluence.

Fluctuations in the Giant Barred Frog populations appear to be driven by prevailing weather conditions. The populations were at their lowest during the 2013-2014 drought. These fluctuations account for more than 20% of the previous year's population. Such large changes in frog populations from year to year can easily mask other impacts on the frogs. This study has incorporated a suite of control sites to help uncouple coinciding impacts, however, wide-ranging weather and climate shifts will impact both experimental and control sites and make determinations about subordinate impacts more difficult to quantify.

8.3 BREEDING SUCCESS

Tadpoles or juvenile frogs were initially only found in Survey Areas 4 and 7. The scarcity of tadpoles appears to reflect the low river levels and drier weather condition before and during the survey. However, by January 2014, juvenile frogs had been found at all of the areas along the MJR.

Based on the number of new frogs at each survey area it appears that the successful recruitment rate in 2014 to 2015 was, on average, about 11% across Areas 1, 2, 3 and 4 in the MJR catchment. This was the highest recruitment measured during the surveys. The average rate is 9% (based on the previous three surveys). It appears that the tadpoles that survived by over-wintering produced young frogs in early spring that were the main contributors to the population influx.

The impact of late spring/early summer breeding is more variable. In some years, none of these later breeding seasons froglets survive the winter months and hence do not contribute to the population growth. If winter conditions are benign, some young frogs survive and appear in the population as adults by the next spring.

8.4 HABITAT QUALITY AND AVAILABILITY

Habitat quality varies greatly within the catchment. The majority of the riparian habitat in the MJR catchment had been degraded through earlier vegetation clearing and timber felling and more recent degradation due to cattle grazing and agricultural activity. These activities denuded the riverbanks of native vegetation in many areas. Ongoing cattle damage is resulting in accelerated erosion of the banks and the widespread use of agricultural sprays and chemicals impacts water quality in the river.

Despite these impacts, some high-quality habitat area survive where the riparian vegetation is either completely or partially intact, where cattle have been fenced out of the river, and where agricultural activity is minimal.

The Crawford River was selected as a control site (outside of the MJR catchment) as it is minimally impacted by agriculture and had not suffered through loss of riparian vegetation. In the areas where the riparian vegetation is intact and agriculture is minimal, Giant Barred Frog numbers are high.

Some areas, such as the lower and middle sections of the Wards River arm of the MJR catchment and the Terreel Valley section of the MJR were extensively cleared and habitat suitable for the Giant Barred Frog had not returned to these areas.

8.5 FROG CHYTRID DISEASE

Batrachochytrium dendrobatidis, the pathogen that causes the fatal Frog Chytrid Disease, is widespread throughout the MJR catchment. Not only is the pathogen present in Giant Barred Frogs, it is also present in other common riparian frogs such as Wilcox's Frog and Eastern Leaf Green Tree Frog.

Antibody data collected during the surveys revealed that between 40-50% of the Giant Barred Frogs swabbed have had exposure to the disease. As deaths to the disease appeared to be relatively modest, it was assumed that the frogs may have developed some degree of resistance to the pathogen. It is also possible that Chytrid infection rates are kept to sub-lethal levels by the incipient salt that leeches into the river during times of low water flow.

Skin swabs were collected each season and sent to the University of Newcastle to assess the infection rates. Infection rates were greatly influenced by weather conditions, for example, the 2013-2014 data showed that infection rates fell to only a few percent, in response to the prevailing hot and dry conditions before and during the survey period. This was an unexpected consequence of weather conditions that are otherwise rather unfavourable for frogs.

Conversely, when skin swab data was collected after long, wet periods (e.g. in October and November 2014) infection rates rose dramatically, both in terms of the number of infected frogs found but also in terms of the spore loads that each frog was carrying.

8.6 RESPONSE TO FLOODING

The position of Giant Barred Frogs away from the riverbank was recorded for each frog capture and this data was correlated with the prevailing river height. The data showed a strong correlation between river height and distance from the river. When the river was rising and high, the frogs moved out onto the river flat, away from the main channel. Once river levels began to fall, the frogs moved back to the main channel and resumed occupancy of the stream banks until the next episode of high water flow returned to the river.

When the river is high or breaking its banks, the frogs are unable to forage or seek mates along the banks. In addition, there is a risk of being swept away by fast flowing water. Frogs moving out onto the river flats may still be able to forage but they still cannot breed there (as they need the overhung riverbanks as egg deposition sites).

If the river breaks its banks and inundates the river flats, the frogs are still at low risk of being swept away by moving water. The frogs may take shelter under low, ground vegetation and may be covered by water for some days but this is not a problem for them. Giant Barred Frogs, like most frogs, are able to absorb low levels of oxygen directly through their skin when submerged. By sitting still and not raising their oxygen demands, the frogs can survive in this inactive state where they can cease lung-breathing for days or weeks.

The risk for Giant Barred Frogs submerged on flooded river flats is twofold. Fish such as eels may forage in the shallow flood water and these frogs become potential prey, but also the frogs risk being buried by deposited silt, sand and debris.

The significant flood of 2015 dramatically demonstrated the ability of these frogs to survive flooding. That flood was abrupt and severe. The river rose within hours of the onset of rain and water flow was extreme; trees and fences along the riverbanks were uprooted and washed away. Giant Barred Frogs survived the deluge with little noticeable impact on their population. Adult frogs appeared to have survived unharmed, but the same was not true for juveniles. Six months later, there was still a gap evident in the tadpole cohorts in the MJR catchment. Tadpoles do not have the same capacity to avoid fast flowing water as adult frogs. Tadpoles can seek backwaters or small side channels that feed into the main channels as immediate refuges, but large floods overrun these areas and the tadpoles are quickly swept away.

8.7 RESPONSE TO DROUGHT

The Gloucester area experienced drought between 2013 and 2014. During this period, the river was consistently very low and stopped flowing for short periods. Isolated pools remained along the river but the water quality in these pools deteriorated over time. The most noticeable change was the increase in salt concentration in the standing water. Salt is present in many of the finer sedimentary layers in the Gloucester basin and it is constantly leaching out wherever a watercourse has intersected the salt-rich sediments. While the river is flowing, salt is prevented from accumulating and the river remains relatively fresh. During times of drought, the remaining standing water eventually becomes too saline for some frog species to use.

Giant Barred Frogs were detected in good numbers throughout the drought years. Breeding had been suspended when the river ceased flowing and salt levels rose in the remaining water. The frogs continued to use the riverbanks during the warmer months of the year to forage and seek temporary shelter.

It was noticeable that during this period, Giant Barred Frogs would often be out on cold nights when dew was forming. This behaviour suggested that the frogs were supplementing their water intake by absorbing water droplets from their skin's surface when the dew was forming. By doing this, the Giant Barred Frogs did not need to venture into the salt-rich pools in the river channel and could forage along the dry banks.

During the drought, the ground cover vegetation along the stream banks eventually disappeared in places. The loss of stream-side vegetation corresponded with a noticeable decline in invertebrate animal life in the leaf litter along the river. This was one of the few times that cannibalism was observed in Giant Barred Frogs with larger frogs consuming smaller frogs of the same or other species.

The adult population of Giant Barred Frogs in the MJR catchment reduced by only 6% in 2013-2014. This decline was not due to the deaths of adult frogs, but instead due to the relatively low recruitment of juvenile frogs. Young frogs did not fare well during the drought as their smaller body mass means that they lose body water relatively faster than larger frogs and they are preyed upon by larger frogs.

8.8 POPULATION VIABILITY

As indicated in the two preceding segments (Sections 8.6 and 8.7), drought and flood did not greatly change the size of the adult Giant Barred Frog population in the MJR catchment. Table 30 shows quite clearly that the population of Giant Barred Frogs in Areas 1, 2, 3 and 4 in the MJR catchment had stable numbers throughout the surveys with frog densities ranging from one frog every 25 m in Areas 1 and 2 to one frog every 10m to 15 m in Areas 3 and 4. The frog density was greatest along the Crawford River where densities reached one frog every five metres. The Crawford River Giant Barred Frogs were not only more numerous along the riverbanks, but their population fluctuated less than the Barred frogs along the MJR.

Despite being relatively stable, both frog populations are at some risk. For Giant Barred Frogs in the MJR, the risks are related to poorer quality habitat (especially in Areas 1 and 2), site disturbance, and habitat loss due to agricultural impacts and changes in the hydroperiod of the river (associated with the changes in water run-off from the river flats). These impacts also make the frogs more susceptible to Chytrid disease.

For the Giant Barred Frogs along the Crawford River, the risks are not related to habitat quality. For the Giant Barred Frogs in the Crawford River, the biggest threat is their relative isolation. The Frogs in the Crawford River have only a 20 km section of river that is suitable for them and no safe movement corridor to another waterway. The Giant Barred Frogs along the MJR have much longer lengths of riverbanks to utilise and have tributaries, such as Wards River and Coal Creek that allow them to approach the headwaters of neighbouring waterways.

Overall, both populations should be considered reasonably secure at present, but both populations could decline rapidly should conditions and impacts change.

9. POTENTIAL IMPACTS

During the monitoring programs several potential impacts to the Giant Barred Frog population in the MJR catchment were identified. Whilst these potential impacts are significant, this was not the primary purpose of this study and no further discussion is included within this report.

- Altered hydrology and flow patterns in MJR.
- Water quality degradation including increased salinity.
- Agricultural practices including land clearing and fertiliser application.
- Livestock management.
- Exotic weed invasion.
- Predation by feral animals.

10. CONCLUSION

Monitoring of the Giant Barred Frog population in the MJR catchment was undertaken between 2010 and 2018.

The original reason for the monitoring and surveys was to establish baseline data so that potential impacts from the additional proposed mine water irrigation areas approved under the Duralie Extension Project could be monitored over time. However, DCPL did not commence irrigation of the additional irrigation areas and mining operations at the DCM have also now ceased.

The study of the Giant Barred Frog in the MJR has instead provided a unique opportunity to observe and collect meaningful ecological data on an endangered frog species.

Prior to the commencement of the assessments and surveys implemented for the DCM, Giant Barred Frogs were scarcely recorded within the MJR catchment. The detailed monitoring of the Giant Barred Frog allowed for the collection and collation of detailed information about this species over a number of years, and under a range of climatic circumstances. This data is significant for the conservation of this species along the MJR and elsewhere within its range.

Key findings from this study are:

- The Giant Barred Frog is widely distributed throughout the MJR catchment.
- The Giant Barred Frog is most common along the middle sections of the MJR, from north of Stroud to the Mavis Tersteeg Crossing.
- Giant Barred Frogs occur in reasonable numbers in Mill Creek, and Saggers Creek, close to the MJR. They were present in exceptionally high numbers along the lower and middle sections of Crawford River.
- Giant Barred Frogs were in high abundance in areas where the riparian ground and canopy vegetation was intact and where water quality was not compromised by agricultural or sustained salt influxes from surrounding geology.
- The population of Giant Barred Frogs in the MJR was estimated to be 271-317 adult frogs.
- An average recruitment rate of ~9% was found and it appears that the tadpoles that survived by over-wintering produced young frogs in early spring that were the main contributors to the population influx.
- *Batrachochytrium dendrobatidis*, the pathogen that causes the fatal Frog Chytrid Disease, is widespread throughout the MJR catchment. Antibody data collected during the surveys revealed that typically between 40-50% of the Giant Barred Frogs swabbed have had a previous exposure to the disease. As deaths to the disease appeared to be relatively modest, it was assumed that the frogs may have developed some degree of resistance to the pathogen. It is also possible that Chytrid infection rates are kept to sub-lethal levels by the incipient salt that leeches into the river during times of low water flow.
- Habitat quality varies greatly within the catchment. The majority of the riparian habitat in the MJR catchment had been degraded through earlier vegetation clearing and timber felling and more recent degradation due to cattle grazing and agricultural activity. Despite these impacts, some high-quality habitat area persist where the riparian vegetation is either completely or partially intact, where cattle have been fenced out of the river and where agricultural activity is minimal.

  Overall, the populations in the MJR catchment and Crawford River are considered as reasonably secure at present, but both populations could decline rapidly should conditions and impacts change.

11. REFERENCE LIST

Anstis, M. (2002) Tadpoles of South-eastern Australia – a Guide with Keys. New Holland Publishers.

Anstis, M. (2013). Tadpoles and Frogs of Australia. New Holland Publishers.

Anstis, M. (2017). *Tadpoles and Frogs of Australia*.2nd Edition. New Holland Publishers.

Berger, L., Speare, R. and Hyatt, A. (1999). Chytrid fungi and amphibian declines: overview, implications and future directions. In Declines and Disappearances of Australian Frog., A. Campbell (ed.) National Heritage Trust, Canberra.

Biosphere Environmental Consultants (2010-2011) Surveys for Duralie Coal Pty Ltd - unpublished data.

Biosphere Environmental Consultants (2012) Giant Barred Frog (*Mixophyes iteratus*) Monitoring Results September 2011 to February 2012. Prepared for Duralie Coal Pty Ltd.

Biosphere Environmental Consultants (2013) Giant Barred Frog (*Mixophyes iteratus*) Monitoring Results September 2012 to February 2013. Prepared for Duralie Coal Pty Ltd.

Biosphere Environmental Consultants (2014) Giant Barred Frog (*Mixophyes iteratus*) Monitoring Results September 2013 to January 2014. Prepared for Duralie Coal Pty Ltd.

Biosphere Environmental Consultants (2015) Giant Barred Frog (*Mixophyes iteratus*) Monitoring Results October 2014 and February 2015. Prepared for Duralie Coal Pty Ltd.

Department of Environment and Climate Change (2009) *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna – Amphibians*.

Department of Environment, Climate Change and Water (2009) Threatened Species Home Page.
Website: www.threatenedspecies.environment.nsw.gov.au.

Department of Primary Industries, New South Wales Office of Water (2012) Real Time Data – Streams and Rivers.
Website: http://www.water.nsw.gov.au/realtime-data/default.aspx
Date Accessed: 24 October 2012.

Department of Planning, Industry & Environment (1999). *Giant barred frog (Mixophyes iteratus) - Endangered Species Listing*.
Website: https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/nsw-threatened-species-scientific-committee/determinations/final-determinations/1996-1999/giant-barred-frog-mixophyes-iteratus-endangered-species-listing

Department of Sustainability, Environment, Water, Population and Communities (2012) *Mixophyes iteratus* in Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra.
Website: http://www.environment.gov.au/sprat.

Department of the Environment, Water, Heritage and the Arts (2010) *Survey Guidelines for Australia's Threatened Frogs*.

EcoBiological (2009) Flora and Fauna Survey Report: Duralie Coal Mine, Gloucester, New South Wales. Report prepared for Duralie Coal Pty Ltd.

Gilbert & Associates (2010) *Duralie Coal Mine Surface Water Assessment*.

Goldingay, R., Newell, D. and Graham, M. (1999) *The status of Rainforest Stream Frogs in* north-eastern New South Wales: decline or recovery?

Hines, H., Mahony, M. and McDonald, K. (1999) An Assessment of Frog Declines in Wet Subtropical Australia.

Hines, H. (2012). Giant Barred Frog in LK Curtis, AJ Dennis, KR McDonald, PM Kyne, and S Debus (eds). Queensland's Threatened Animals. CSIRO Publishing, Collingwood. pp 331-334.

Ingram, G.J. and McDonald, K.R. (1993). An update on the decline of Queensland's frogs. pp. 297-303. In: Lunney, D. and Ayers, D. (eds). Herpetology in Australia. A Diverse Discipline. Mosman: Royal Zoological Society of New South Wales.

Kendall, W.L., Pollock, K.H. and Browne, C. (1995). A likelihood approach to capture-recapture estimation of demographic parameters under the robust design. *Biometrics.* 12: 293-308.

Kendall, W.L., Nichols, J.D. and Hines, J.G. (1997). Estimating temporary emigration using capture-recapture data with Pollock's robust design. Ecology 78(2): 563-578.

Knowles, R., Thumm, K., Mahony, M., Hines, H., Newell, D. and Cunningham, M. (2015) *Oviposition and egg mass morphology in barred frogs (Anura: Myobatrachidae: Mixophyes Günther, 1864), its phylogenetic significance and implications for conservation management*. Australian Zoologist 37(3): 381-402.

Koch, S. and Hero, J.M. (2007) The relationship between environmental conditions and activity of the Giant Barred Frog (*Mixophyes iteratus*) on the Coomera River, South-East Queensland. Australian
Journal of Zoology, 55: 89–95.

Lemckert, F. and Brassil, T. (2000) Movements and habitat use of the endangered giant barred river frog (*Mixophyes iteratus*) and the implications for its conservation in timber production forests. Biological Conservation 96(2): 177-184.

Laurance, W.F., McDonald, K.R. and Speare, R. (1996). Epidemic disease and the catastrophic decline of Australian rainforest frogs. Conservation Biology 10: 1-9.

Lemckert, F. and Shoulder, J. (2007). The diets of three sympatric Barred River Frogs (*Anura: Myobatrachidae*) from south-eastern Australia. Herpetological Review 38(2):152–154.

Lewis, B.D. and Rohweder, D.A. (2005). Distribution, habitat, and conservation status of the Giant Barred Frog *Mixophyes iteratus* in the Bungawalbin catchment, north-eastern New South Wales. Pacific Conservation Biology 11: 189-197.

Lollback, G.W., Lockwood, M.A. and Hannah, D.S. (2020). New information on site occupancy and detection rate of *Mixophyes iteratus* and implications for management. Pacific Conservation Biology
Website: https://www.publish.csiro.au/pc/PC20075.

Madani, G. (2021) Notes on the diet and foraging habits of the Giant Barred Frog *Mixophyes iteratus*. Australian Zoologist 41 (2): 200–204.

Mahony, M.J. (1993). The status of frogs in the Watagan Mountains area the Central Coast of New South Wales in D Lunney and D Ayers (eds) Herpetology in Australia: A diverse discipline. Royal Zoological Society of New South Wales, Sydney. Pp 257-264.

Mahony, M., Knowles, R. and Pattinson, L. (1997). ''6. Gold-eyed Barred Frog, *Mixophyes iteratus*. In '*Threatened Frogs of New South Wales: Habitats, Status and Conservation'.* H. Ehmann, ed., Frog and Tadpole Study Group of NSW, Sydney, 78-84. Published by the Frog and Tadpole Study Group of New South Wales Inc.

Mary River Catchment Coordinating Committee (2016) *Annual Report 2016.*

Meyer, E., Hines, H. and Hero, J.M. (2001). Wet forest frogs of south-east Queensland. Griffith University, Brisbane. P 28.

New South Wales National Parks and Wildlife Service (2000) Threatened Species of the Lower North Coast of New South Wales. NSW National Parks and Wildlife Service, Coffs Harbour.

New South Wales National Parks and Wildlife Service (2001) *Hygiene Protocol for the Control of Disease in Frogs.*

Newell, D. (2018). An update on frog declines from the forests of subtropical eastern Australia in H. Heatwole and J.J.L Rowley (eds) Status of conservation and decline of amphibians Australia, New Zealand, and Pacific Islands. CSIRO publishing, Clayton South. pp 29-37.

NSW Scientific Committee (1999) *Giant Barred Frog – Endangered Species Listing*. NSW Scientific Committee Final Determination.

Office of Environment and Heritage (2017) *Atlas of NSW Wildlife Database Search*.

Streatfield, C. (1999). Spatial movements of *Mixophyes iteratus* and *M. fasciolatus* in Southeast Queensland. Hons. Thesis. Brisbane, Queensland; Griffith University.

White, A.W. (2008) The distribution and conservation status of Barred Frogs in the Sydney Basin. Part 1. Giant Barred Frog *Mixophyes iteratus*. *Herpetofauna*, 38(1):24-33.

Wood, P. (2017). *Mixophyes iteratus* Survey Report No. 10 iii Bruce Highway (Cooroy to Curra) Upgrade Section A (Cooroy southern interchange to Sankeys Road). Report for Department of. Transport and Main Roads, Queensland.

ATTACHMENT 1
SUMMARY OF BASELINE CAPTURE DATA
ADULT AND JUVENILE GIANT BARRED FROG CAPTURE DATA

Table A-1
Summary of Baseline Capture Data
Adult and Juvenile Giant Barred Frog Capture Data

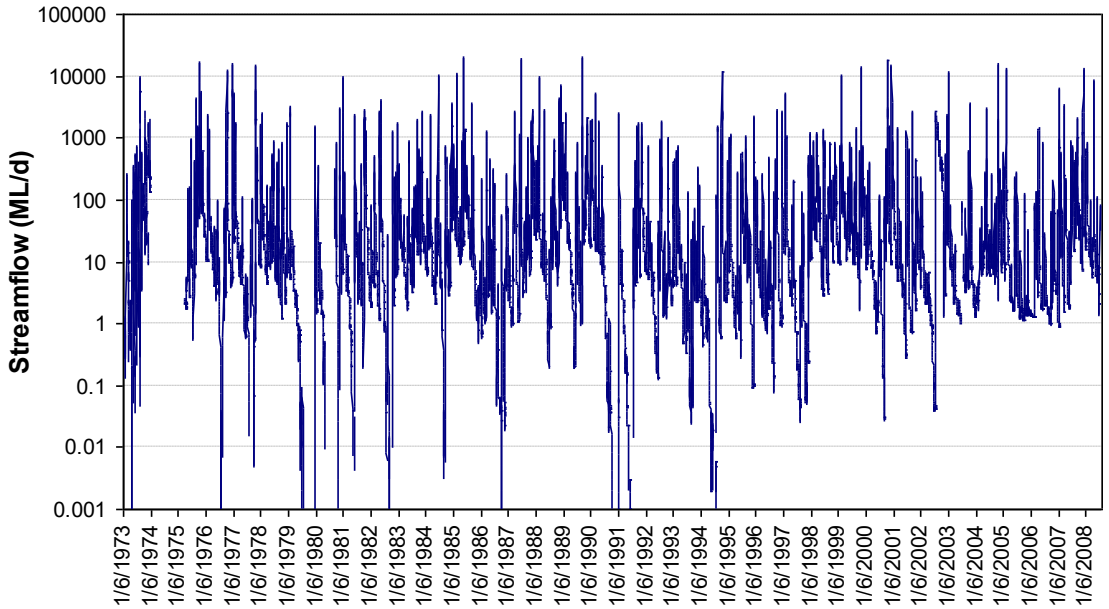
DATE	PIT TAG No.	Recapture	SEX	Snout-Vent Length (mm)	Body Weight (g)	Gravid or non-gravid	Injury or Disease	Swabbed For Chytrid	Site where First Found	Other Observations
29/11/2010	068B0158	No	F	98.6	-	Non	Nil	No	3	
30/11/2010	068B10B7	No	F	96.2	-	Non	Nil	No	8	
30/11/2010	068B242D	No	M	73.6	-	-	Nil	No	9	
30/11/2010	068B1B66	No	Sub-adult	44.8	-	-	Nil	No	0	
30/11/2010	068B13B3	No	M	73.0	-	-	Nil	No	9	
13/12/2010	068BA233	No	M	83.3	-	-	Nil	Yes	2	
13/12/2010	068B3DB9	No	F	88.5	-	Non	Nil	Yes	2	
13/12/2010	068B46C0	No	M	76.0	-	-	Nil	Yes	11	
14/12/2010	068BA233	Yes	M	83.3	-	-	Nil	No	2	
14/12/2010	068B242D	Yes	M	73.6	-	-	Nil	Yes	9	
14/12/2010	068B7176	No	F	88.5	-	Non	Nil	Yes	9	
15/12/2010	068A9623	No	M	66.6	-	-	Nil	Yes	9	
15/12/2010	068B288A	No	M	69.4	-	-	Nil	Yes	11	
5/01/2011	068B3985	No	M	74.2	44.0	-	Nil	Yes	3	
5/01/2011	068B0E1C	No	M	73.8	46.5	-	Nil	Yes	28	
7/01/2011	-	-	Juv	24.1	5.7	-	Nil	Yes	7	
7/01/2011	-	-	Juv	36.8	9.8	-	Nil	Yes	28	
8/01/2011	068B67AE	No	F	91.7	145.6	Poss gravid	Nil	Yes	3	
8/01/2011	-	-	Juv	39.5	17.0	-	Nil	Yes	3	
8/01/2011	O68B5EE8	No	F	95.9	136.6	Non	Nil	Yes	3	
8/01/2011	068B6304	No	M	73.8	55.6	-	Nil	Yes	3	
27/01/2011	068B8610	No	M	73.8	46.0	-	Nil	Yes	2	
27/01/2011	-	-	Juv	39.8	8.0	-	Nil	Yes	2	
27/01/2011	068B67AE	Yes	F	92.1	120.0	-	Nil	No	3	
27/01/2011	-	-	Juv	38.5	8.5	-	Nil	Yes	28	
27/01/2011	068B0E1C	Yes	M	70.6	47.2	-	Nil	No	28	
27/01/2011	068B4A44	No	M	64.6	42.0	-	Nil	Yes	28	
27/01/2011	-	-	Juv	35.3	5.5	-	Nil	Yes	28	
27/01/2011	-	-	Juv	27.7	4.5	-	Nil	Yes	28	
28/01/2011	068B31B7	No	F	102.2	186	Poss gravid	Nil	Yes	4	
28/01/2011	-	-	Juv	32.5	5.5	-	Nil	Yes	24	
28/01/2011	068B242D	Yes	M	79.6	65.0	-	Nil	No	9	
29/01/2011	068B4C0C	No	M	83.3	-	-	Nil	Yes	2	
29/01/2011	068B4FFE	No	F	93.4	107.0	Non	Nil	Yes	2	
29/01/2011	-	-	Juv	37.2	5.0	-	Nil	Yes	11	
30/01/2011	068B67AE	Yes	F	92.1	120.0	Non	Nil	No	3	
30/01/2011	068B31B7	Yes	F	102.2	143.0	Non	Yes	No	4	Trampled by cows, severed L arm.
30/01/2011	068B1B4A	No	F	95.3	134.0	Poss gravid	Nil	Yes	4	
30/01/2011	068B18BC	No	M	69.8	60.0	-	Nil	Yes	9	
30/01/2011	068B020F	No	M	52.0	34.5	-	Nil	Yes	9	
30/01/2011	-	-	Juv	39.5	8.5	-	Nil	Yes	28	

DATE	PIT TAG No.	Recapture	SEX	Snout-Vent Length (mm)	Body Weight (g)	Gravid or non-gravid	Injury or Disease	Swabbed For Chytrid	Site where First Found	Other Observations
31/01/2011	068B162A	No	F	60.0	60.0	Non	Nil	Yes	6	
16/02/2011	068B67AE	Yes	F	91.9	145.0	Non	Nil	Yes	3	
16/02/2011	068B56E9	No	M	69.7	47.5	-	Nil	Yes	3	
17/02/2011	068B242D	Yes	M	77.4	44.2	-	Nil	No	9	
17/02/2011	-	-	Juv	39.9	10.0	-	Nil	Yes	9	
17/02/2011	O68B330F	No	M	56.4	28.5	-	Nil	Yes	9	
17/02/2011	068B0E1C	Yes	M	72.8	37.6	-	Nil	No	28	
17/02/2011	068B2E7A	No	F	75.3	81.0	Non	Nil	Yes	28	
18/02/2011	068B56E9	Yes	M	70.2	48.0	-	Nil	No	3	
18/02/2011	-	-	Juv	30.3	5.0	-	Nil	Yes	7	
18/02/2011	-	-	Juv	29.1	4.4	-	Nil	Yes	11	
18/02/2011	-	-	Juv	33.4	6.2	-	Nil	Yes	11	
19/02/2011	068B6713	No	M	49.7	22.0	-	Nil	Yes	2	
19/02/2011	-	-	Juv	39.9	6.7	-	Nil	Yes	2	
19/02/2011	068B9F18	No	M	69.2	51.0	-	Nil	Yes	2	
19/02/2011	068B4C0C	Yes	M	71.3	63.0	-	Nil	No	2	
19/02/2011	068AFF03	No	F	93.1	110.0	Non	Nil	Yes	9	
19/02/2011	068B242D	Yes	M	76.5	45.0	-	Nil	No	9	
19/02/2011	068B233C	No	M	69.5	43.5	-	Nil	Yes	9	
20/02/2011	068B30F6	No	F	87.5	110.0	Non	Nil	Yes	4	
10/03/2011	068B3225	No	F	100.3	124.0	Non	Nil	Yes	6	
10/03/2011	068B4EFF	No	M	65.2	48.0	-	Nil	Yes	6	
10/03/2011	068B9610	Yes	M	67.2	50.0	-	Nil	No	2	
10/03/2011	068B2E7A	Yes	M	75.5	45.5	-	Nil	No	28	
10/03/2011	068B419A	No	Sub-adult	45.3	8.5	-	Nil	Yes	28	
10/03/2011	068B0E1C	Yes	M	73.2	58.0	-	Nil	No	28	
10/03/2011	068BFFC2	No	M	62.8	40.0	-	Nil	Yes	28	
11/03/2011	068B0158	Yes	F	100.9	120.0	Non	Nil	No	3	
11/03/2011	068B56E9	Yes	M	59.8	46.0	-	Nil	No	3	
11/03/2011	-	-	Juv	39.6	7.4	-	Nil	Yes	3	
11/03/2011	068B6AF5	No	F	85.6	98.0	Non	Nil	yes	7	
12/03/2011	068B38ED	No	F	93.6	118.0	Non	Nil	Yes	2	
12/03/2011	068B242D	Yes	M	80.6	55.0	-	Nil	No	9	
12/03/2011	068B233C	Yes	M	69.3	38.0	-	Nil	No	9	
12/03/2011	-	-	Juv	39.4	6.8	-	Nil	Yes	9	
12/03/2011	068B0E1C	Yes	M	60.8	45.0	-	Nil	No	28	
12/03/2011	068AE033	No	Sub-adult	42.5	8.0	-	Nil	Yes	28	
12/03/2011	-	-	Juv	33.3	4.0	-	Nil	Yes	28	
12/03/2011	068B447D	No	F	99.5	145.0	Poss gravid	Nil	Yes	28	
12/03/2011	068B2F04	No	Sub-adult	46.2	12.0	-	Nil	Yes	28	
13/03/2011	-	-	Juv	31.1	3.5	-	Nil	Yes	28	
14/03/2011	068B13B3	Yes	M	74.3	48.0	-	Nil	No	9	
14/03/2011	068B242D	Yes	F	90.0	85.0	Non	Nil	No	9	

Juveniles snout-vent length less than 40 mm
Sub-adult snout-vent length greater than 40 mm but sex cannot be determined from external features (i.e. between 40 and 50 mm length).
Adults –sex can be determined.

ATTACHMENT 2
CHARTS

LIST OF CHARTS



Source: Gilbert & Associates (2010)

Chart 1 Recorded Stream Flow Hydrograph for MJR at Pikes Crossing Gauging Station (GS209002)

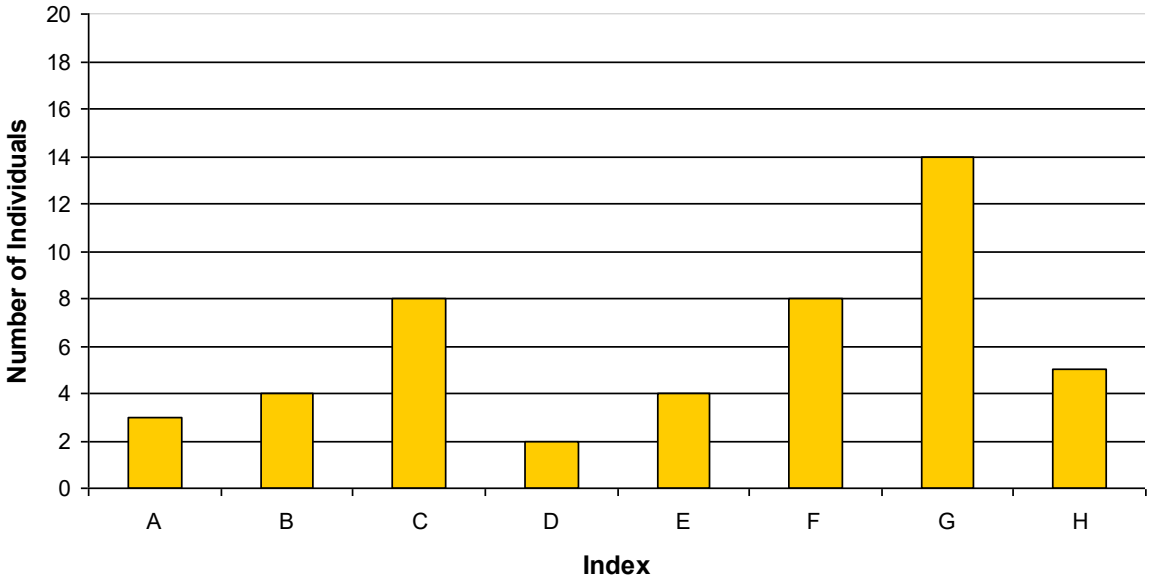
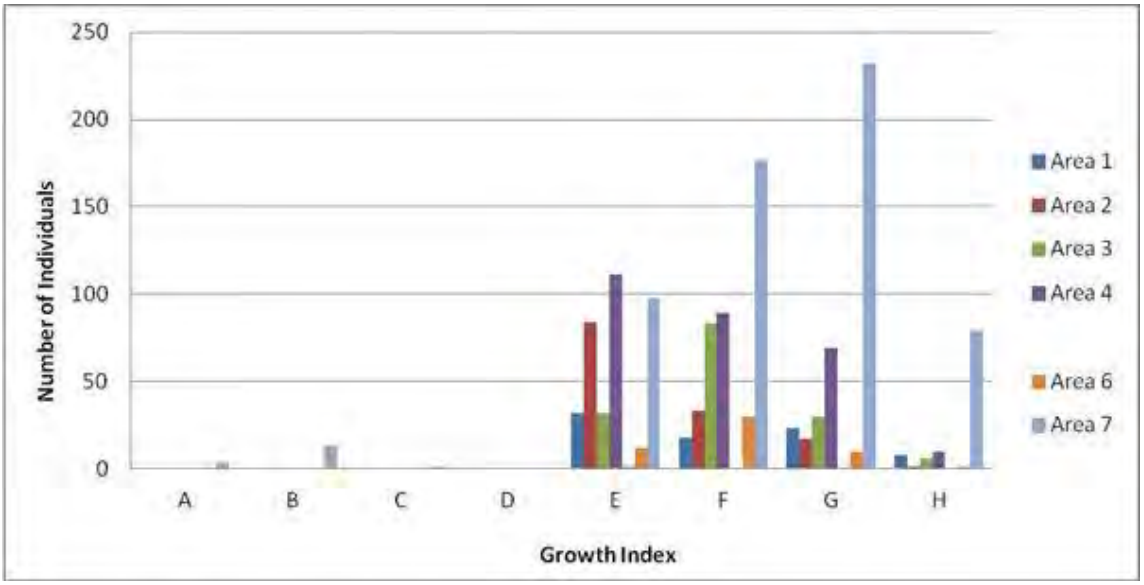
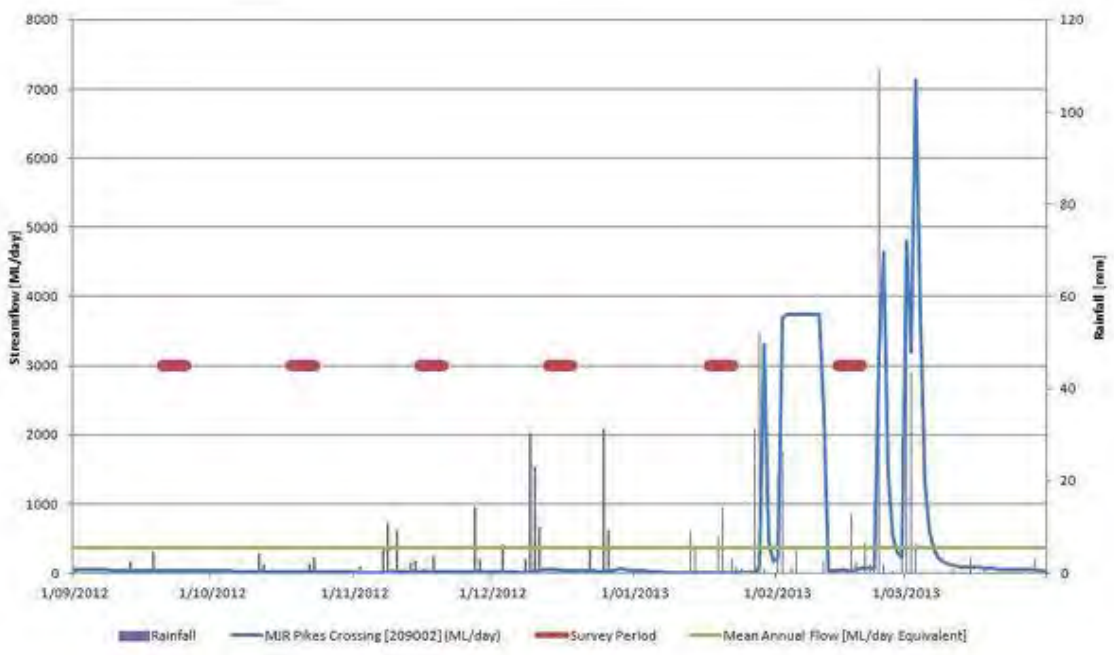


Chart 2 Example - Number of Individuals per Age Class



A – Stages 1-23, B – Stages 24-25, C – Stages 26-42, D – Stages 43-46 (refer Table 3).
E – Juvenile (<40 mm SVL), F – Adult (40-65 mm SVL), G – Adult (65-85 mm SVL), H – Adult (>85 mm SVL).

Chart 3 Number of Individuals per Age Class 2011 - 2012



Source: Department of Primary Industries NSW Office of Water (2012)

Chart 4 Recorded Stream Flow Hydrograph for MJR at Pikes Crossing Gauging Station (GS209002)

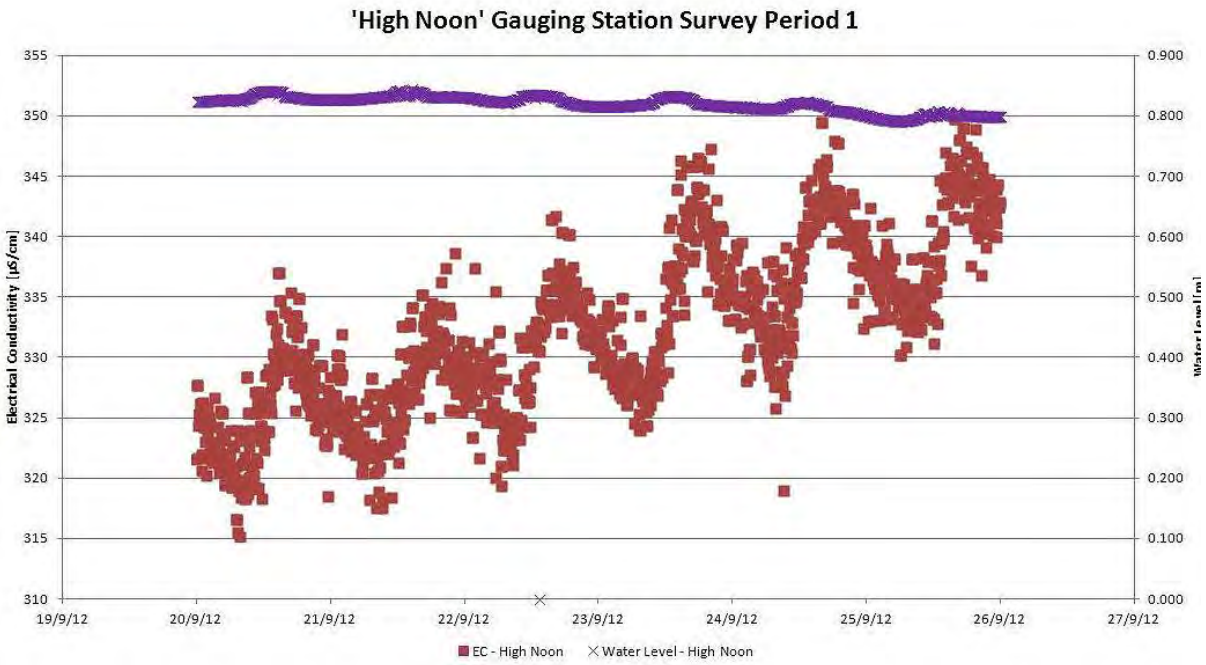


Chart 5 **High Noon Gauging Station – Survey Period 1 (September 2012)**

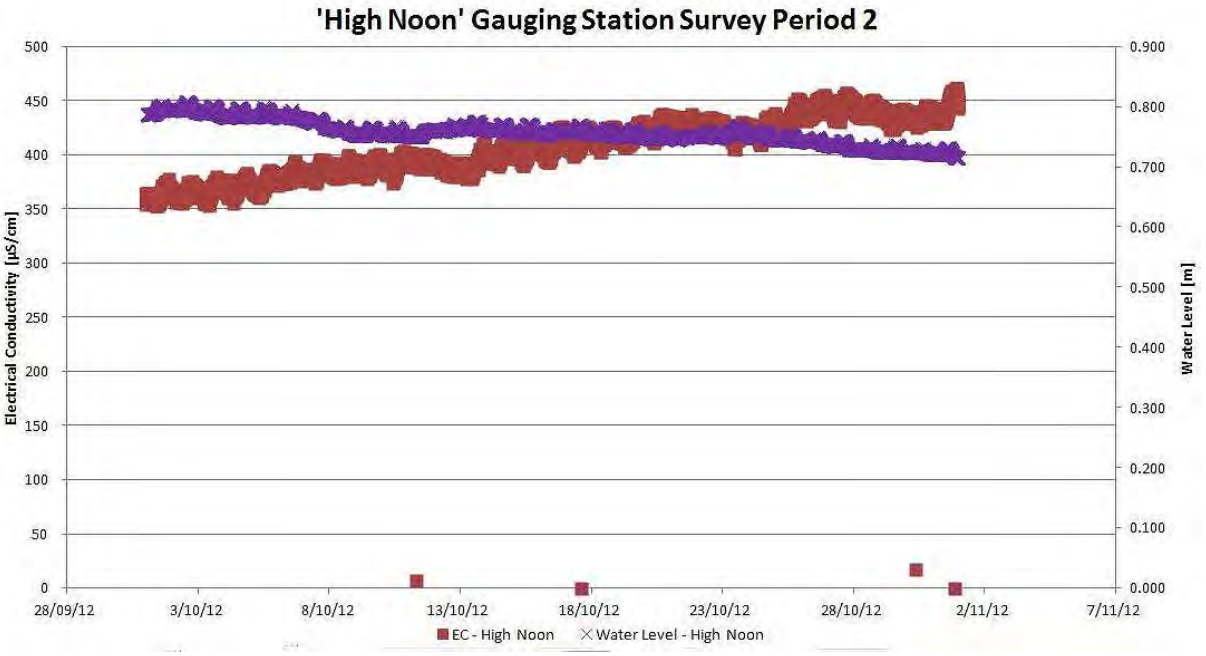


Chart 6 **High Noon Gauging Station – Survey Period 2 (October 2012)**

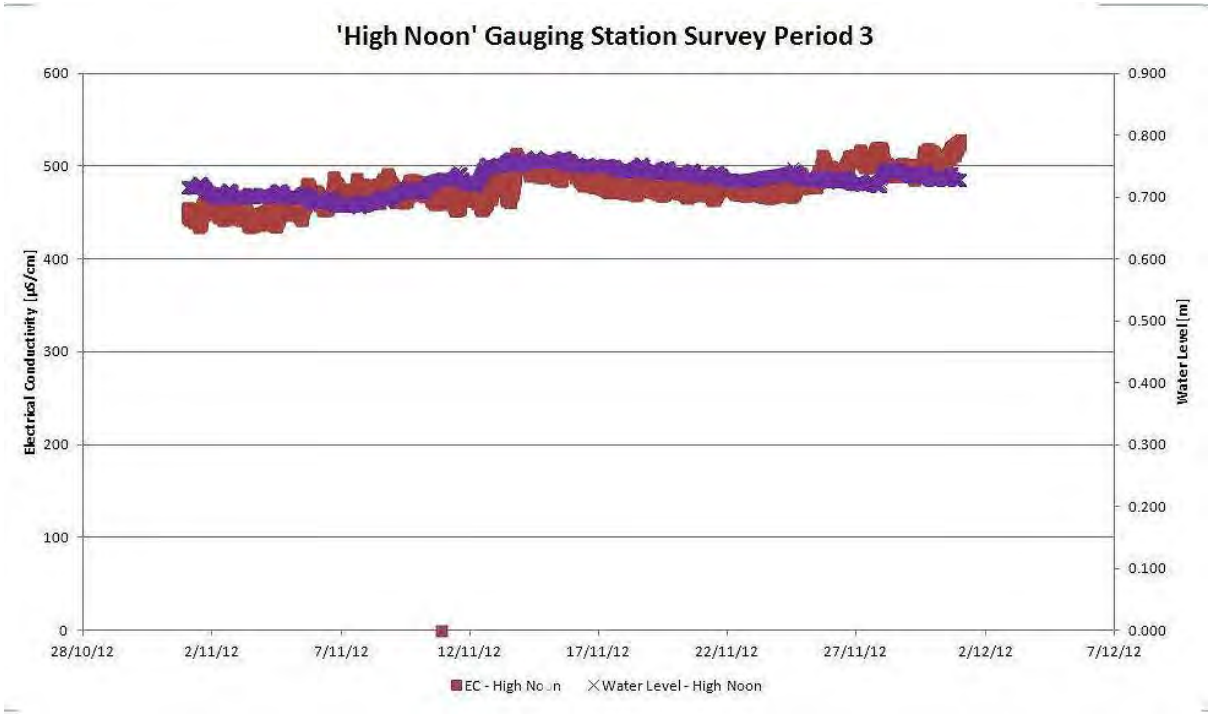


Chart 7 High Noon Gauging Station – Survey Period 3 (November 2012)

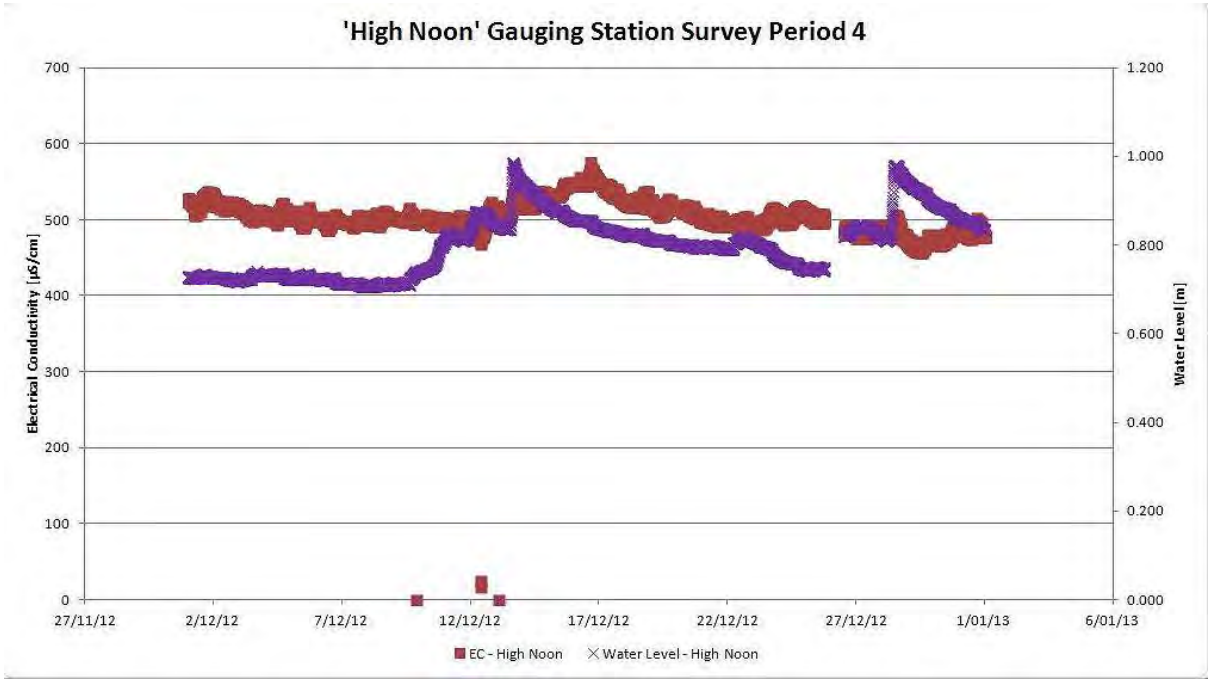


Chart 8 High Noon Gauging Station – Survey Period 4 (December 2012)

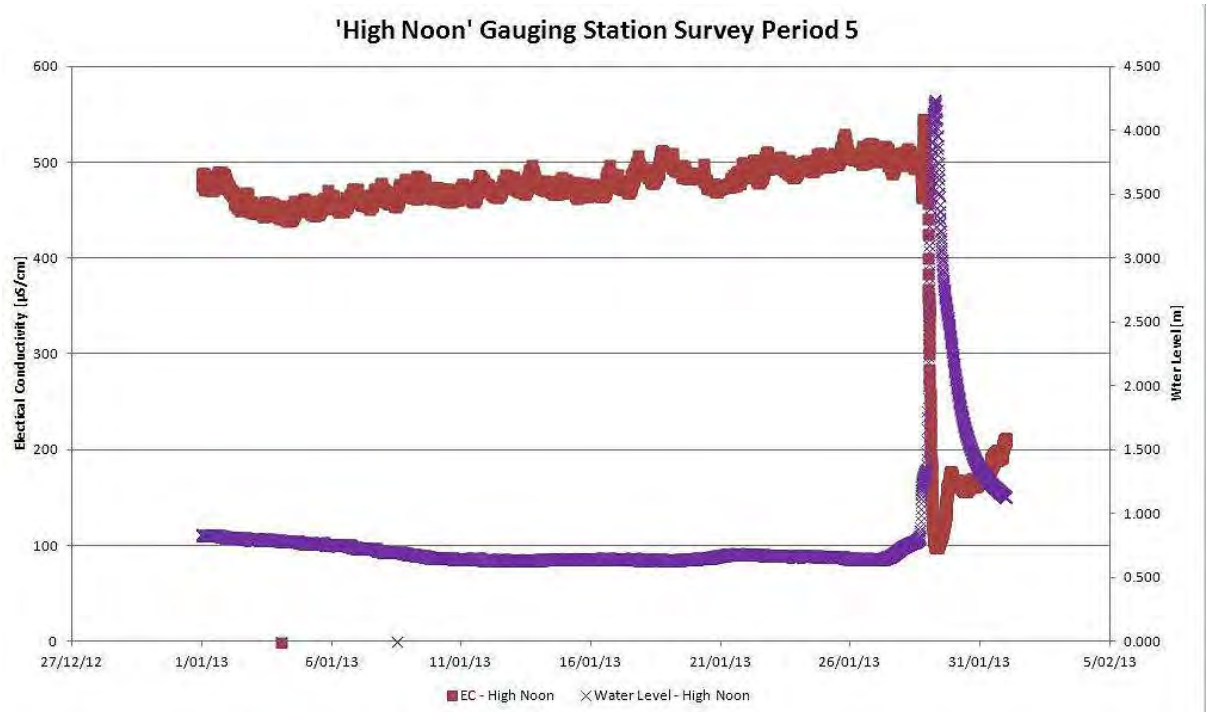


Chart 9 **High Noon Gauging Station – Survey Period 5 (January 2013)**

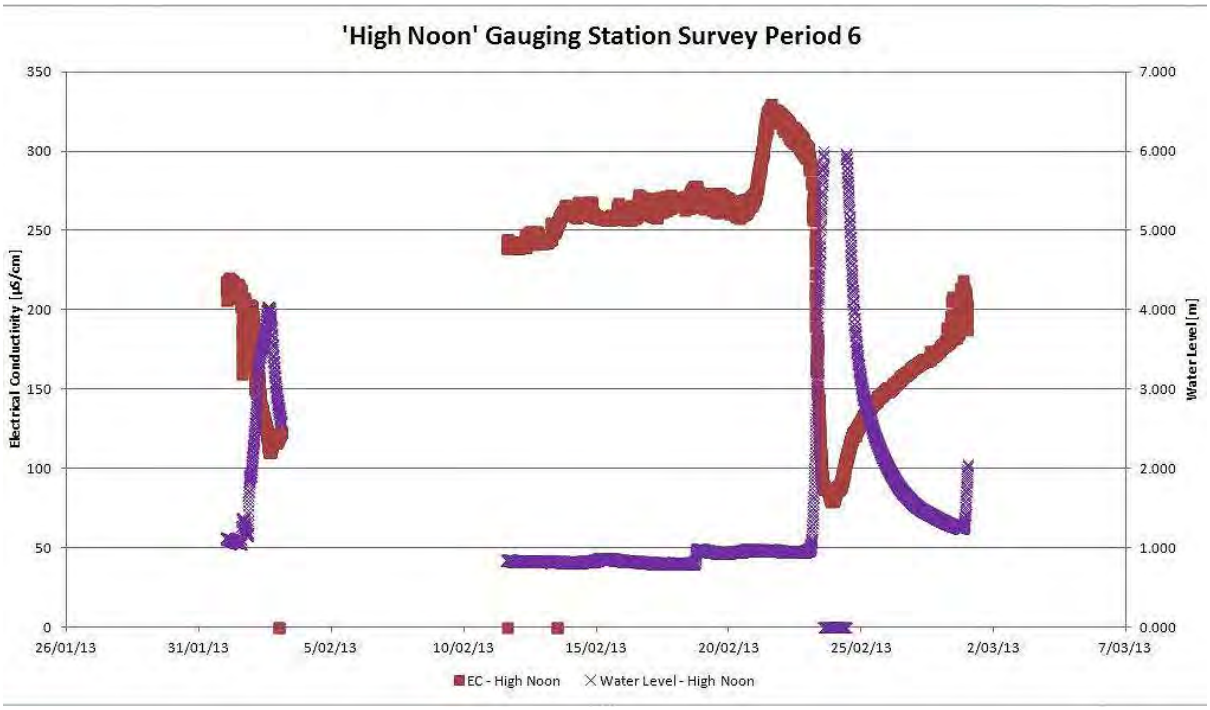
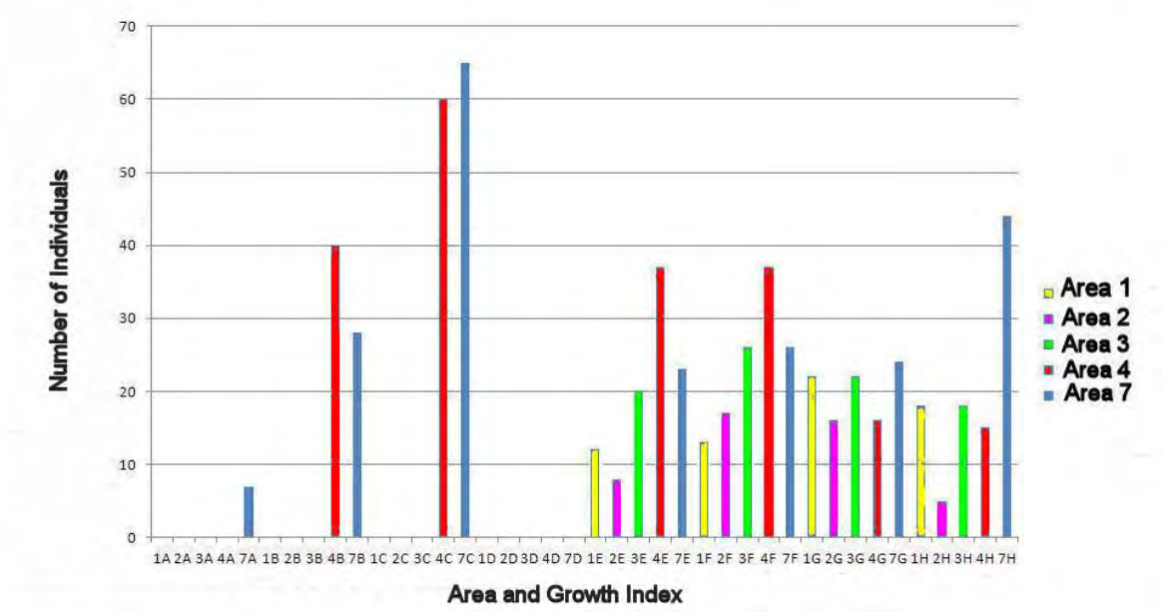
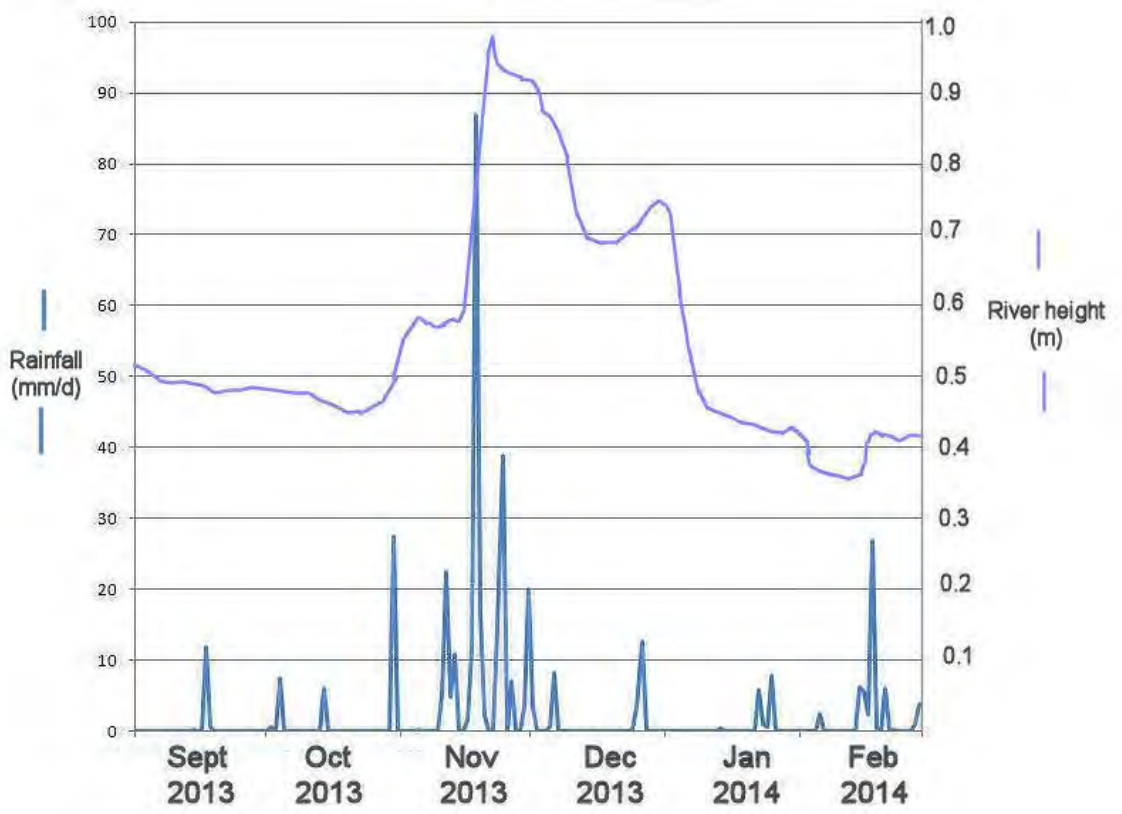


Chart 10 **High Noon Gauging Station – Survey Period 6 (March 2013)**



A – Stages 1-23, B – Stages 24-25, C – Stages 26-42, D – Stages 43-46 (refer Table 3).
E – Juvenile (<40 mm SVL), F – Adult (40-65 mm SVL), G – Adult (65-85 mm SVL), H – Adult (>85 mm SVL).

Chart **11** **Number of Individuals per Age Class 2013 - 2014**



Source: Department of Primary Industries NSW office of Water (2013-2014).

Chart 12 Recorded Stream Flow Hydrograph for MJR at Pikes Crossing Gauging Station (GS209002)

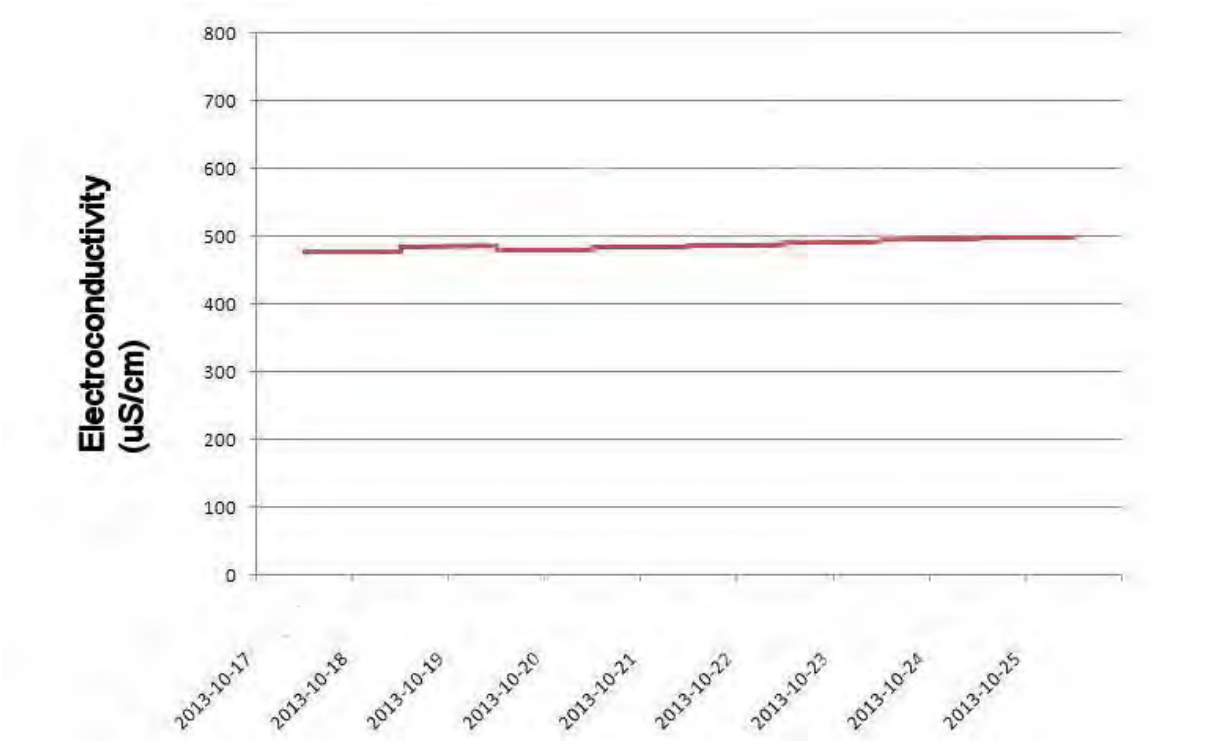


Chart 13 **High Noon Gauging Station – Survey Period 1 (October 2013)**

Chart 14 **High Noon Gauging Station – Survey Period 2 (November 2013)**

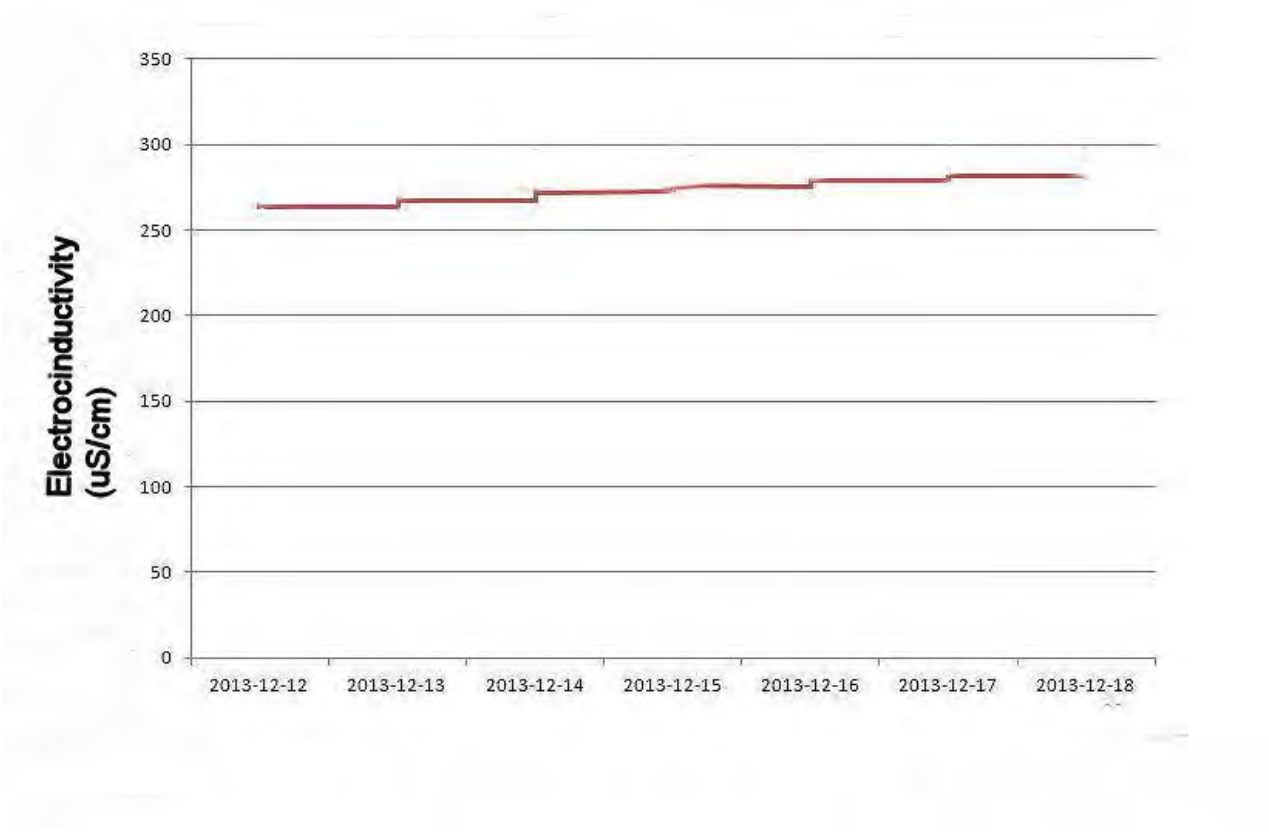


Chart 15 High Noon Gauging Station – Survey Period 3 (December 2013)

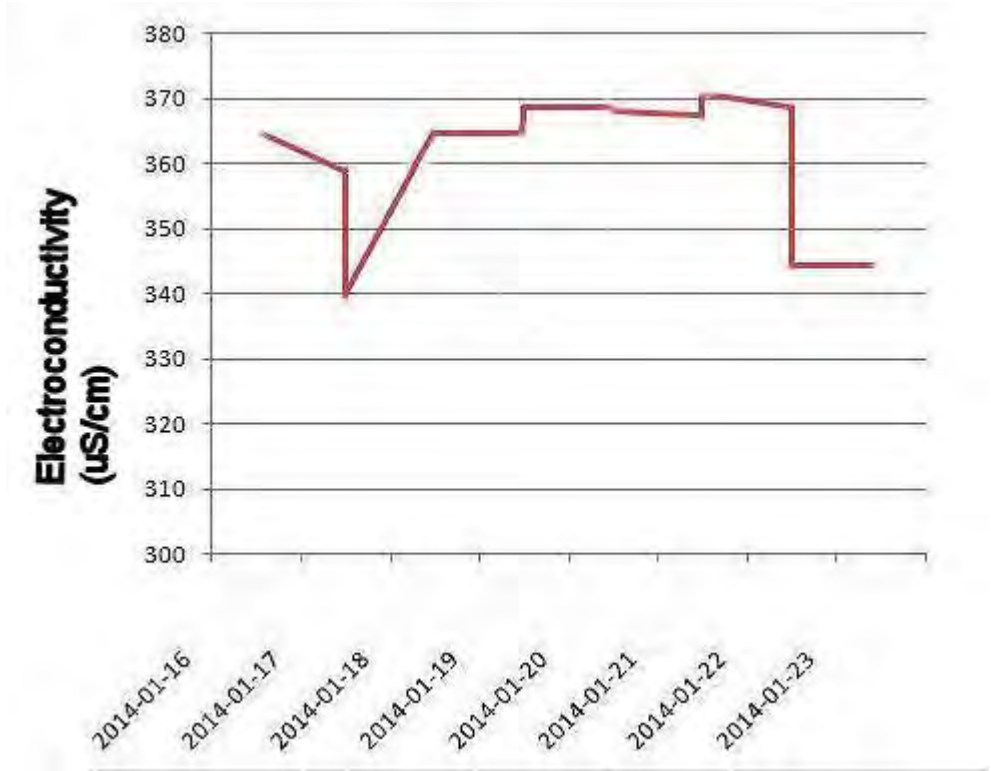
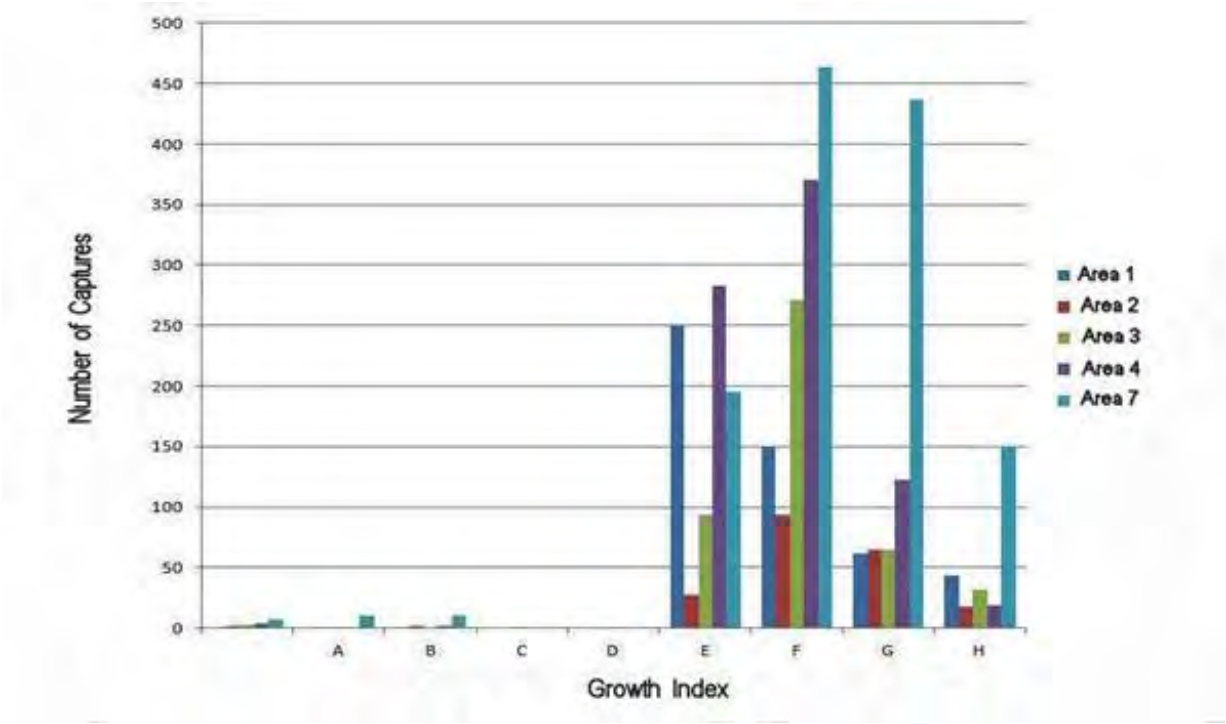


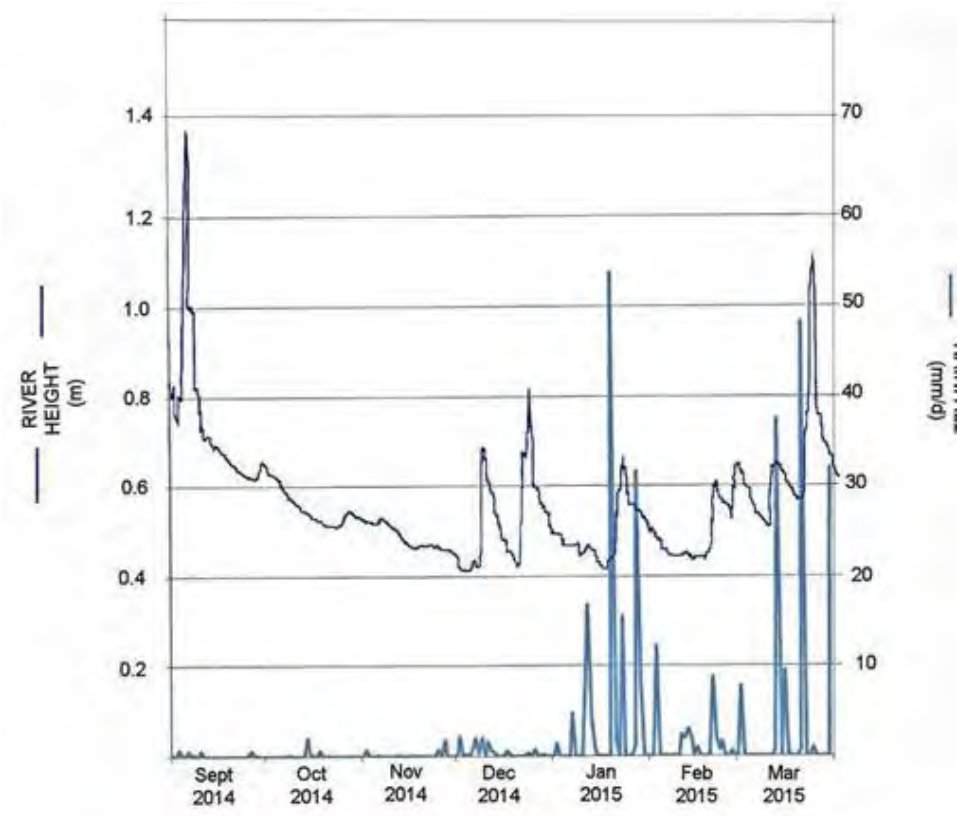
Chart 16 High Noon Gauging Station – Survey Period 4 (January 2014)



A – Stages 1-23, B – Stages 24-25, C – Stages 26-42, D – Stages 43-46 (refer Table 3).

E – Juvenile (<40 mm SVL), F – Adult (40-65 mm SVL), G – Adult (65-85 mm SVL), H – Adult (>85 mm SVL).

Chart 17 Number of Individuals per Age Class 2014 – 2015



Source: Department of Primary Industries NSW office of Water (2014-2015).

Chart 18 Recorded Stream Flow Hydrograph for MJR at Pikes Crossing Gauging Station (GS209002)

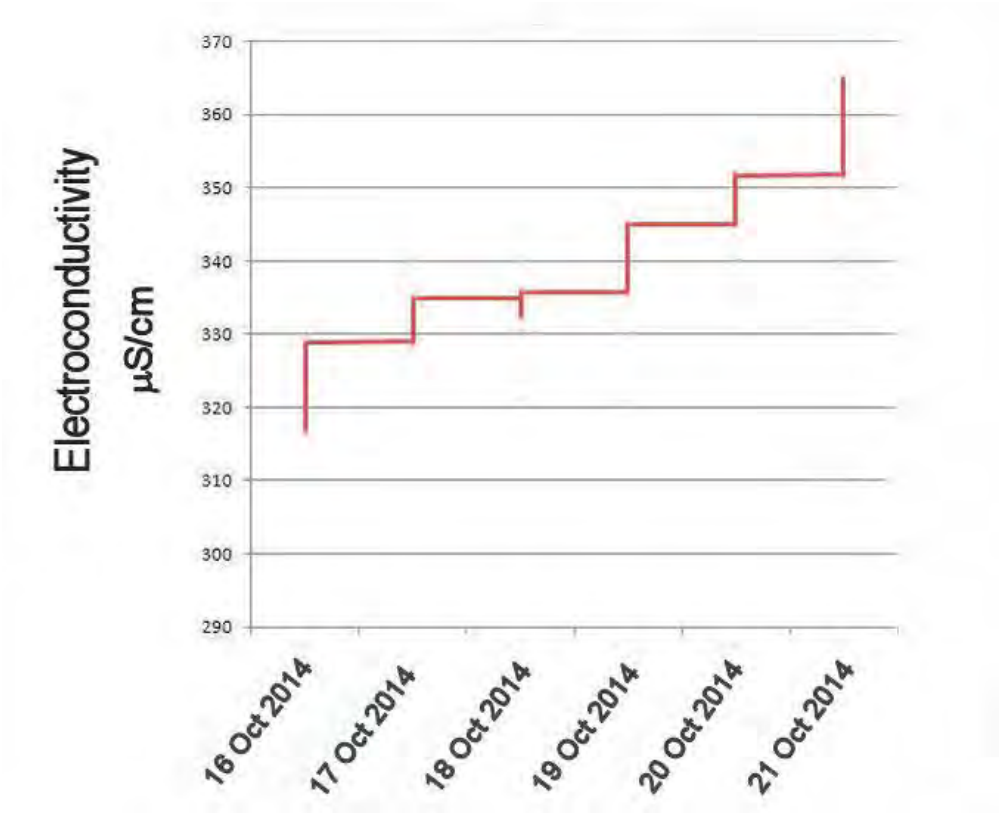


Chart 19 **High Noon Gauging Station – Survey Period 1 (October 2014)**

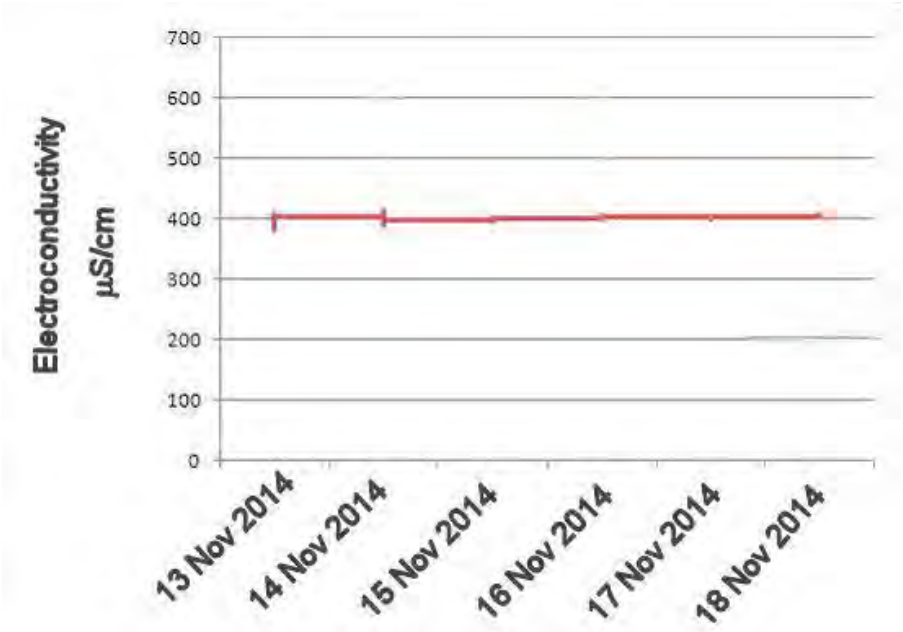


Chart 20 **High Noon Gauging Station – Survey Period 2 (November 2014)**

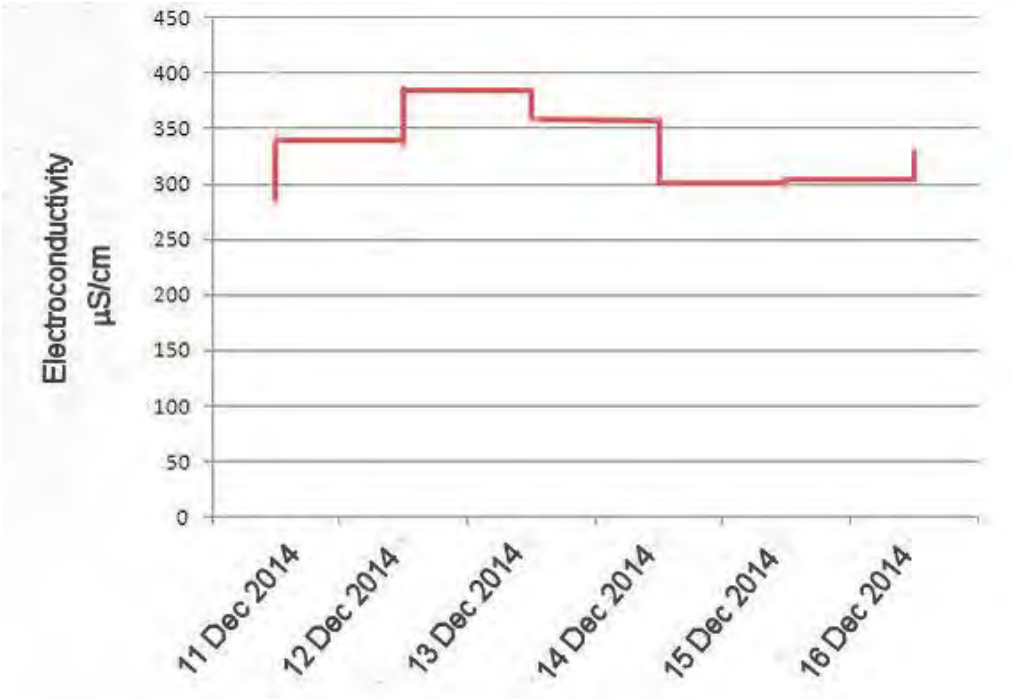


Chart 21 **High Noon Gauging Station – Survey Period 3 (December 2014)**

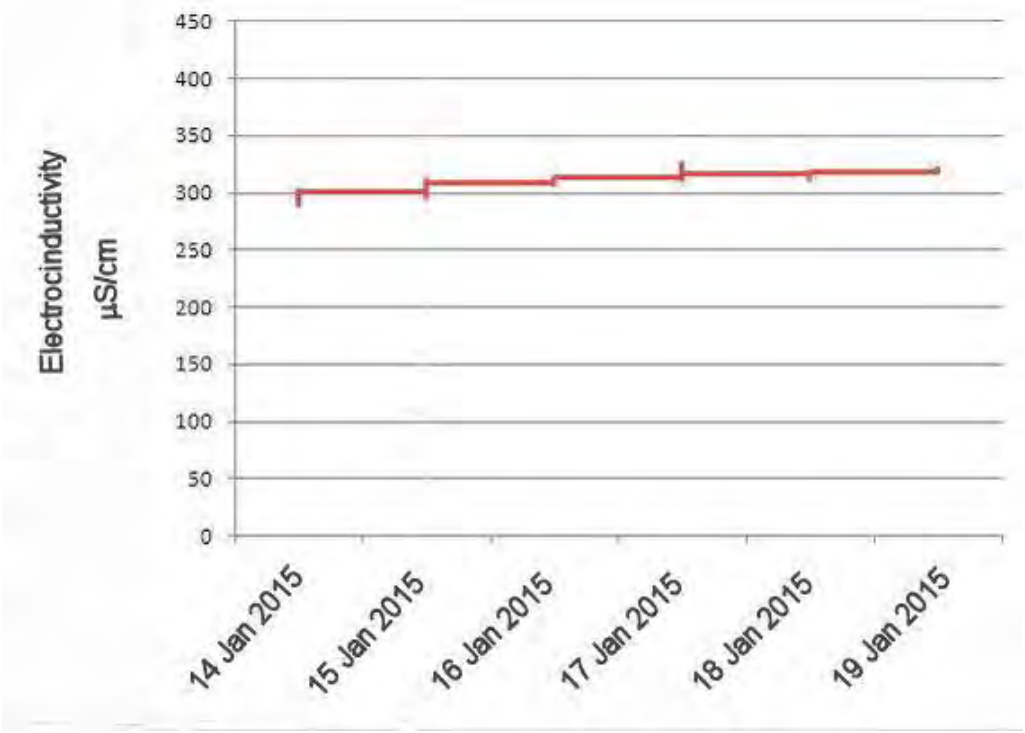


Chart 22 **High Noon Gauging Station – Survey Period 4 (January 2015)**

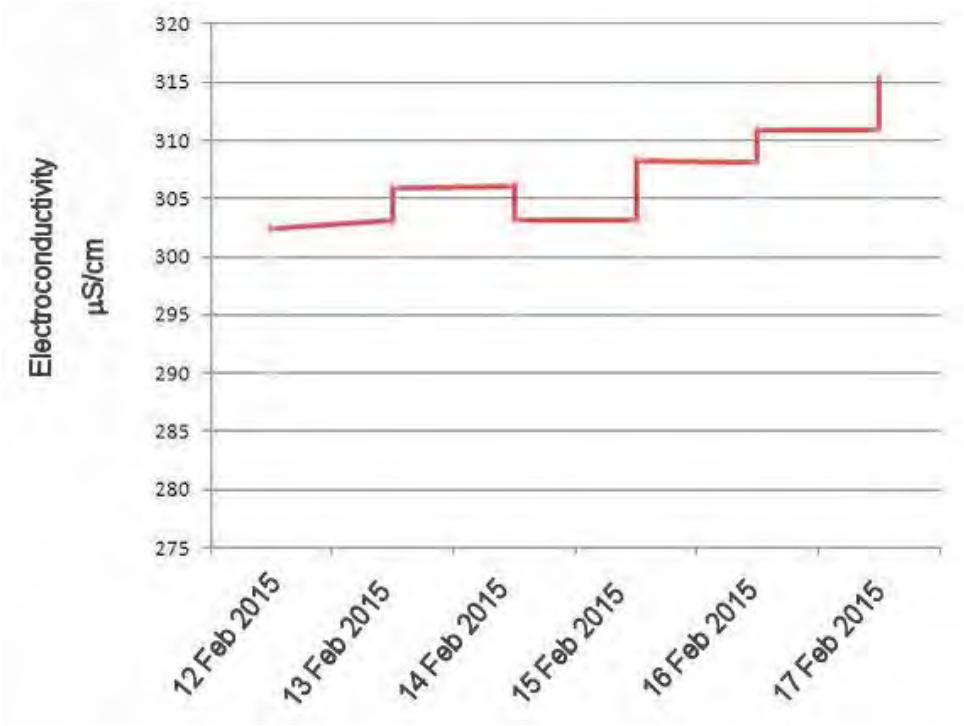


Chart 23 High Noon Gauging Station – Survey Period 5 (February 2015)

APPENDIX 2

REVIEW BY SUITABLY QUALIFIED AND EXPERIENCED PERSON: DURALIE COAL MINE GIANT BARRED FROG MANAGEMENT PLAN 2023 (WHITE, 2023b)

Dr Arthur White

(Ecologist)

Mail Address: 69 Bestic St. Rockdale NSW 2216
e-mail: arfawhite@gmail.com A.B.N. 17 181 438 562

Review: Duralie Coal Mine Giant Barred Frog Management Plan 2023

Introduction

The Duralie Coal Mine Giant Barred Frog Management Plan 2023 was produced in response to the closure of the mine and compliance requirements associated with potential long-term environmental impacts arising form the past operation of the mine. The mine had commissioned a series of fauna studies in the early years of its operation and, in later years, additional targeted studies on threatened species known to be within a potential impact proximity of the mine or its discharge. The Baseline Study for the Giant Barred Frog (GBF) was commissioned to asses the range and abundance of GBFs above and below a proposed waste water release area (waste water to be dispersed as irrigation water which may then infiltrate back into the Mammy Johnsons River). The mine further commissioned a GBF Monitoring Program which better determined the GBF population within the Mammy Johnsons River valley, but also quantified GBF habitat in the riparian zone of the river.

The release of irrigation water was never undertaken by the mine but the frog studies continued. As a result, the GBF is the Mammy Johnsons River have the best long-term data for any threatened ground frog in Australia.

The proposed closure of the mine brought a closure to the frog studies but with the closure of the mine some potential impacts from the mining operations still remain. The Duralie Coal Mine Giant Barred Frog Management Plan 2023 describes the proposed measures that will be adopted to conserve the GFB during the closure years of the mine.

Adequacy of the Duralie Coal Mine Giant Barred Frog Management Plan 2023

The Duralie Coal Mine Giant Barred Frog Management Plan 2023 is a very good summary of events leading to the instigation of the Baseline Study and subsequent GBF Monitoring Program. It highlights some of the major findings of those studies.

It also details the compliance requirements of the Duralie Mine during operation, and now, during mine closure. The compliance details were many and the mine acted commendably to fulfill the requirements of their licence. The GBF Study is a testament to the mine’s commitment to environmental protection.

The Duralie Coal Mine Giant Barred Frog Management Plan 2023 more importantly, lists the measures that will be undertaken by the mine during closure to help minimize or negate any potential impacts should irrigation activity resume.

These major facets of the study give good coverage of the events, compliance and proposals at hand.

Issues Arising from the Duralie Coal Mine Giant Barred Frog Management Plan 2023

Chapter 9 of the Duralie Coal Mine Giant Barred Frog Management Plan 2023 lists management options that have been used or are available for use in helping to conserve the GBFs. Some of these measures are somewhat contentious and should be raised here.

1. Some of the ongoing impacts on GBF during the GBF Study were related to the presence of cattle in the riparian corridor. Cattle had been used to keep down vegetation growth in this zone and as such help with bushfire reduction as well as some weed control. But the cattle also constituted a threat to the GBFs in the area. The cattle had two prime impacts; direct trampling of sheltering GBFs and the destruction of GBF habitat in the riparian zone. Discussion with the mine had flagged the need to create "cattle exclusion area' along the riparian zone; these areas would contain sites where GBFs were known to be present in high density close to the river's edge. A long-term, post mining impact could remain if cattle were allowed to free-range in the sensitive habitat areas.

2. Weed control is necessary to protect GBF habitats. The GBF Study highlighted the loss of GBF in non-mine areas (such as along Wards River) where privet and other riparian weeds had completely removed GBF habitat from the area. However, the measure used to control the weeds may also pose a significant risk to the frogs.

   Two measures of note that have been proposed are burning and cattle grazing to control weedy growth. The use of cattle, while effective in controlling weeds, imposes habitat damage and potential injury or death to the frogs (see 1 above). If cattle are to be used in this way, there are some areas along the Mammy Johnsons River where cattle numbers should be carefully controlled, or excluded.

   The second measure proposed is burning. Burning may also injure and kill GBFs sheltering in the leaf litter. If burning is used, it needs to be controlled so that the fire is a "low intensity" burn that is excluded from known GBF shelter sites.

   The use of slashers or mechanical devices also poses the risks of injuring sheltering frogs in the leaf litter.

Herbicides are generally not used in frog habitat areas, however, there are times when herbicides can be used safely. In general, herbicide spraying is not considered safe or acceptable. The direct application of herbicide (eg. cut and painting privet) would be acceptable in certain areas.

Weed control is contentious when threatened species are also present. I would advise that whatever methods are to be used, prior advice should be sought from a suitably qualified herpetologist about the risks to the frogs and how best to mitigate these risks during weed control.

3. Future site use: Duralie Mine owned a number of properties fronting the Mammy Johnsons River. With the closure of the mine, the future of these lands is not specified. The GBF Study identified a number of current agricultural practices that are highly detrimental to the GBFs and it would be counter-productive if these lands should be allowed to be used in a way that harms the frogs or their habitats.

Conclusion

The Duralie Coal Mine Giant Barred Frog Management Plan 2023 overviews a significant conservation effort by Duralie Mine. The Plan itemizes the various environmental measures used throughout the life of the mine to help conserve GBFs in the Mammy Johnsons River catchment. This Plan marks the end of a long conservation program for an endangered frog species.

Dr Arthur White

10 June 2023.

APPENDIX 3

RECORD OF CONSULTATION WITH THE NSW CONSERVATION PROGRAMS, HERITAGE AND REGULATION DIVISION (FORMALLY BIODIVERSITY CONSERVATION DIVISION) AND COMMONWEALTH DEPARTMENT OF CLIMATE CHANGE, ENERGY, THE ENVIRONMENT AND WATER

Department of Planning and Environment

Our ref: DOC23/742933

Mr Michael Plain
Environment and Community Superintendent
Stratford Coal Limited

By email: Michael.plain@yancoal.com.au

Dear Mr Plain

Revised Duralie Coal Mine Giant Barred Frog Management Plan

I refer to your request of the 23 August 2023 for comment on the revised Duralie Coal Mine Barred Frog Management Plan.

Biodiversity and Conservation Division's (BCD) detailed comments are provided in **Attachment A.** In summary, Consent Condition 32, Schedule 3 of PA 08_0203 which required a giant barred frog management Plan and associated monitoring program is not considered relevant, as the anticipated irrigation of the mine did not eventuate. However, BCD supports the implementation of the recommendations in the post mine closure Management Plan provided by the ecological consultant, Dr Arthur White.

If you have any further questions about this issue, please contact Steven Crick, Senior Team Leader, Planning on 4927 3248 or at huntercentralcoast@environment.nsw.gov.au

Yours sincerely

Joe Thompson
Director Hunter Central Coast Branch
Biodiversity and Conservation Division

7 September 2023

Enclosure: Attachment A

BCD's comments

REVISED DURALIE COAL MINE GIANT BARRED FROG MANAGEMENT PLAN

1. The Duralie Coal Mine Barred Frog Management Plan is redundant

The Duralie Coal Mine Barred Frog Management Plan was set up in 2011 to satisfy Consent Condition 32, Schedule 3 of PA 08_0203. PA 08_0203 related to the commencement of irrigation over areas within the coal mine due to an extension of the open cut mining at Duralie. This irrigation has never taken place and now mining operations have ceased (as of 31 December 2021).

Annual reports on the status of the giant barred frog, *Mixophyes iteratus*, were initially provided to BCD for review, but ceased after four seasons (years). After this, monitoring was not carried out in accordance with the consent and only 'incidental surveys' were carried out (twice between 2018 – 2023).

Recommendation 1

BCD agrees that Consent Condition 32 of Schedule 3 of PA 08_0203, relating to the irrigation of the Duralie Coal Mine area, is not relevant.

2. BCD supports the recommendations of the consultant ecologist to protect the frogs from agricultural practices which would have a negative effect on their habitat

Dr Arthur White has provided in the Duralie Coal Mine Giant Barred Frog Management Plan 2023, the measures that will be undertaken by the mine during closure to help minimize or negate any potential impacts caused by the continued use of the mine area for agricultural practices (e.g. grazing). BCD supports his recommendations including the control of annual and other weeds such as privet to protect giant barred frog habitat. Any crash/pulse grazing in the riparian corridor should only be undertaken during the time of the year when the frogs are not active. Dr White also states that cattle should always be excluded from some sections of the riparian zone. As slashing with machines and herbicides damage frog habitat and injure frogs, these practices should be avoided in areas where frogs have been recorded.

Baseline control sites were set up at the beginning of the project in order to be able to assess the effects of agricultural practices on the population of giant barred frogs, and to be able to differentiate the effects of agricultural practices from the effects of irrigation. Due to difficulties achieving statistically robust control sites for agricultural sites, the agricultural control sites were no longer surveyed. As this data is not available to use, all the other sites monitored until 2015 should be established as baseline data in order to be able to assess in future how the frog population is responding to the post mine closure land-use.

Recommendation 2

A post-mine closure frog population monitoring plan should be implemented to establish how agricultural practices are affecting the giant barred frog population.

Australian Government
Department of Climate Change, Energy, the Environment and Water

EPBC 2010/5396

Michael Plain
Mine Closure Specialist
Stratford Coal Ltd
Michael.Plain@yancoal.com.au
Cc Thomas.Kirkwood@yancoal.com.au

Approval of a Revised Action Management Plan for Duralie Coal Extension Project, Stroud, Gloucester Valley, New South Wales

Dear Mr Plain

Thank you for your email dated 22 August 2023 to the Department of Climate Change, Energy, the Environment and Water (the department), seeking approval of your Revised Action Management Plan, in accordance with condition 23 of the above project under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Officers of the department have advised me on the Revised Action Management Plan and the requirements of the conditions of the approval for this project. On this basis, and as a delegate of the Minister for the Environment and Water, I have decided to approve the Duralie Coal Mine Giant Barred Frog Management Plan, Version GBFMP-R06-A, August 2023.

Now this plan has been approved, it must be implemented. The approved plan must also be published in accordance with your conditions of approval.

As you are aware, the department has an active monitoring program which includes monitoring inspections, desk top document reviews and audits. Please ensure that you maintain accurate records of all activities associated with, or relevant to, the conditions of approval so that they can be made available to the department on request. Should you require any further information please contact Jessica Feder on 02 5162 1744 or by email to PostApproval@dcceew.gov.au.

Yours sincerely

Brendan Linton-Smith
Acting Branch Head
Environment Assessments (Vic and Tas) and Post Approvals Branch
Environment Regulation Division
15 July 2025