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ANNUAL ENVIRONMENTAL MONITORING REPORT 2016

NCIG COAL EXPORT TERMINAL

RAMBOLL

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NCIG COAL EXPORT TERMINAL

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1. INTRODUCTION

This Annual Environmental Management Report (AEMR) has been prepared for the Newcastle Coal Infrastructure Group (NCIG) Coal Export Terminal project (the Terminal) in accordance with the conditions of the approved Operation Environmental Management Plan (OEMP). The OEMP was prepared in accordance with Condition 7.5, within Schedule 2 of the Project Approval (PA) (06_0009) which was granted on 13 April 2007.

This is the eighth AEMR prepared for the NCIG Project and it covers the period June 2015 to June 2016 (inclusive), which includes the sixth year of terminal operation.

The AEMR reviews the performance of the Project against the requirements of the Project Approval and provides an overview of environmental management actions and summarises monitoring results over the 12 month reporting period. The AEMR will be distributed to relevant government agencies and stakeholders, and copies provided to other interested parties, if requested.

1.1 Approvals, leases, licences and permits

The Project is being undertaken under the approvals, leases, licences and permits presented in Table 1.1.

Table 1.1 Project Approval, Leases, Licences and Permits

Instrument	Relevant Authority	Date Granted	Duration of Approval
Project Approval (06_0009)	Department of Planning and Environment	13 April 2007	5 years unless substantially commenced
Modification of Minister's Approval MP06_0009	Department of Planning and Environment	27 November 2007	N/A (conditions appended to the Project Approval)
Modification of Minister's Approval MP06_0009 MOD2	Department of Planning and Environment	13 May 2013	N/A (conditions appended to the Project Approval)
Project Lease	State Property Authority	22 January 2008	35 years
Environmental Protection Licence (EPL) (No. 12693)	NSW Environment Protection Authority	26 October 2007	Until the Licence is surrendered or revoked. The Licence is subject to review every 5 years.
Environment Protection and Biodiversity Conservation Act 1999	Department of the Environment and Energy	11 October 2007	Perpetuity
Maritime Services Act 1935 s13JE	NSW Roads and Maritime Services	02 October 2007	Perpetuity
Environmental Representative	Department of Planning and Environment	03 October 2007	Perpetuity
Project Ecologist	Department of Planning and Environment	02 May 2007 & 25 October 2007	Perpetuity
Licence for Minor Operations – Green and Golden Bell Frog Research Area (Trial Site)	National Parks and Wildlife Service	25 June 2012	5 years (until 24 June 2017)
Licence for Minor Operations – Green and Golden Bell Frog Compensatory Habitat	National Parks and Wildlife Service	31 March 2013	5 years (until 30 March 2019)
Determination Notice for External Proponents – Green and Golden Bell Frog Compensatory	National Parks and Wildlife Service	7 March 2013	Perpetuity

Table 1.1 Project Approval, Leases, Licences and Permits			
Instrument	**Relevant Authority**	**Date Granted**	**Duration of Approval**
Habitat (Ref No. CCHR 1317_17)			
Determination Notice for External Proponents – Green and Golden Bell Frog Trial Ponds (Ref. No. CCHR 1112_28)	National Parks and Wildlife Service	1 June 2012	Perpetuity
Deed for the provision of compensatory habitat for migratory shorebirds on Kooragang Island (Area E)	(the Minister for) National Parks and Wildlife Service	22 February 2016	Cessation of NCIG CET, surrender of Project Approval 06_0009 or expiry of the lease
Determination (National Parks and Wildlife Service) – Shorebird Compensatory Habitat project at Fish Fry Flats (Appl No. CCHR 1415_21)	National Parks and Wildlife Service	28 June 2015	Perpetuity
Licence for Minor Operations – Shorebird Habitat Compensation Area E, Kooragang Island	**National Parks and Wildlife Service**	30 December 2014	35 years (until 29 December 2039)

1.2 Management plans and monitoring programmes

In accordance with the PA 06_0009, the Project is currently being undertaken consistent with a number of approved environmental management plans and monitoring programmes, including:

<u>Operations Management Plans</u>

- Operation Environmental Management Plan
- Operation Dust and Air Quality Management Plan
- Operation Noise Management Plan
- Operation Spontaneous Combustion Management Plan
- Operation Water Management Plan

<u>Other Management Plans and Programs</u>

- Ecological and Land Management Plan
- Waste Management Plan
- Site Water Management Plan (incorporated into the Operation Water Management Plan)
- Green and Golden Bell Frog Management Plan (incorporated into the Ecological and Land Management Plan)
- Materials Management Areas Procedure
- Compensatory Habitat and Ecological Monitoring Program
- Green and Golden Bell Frog Compensatory Habitat Management Plan
- Monitoring, Evaluation, Reporting and Improvement (MERI) Plan for the Migratory Shorebird Habitat Establishment
- Compliance Tracking Program
- Coordinated Environmental Monitoring and Management Protocol (with PWCS)

Monitoring Programs

- Environmental Monitoring Program (contained within the OEMP)
- Green and Golden Bell Frog Monitoring Program (contained in the ELMP)
- Deep Pond Bird Monitoring Program (contained in the ELMP)

1.3 Project Contacts

Contact Details for the Project are provided below:

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1.4 Project Background

The Newcastle Coal Infrastructure Group (NCIG) Coal Export Terminal (CET) (the Project) is located on Kooragang Island in Newcastle, New South Wales (NSW) (Figure 1). The Project includes the construction and operation of a CET up to 66 million tonnes per annum (Mtpa), including associated rail and coal handling infrastructure and wharf/ship loading facilities on the south arm of the Hunter River.

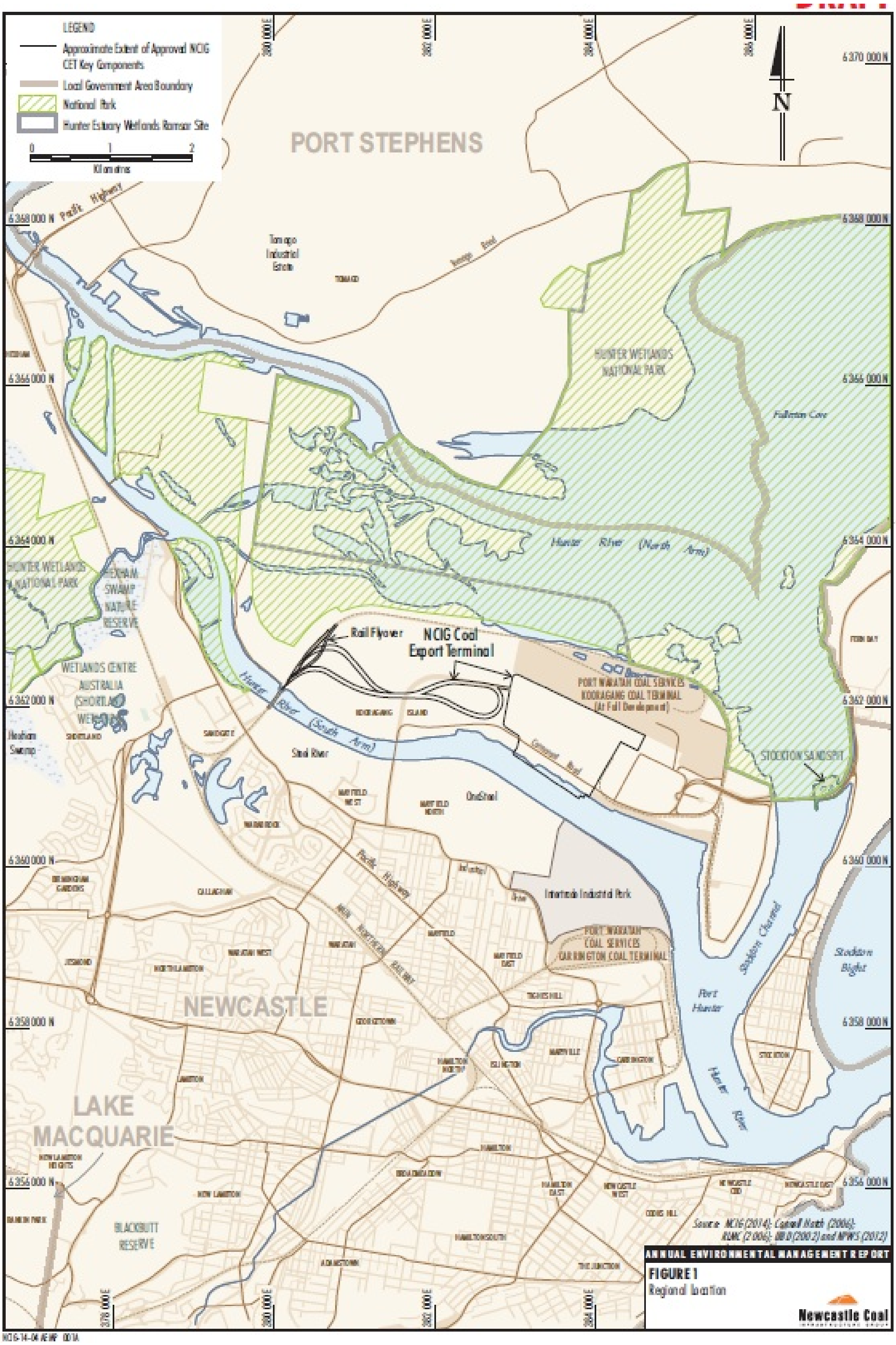

Figure 1: Project location

NCIG is the proponent of the Project and is a consortium of the following five companies:

- Banpu Public Company Limited;
- Hunter Valley Energy Coal Limited;
- Peabody Energy Corporation;
- Yankuang Group; and
- Whitehaven Coal Mining Pty Ltd.

NCIG was formed in response to a call for Expressions of Interest for the development of land on Kooragang Island by the NSW State Government in 2004. The outcome of this process was that in 2006 NCIG was awarded the right to develop the parcel of land that is now the Project site. PA 06_0009 was granted in April 2007 and construction of Stage 1 of the coal export terminal commenced in April 2008. Stage 1 of construction was completed and subsequently handed to NCIG for operation in July 2010. Stage 2AA construction commenced in the first half of 2010, with mechanical completion achieved in June 2012. Stage 2F construction commenced in June 2012 and was completed in June 2013. The Rail Flyover commenced in October 2013 and was completed in August 2015.

The project general arrangement is shown on Figure 2. The general arrangement is designed to support the planned maximum coal throughput of 66 Mtpa. The main activities associated with the construction of the Project include:

- re-use of dredged materials from the south arm of the Hunter River as preload and engineering fill for construction of the coal storage area, rail corridor and wharf facilities (*NB/ NCIG did not conduct dredging operations during the reporting period*);
- construction of a coal storage area including coal stockpiles, conveyors, transfer points and combined stacker/reclaimers;
- construction of wharf facilities, ship loaders, conveyors and buffer bins;
- foundation preparation, formation construction and capping of a rail corridor traversing the existing Kooragang Island Waste Emplacement Facility (KIWEF) for the development of the rail spurs, rail sidings and rail loops;
- construction of rail spurs, rail sidings and rail loops, rail overpass, train unloading stations and connecting conveyors;
- development of water management infrastructure including site drainage works, stormwater settlement ponds, primary and secondary settling ponds, site water pond, water tanks and stockpile spray system;
- installation of electricity reticulation and control systems;
- development of access roads and internal roads;
- construction of administration and workshop buildings; and
- other associated minor infrastructure, plant, equipment and activities.

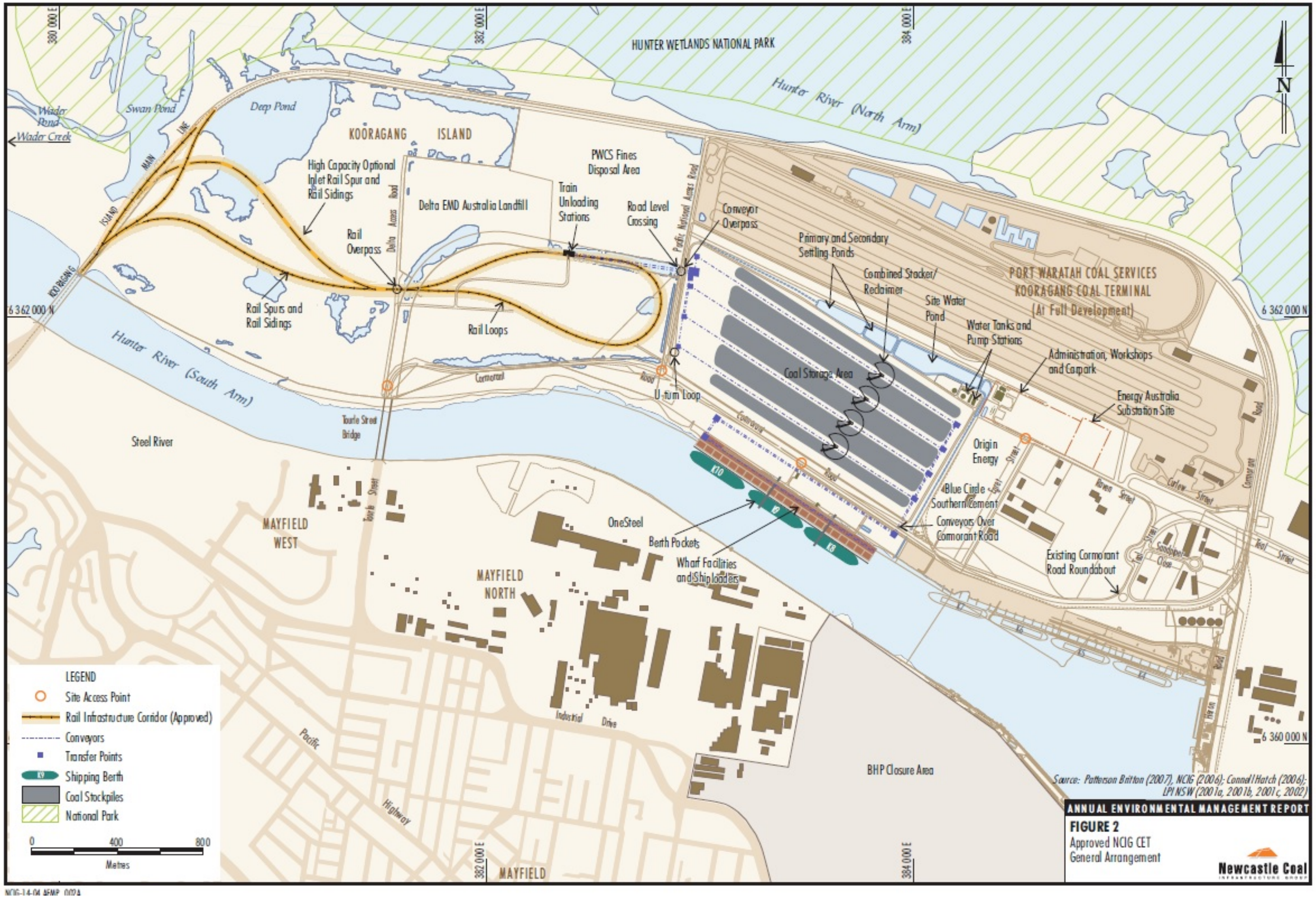

Figure 2: Project General Arrangement

2. OVERVIEW OF ACTIVITIES

2.1 Operation

June 2015 to June 2016 reporting period included a continuation of Stage 1, Stage 2AA and Stage 2F operations. This means that all mechanical equipment within the approved project were operational during the period, namely Dump Stations 1 and 2, Stacker/Reclaimers 1, 2, 3 and 4 and Ship loaders 1 and 2, along with associated inbound and outbound conveyor systems. Milestones achieved in this reporting period include:

- Provided 66 million tonnes of capacity.
- Loaded 50.1 million tonnes of coal.
- Record financial year average Gross Load Rate (GLR) 5,472tph onto 526 vessels.
- Financial year record Gross Unload Rate (GULR) of 8,294 tph.

Operational activities are shown in Figures 3 to 10.

Figure 3: NCIG Site Overview Facing East

Figure 4: NCIG Site Overview Facing North

Figure 5: NCIG Site Overview at Night

Figure 6: Stockyard with Dust Suppression System

Figure 7: Stockyard with Stacker Reclaimers in Operation

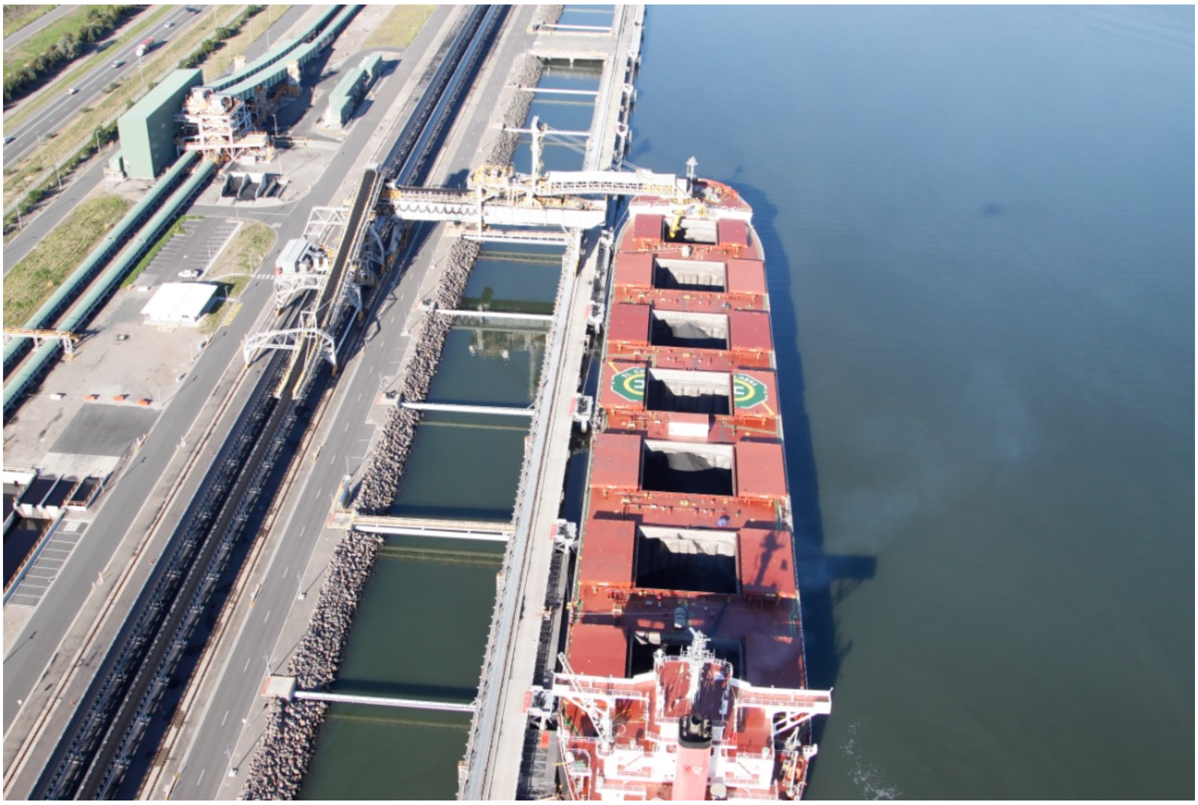

Figure 8: Ship Loading

Figure 9: Tamping machine for stockyard rail maintenance

Figure 10: December 2015 Aerial Photograph of Project

3. ENVIRONMENTAL MANAGEMENT AND PERFORMANCE

3.1 Meteorology

3.1.1 Environmental Management

In accordance with Condition 2.8, Schedule 2 of PA 06_0009, an on-site automated meteorological monitoring station was operated during the reporting period to monitor weather conditions representative of the site. This station was installed on the NCIG site (see Figure 12) in accordance with the requirements of the CEMP and OEMP.

The automated meteorological monitoring station allows parameters such as wind direction to be used in the control of stockyard sprays. This includes activation of sprays based on evaporation of surface moisture from the coal stockpiles and deactivation of sprays under wind conditions where sprays would otherwise be ineffective in reaching coal stockpiles.

NCIG installed a new Luft meteorological monitoring station in March 2016, which replaced the existing sensors with a set of factory calibrated sensors for the measurement of temperature, humidity, air pressure, wind direction, wind speed and solar radiation. A photograph of the new sensor head is shown in Figure 11.

Figure 11: Sensor head on new meteorological station.

3.1.2 Environmental Performance

Table 3.1 outlines the monitoring locations, meteorological parameters recorded and frequency of monitoring for the Project in accordance with the CEMP.

Table 3.1 Summary of the Meteorological Monitoring Program

Monitoring Parameter	Monitoring Sites	Frequency	Criteria
• Temperature • Relative humidity • Net solar radiation • Rainfall • Wind speed and direction • Sigma theta (rate of change of wind direction).	Project automated meteorological station [1].	Continuously monitored and the data averaged over 15 minute periods.	N/A

1 The location of the monitoring sites is shown on **Error! Reference source not found.**.

3.1.3 Monitoring summary

The meteorological monitoring results for the reporting period are summarised below. Monthly statistical information for rainfall is detailed in Table 3.2.

Table 3.2 Rainfall statistics by month

Month	Total rainfall (mm)*	Daily average (mm)	Daily maximum (mm)
July 2015	25 (72.5)	0.80	7
August 2015	26 (74.3)	0.83	18
September 2015	118 (60.3)	4	33
October 2015	53 (72.7)	1.7	11
November 2015	71 (82.8)	2.3	15
December 2015	102 (79.5)	3.3	38
January 2016	449 (101.1)	14.5	118
February 2016	24 (118.3)	0.83	11
March 2016	61 (119.8)	2	32
April 2016	45 (111.9)	1.5	18
May 2016	13 (112.3)	0.42	4
June 2016	183 (121.4)	6.1	79
Annual	1,174 (1127)		

* values in brackets refer to 66-year Williamtown data – sourced from the Bureau of Meteorology.

The monthly statistical information for each of the meteorological monitoring parameters is detailed in Appendix 1.

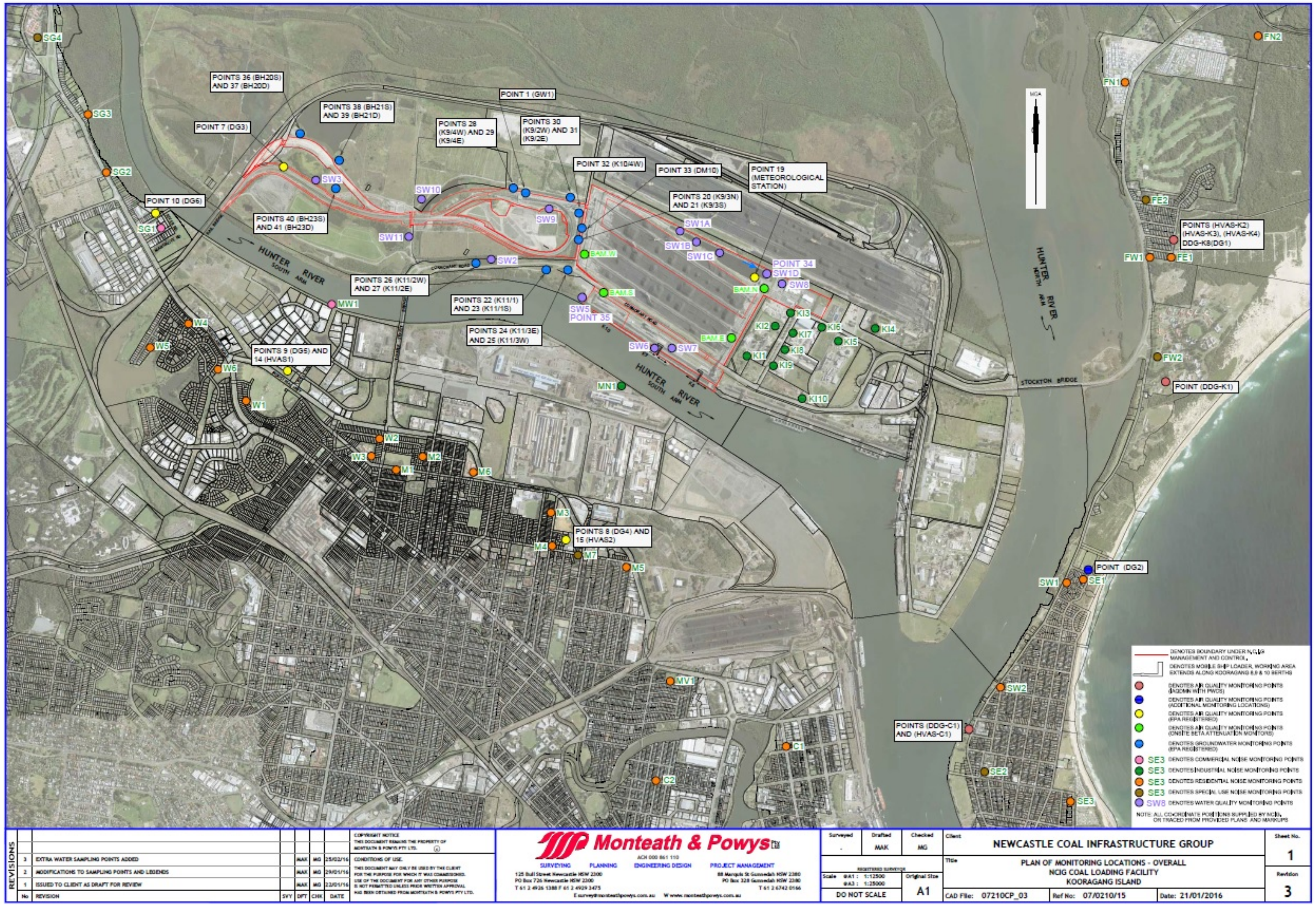

Figure 12: Environmental Monitoring Sites - Meteorology

The monthly and daily rainfall recorded at the project site is shown in Figure 13. A total of 1,174 mm of rain was received on the site during the reporting period with the highest rainfall recorded in January 2016. Low rainfall was recorded during July and August 2015, February 2016 and May 2016

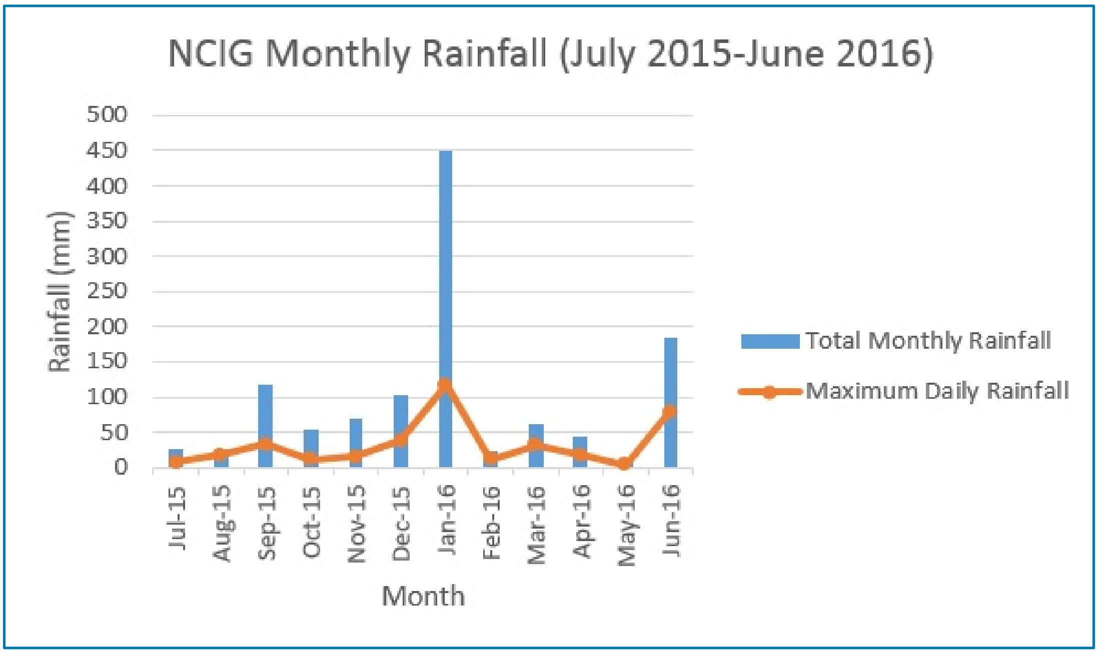

Figure 13: Total and maximum daily rainfall by month

Figure 14 illustrates the variation in average temperature during the reporting period. These variations from the winter to summer seasons are the normal expected seasonal variations. Figure 15 illustrates seasonal wind conditions throughout the reporting period.

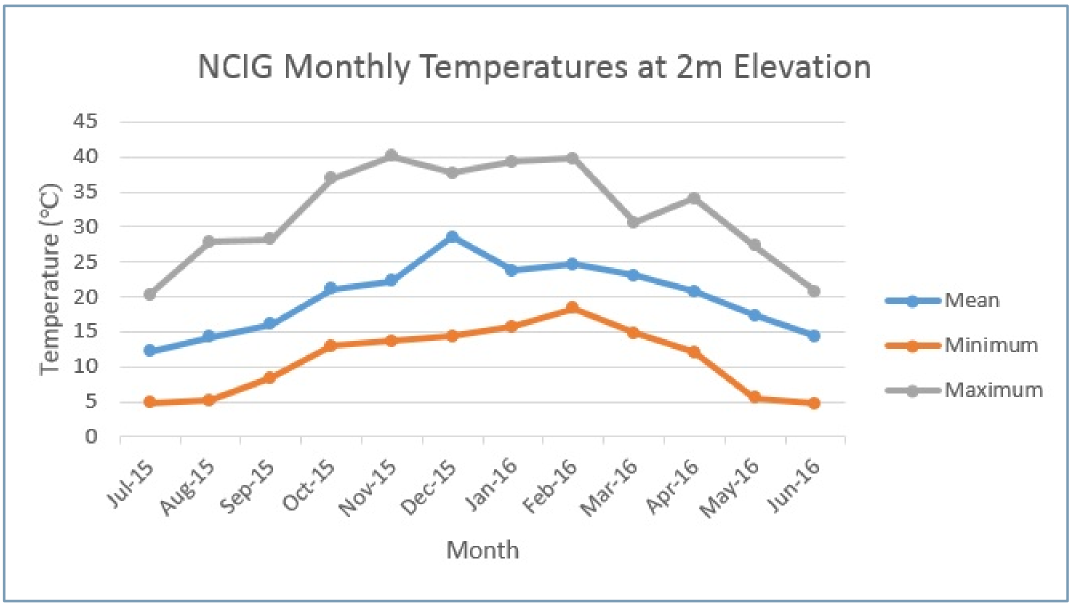

Figure 14: Temperature by month

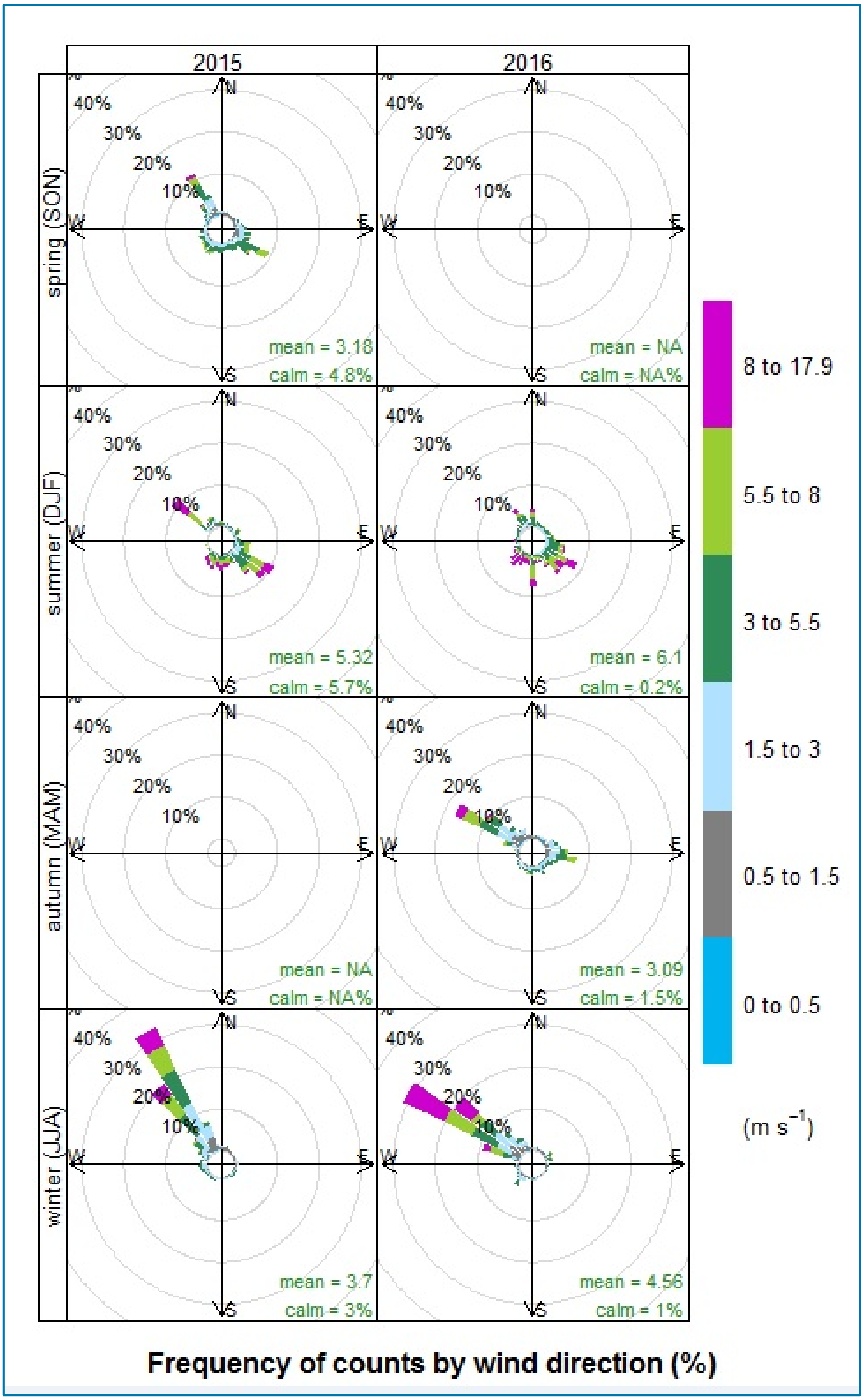

Figure 15: Seasonal Wind Conditions

3.1.4 Reportable incidents

No environmental incidents or complaints relating to meteorological conditions were made during the reporting period.

3.1.5 Further Improvements

NCIG are now receiving additional forecast data for rainfall, with forecast data provided 7 days in advance. This information is used to assist with surface water management.

3.2 Air Quality

3.2.1 Environmental Management

Onsite dust management is conducted consistent with the Operations Dust and Air Quality Management Plan to achieve the following key conditions.

In accordance with Conditions 2.2 and 2.4, Schedule 2 of PA 06_0009 NCIG designed and constructed the Project in a manner that minimises or prevents the emission of visible dust beyond the boundary of the site (including windblown and traffic generated dust).

In accordance with Condition 2.5, Schedule 2 of PA 06_0009 dust emissions are being controlled on all internal roads, trafficable areas and manoeuvring areas by sealing, or otherwise treating surfaces to minimise the potential for dust generation.

In accordance with Condition 2.1, Schedule 2 of the PA 06_0009 NCIG did not permit any offensive odour, as defined under section 129 of the *Protection of the Environment Operations Act, 1997*, to be emitted beyond the boundary of the Project site.

3.2.2 Environmental Performance

Table 3.3 outlines the monitoring locations, air quality parameters recorded, frequency of monitoring and air quality criteria for the Project in accordance with the CEMP. A Depositional Dust Monitoring results are provided with in Appendix 2.

Table 3.3 Summary of the Air Quality Monitoring Programme

Monitoring Parameter	Monitoring Sites*	Frequency	Criteria
Dust deposition[2].	DG1, DG2, DG3, DG4, DG5 and DG6[1].	Monthly during the first three months of construction, then quarterly.	4 g/m^2/month.
Total Suspended Particulates (TSP).	HVAS1, HVAS2, HVAS4.	6-daily.	90µg/m^3 (NHMRC annual average)
Particulate Matter <10 microns (PM10).	HVAS1, HVAS2, HVAS4.	6-daily.	50µg/m^3 (OEH 24hr daily limit, NEPM 24hr daily limit – allows for 5 exceedences in a year) 30µg/m^3(OEH annual average).

* HVAS3 at Stockton was monitored until June 2015, when it was decommissioned and replaced by the Lower Hunter Air Quality Monitoring Network.

1 The location of monitoring sites is shown on Figure 12.

2 Dust deposition was analysed in accordance with AS/NZS 3580.10.1-2003 *Methods for Sampling and Analysis of Ambient Air – Determination of Particulate Matter – Deposited Matter – Gravimetric Method.*

3 TSP was analysed in accordance with AS/NZS 3580.9.3-2003 *Methods for Sampling and Analysis of Ambient Air – Determination of suspended particulate matter – Total suspended particulate matter (TSP) – high volume sampler gravimetric method.*

4 PM10 was analysed in accordance with AS/NZS 3580.9.6-2003 *Methods for Sampling and Analysis of Ambient Air – Determination of suspended particulate matter – PM10 high volume sampler with size selective inlet – Gravimetric method.*

The depositional dust monitoring (insoluble solids) results for the reporting period are displayed in Figure 16 and Figure 17 below.

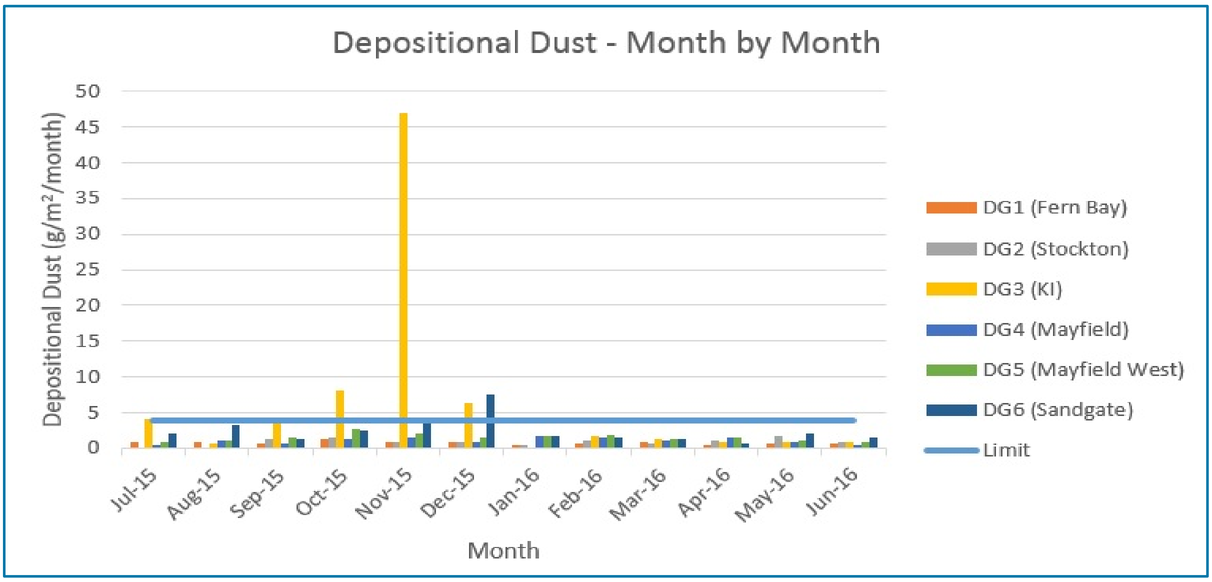

Figure 16: Monthly Depositional Dust

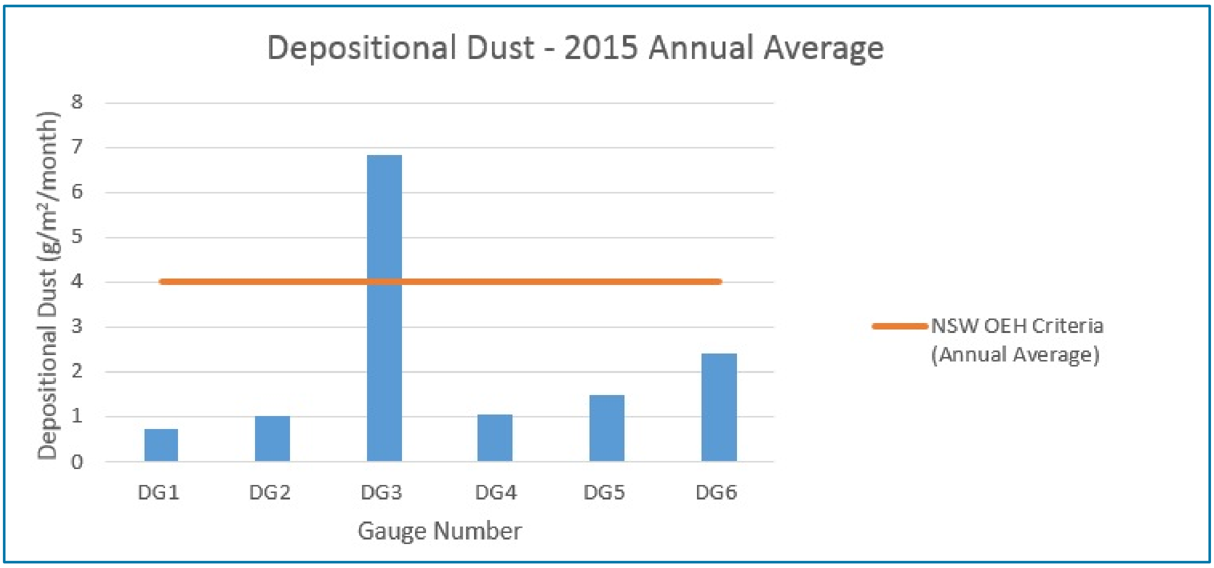

Figure 17: Annual Average Depositional Dust

Average depositional dust results were below the monthly criteria of 4 grams per square metre per month ($g/m^2/month$) at all depositional dust gauge locations aside from DG3 located at Kooragang Island and DG6 located at Mayfield Rail (Figure 17).

Figure 16 shows that individual monthly samples from DG3 exceeded the $4g/m^2/month$ criteria between October 2015 and December 2015. The spike in depositional dust of $46.9g/m^2/month$ in November 2015 was partially due to contamination of the gauge at Kooragang Island with insects and bird droppings, confirmed by the laboratory report.

Figure 18 also shows that individual samples from DG6 at Mayfield Rail exceeded the $4g/m^2/month$ criteria in December 2015. The exceedance at DG6 is unlikely to be due to NCIG activities as the gauge is located over 1km from the site boundary and there are commercial activities within the immediate vicinity of the gauge.

Air quality monitoring results from High Volume Air Sampling (HVAS), as they relate to both Total Suspended Particulate (TSP) and Particulate Matter with an equivalent aerodynamic diameter less than 10 Microns (PM_{10}), are displayed in Figure 18 and Figure 19.

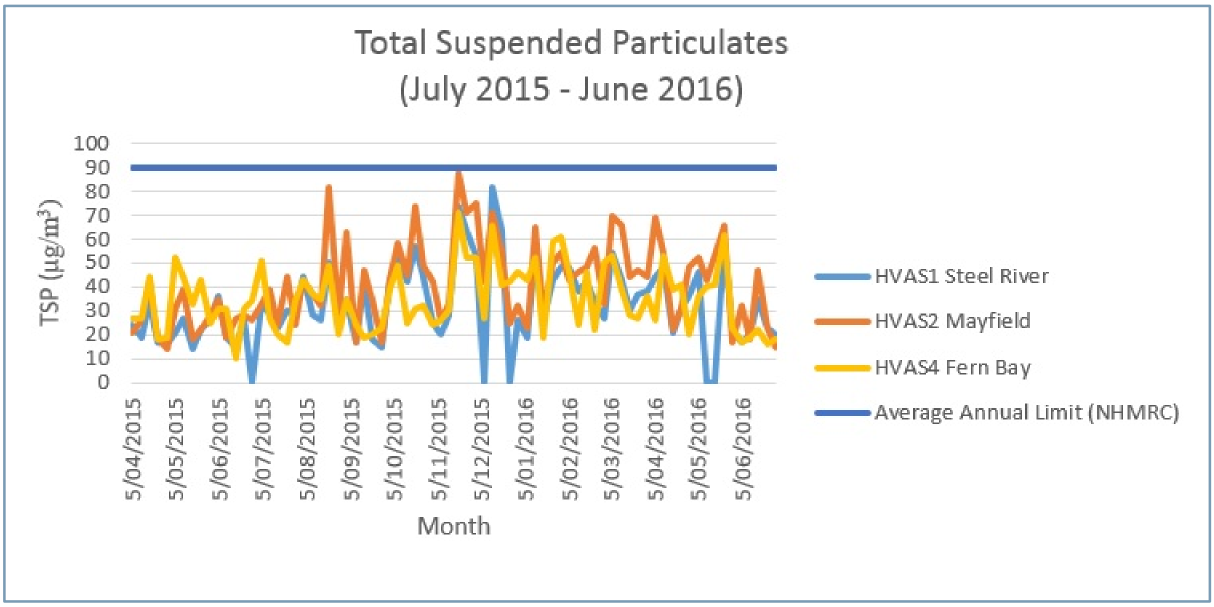

Figure 18: Total Suspended Particulates (TSP)

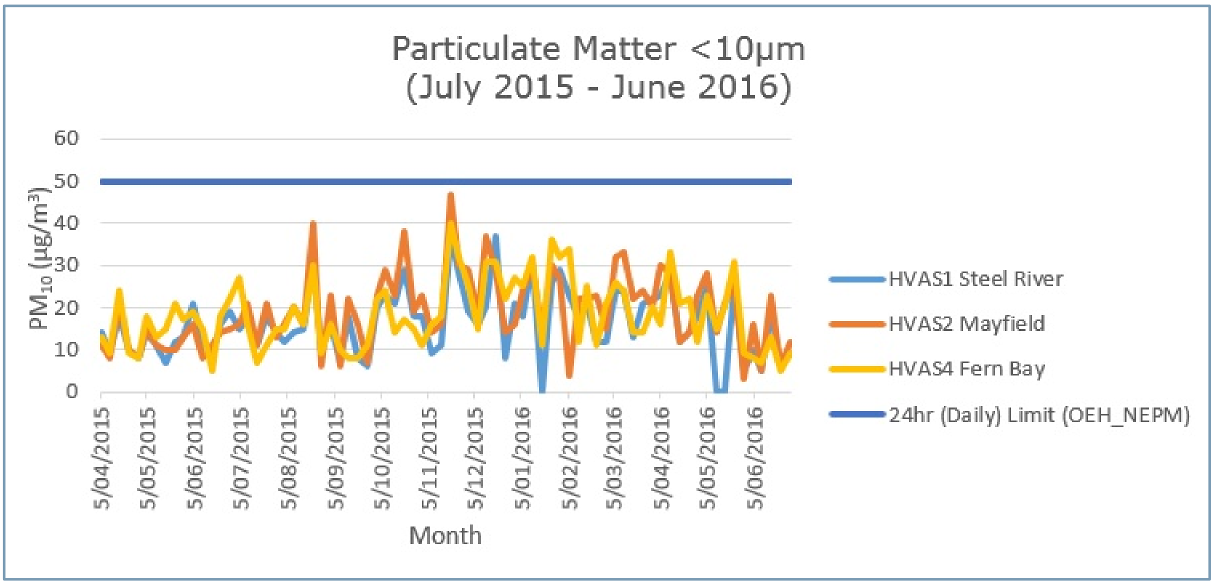

Figure 19: Particulate matter <10µm (PM_{10})

The annual average TSP concentrations for the three monitoring locations were below the NHMRC Annual Average Limit of 90µg/m^3, as shown in Table 3.4.

Daily concentrations of PM_{10} were also below their respective maximum 24-hr average guideline of 50µg/m^3 (OEH and NEPM) for the reporting period.

The OEH criteria of 30µg/m^3 (formerly NSW DEC, 2005) for Annual Average PM_{10} emissions was not exceeded at any of the monitoring stations between July 2015 and June 2016 as shown in Table 3.4 below.

Table 3.4 Annual Average TSP and PM_{10} Concentrations (µg / m³)

Annual Average July 2015 – June 2016	HVAS1 Steel River	HVAS2 Mayfield	HVAS4 Fern Bay
TSP annual average criteria (NSW DEC, 2005)		90	
TSP	37	44	37
PM_{10} annual average criteria (NSW DEC, 2005)		30	
PM_{10}	18	21	19

In accordance with Condition 3.2 e) of PA 06_0009, NCIG utilises real-time monitoring data to inform environmental management decisions associated with the project. This is done through interaction with real-time Beta Attenuation Monitors (BAMs), which measure Total Suspended Particles (TSP). These are located at the boundaries of the stockyard and are used to assist the management of operation to ensure compliance with project obligations.

Dust from coal handling operations was managed primarily through suitable design of plant and machinery, including enclosures and housed areas at the dump station, conveyors, transfer houses, the buffer bin and feeders throughout the site. Additional measures include operation of dust suppression and moisture addition sprays at transfer points positioned both in transfer houses and on the machines (i.e. Stacker/Reclaimers and the Ship loader). Dust suppression spray guns have also been positioned along the stockyard berms directly adjacent the coal stockpiles. These operate on an automatic sequence, which takes into account varying weather conditions and evaporation rates of water from stockpiles. The onsite weather station is also connected to the system. This system is managed in accordance with the Operations Dust and Air Quality Management Plan (ODAQMP), including programming logic known as an Integrated Dust Management System.

NCIG trialled a “Fog Cannon” for a six month period during the 2014/15 reporting period. The aim of the trial was to assess if the Fog Cannon was an effective way to control dust from stacking and reclaiming operations. The effectiveness of the Fog Cannon was observed visually during selected tasks completed on high/ extreme coal types or high/ extreme weather conditions. The observed effectiveness of the Fog Cannon was rated as ‘none’, ‘low’ or ‘moderate’ during stacking and reclaiming. NCIG concluded the Fog Cannon was of limited effectiveness and it was decommissioned.

The Newcastle Air Quality Monitoring Network was commissioned by the Office of Environment and Heritage (OEH) during the period, including real-time air quality measurements at Mayfield, Stockton, Carrington and Newcastle. The network is collectively funded by industrial Environment Protection Licence holders operating in the Newcastle area. This includes measurements of PM10, PM2.5 and other industrial air pollutants. NCIG regularly reviews results from the monitoring network, particularly during adverse weather conditions.

3.2.3 Reportable Incidents

There were no air quality incidents during the reporting period.

One complaint relating to air quality was received during the reporting period which was deemed to be unrelated to the Project (see Section 3.12). Regardless, the complaint was responded to in accordance with the Complaints Response Procedure.

3.2.4 External Dust Studies

Two studies on air quality in the Lower Hunter were reported on during the reporting period, including the Lower Hunter Particle Characterisation Study and the Lower Hunter Dust Deposition Study. The following information is publically available on NSW EPA's website.

The Lower Hunter Particle Characterisation Study studied the composition of airborne particles 2.5 micrometres and smaller in diameter ($PM_{2.5}$) in the Lower Hunter Region and the composition of particles 10 micrometres and smaller in diameter (PM_{10}) in the vicinity of the Newcastle Port. The study was undertaken to provide communities in the Lower Hunter with scientific information about the composition and likely sources of these particles, which are invisible to the eye. The study included one year of sampling from March 2014 to February 2015 at four sites in Newcastle, Beresfield, Mayfield and Stockton followed by sample analysis and modelling to identify the source of air particles. The results indicated that average annual fine particle concentrations are similar at Newcastle, Mayfield and Beresfield but about 40% higher at Stockton. The higher levels at Stockton are mainly due to more sea salt and primary ammonium nitrate, most likely due to emissions from the ammonium nitrate manufacturing facility on Kooragang Island. The source of fine particles over the year was found to be:

- Fresh sea salt particles: 24% at Newcastle, decreasing to 13% at Beresfield;
- Pollutant-aged sea salt: approximately 23% at all sites;
- Wood smoke: 15% at Beresfield, decreasing to 6% at Stockton;
- Secondary ammonium sulfate: approximately 10% at all sites;
- Soil dust: approximately 10% at all sites;
- Vehicles: approximately 10% at three sites and 5% at Stockton;
- Industry factors: approximately 12% at three sites and 24% at Stockton;
- Mixed shopping and industry: approximately 3% at all sites;
- Nitrate: 19% ammonium nitrate at Stockton and secondary nitrate at other sites (6-11%).

The Lower Hunter Dust Deposition Study was commissioned to examine the quantity, composition and likely sources of depositional dust in the Lower Hunter. An interim study report for the first 6 months of the study between October 2014 and July 2015 was released by the end of the reporting period. The six-month averages for dust deposition data collected from the twelve monitoring sites range from $0.7g/m^2$.month to $1.4g/m^2$.month, below the EPA criterion of $4g/m^2$.month. Soil or rock dust comprised the greatest proportion of the samples, followed by coal, soot, black rubber and halite (rock salt). Insect debris, plant debris and miscellaneous fibre were found in many of the samples. No detailed analysis was considered in the interim report. A final report is expected in November 2016.

NCIG is aware of these two studies and will be considering the outcomes of the studies on its operations.

3.2.5 Further Improvements

Stockpiling procedures were changed during the reporting period to improve efficiency and reduce dust generation. Initial stacking operations for each product is conducted at 12m to complete stockpile footprint. Subsequent stacking then conducted at 24m. This change results in a lower stockpile height for a significant period, which results in a reduction in dust emissions (as PM_{10}) due to lower wind speeds.

3.3 Water Quality

3.3.1 Environmental Management

In accordance with Condition 7.6 c), Schedule 2 of PA 06_0009, an Operations Water Management Plan (OWMP) was developed which defines the surface water, stormwater and groundwater controls on the Site during operation. The OWMP includes specific measures designed to avoid sediment-laden, coal-laden or hydrocarbon-impacted surface water from entering Deep Pond, wetland areas or the Hunter River. The OWMP also includes a monitoring programme of surface water utilised on and around the Site. The OWMP identifies water management infrastructure and water requirements for activities such as dust suppression and plant washdown. A site water balance is included, which accounts for water captured on site through rainfall and volumes of water that may be required from the local potable water system.

The OWMP identifies that surface water runoff from disturbance areas during construction and operation of the Project could potentially contain sediments, soluble salts, fuels, oils, grease and other contaminants, in particular coal residue. The potential surface water quality impacts that relate to these contaminants from each area of the Project site are summarised in Table 3.5.

Table 3.5 Potential surface water quality impacts

Project Site	Potential Impact Scenario	Potential Contaminant
Rail Infrastructure Corridor	Uncontrolled drainage of sediment laden runoff to downstream waterbodies within the Kooragang Island Waste Emplacement Facility (KIWEF) during construction of rail embankments.	Sediments, soluble salts, heavy metals, organic contaminants, fuels, oils and grease.
	Uncontrolled drainage of runoff from access roads and construction areas to downstream waterbodies within the KIWEF.	
	Uncontrolled drainage of runoff from exposed soils within the existing KIWEF to downstream waterbodies.	
	Potential erosion and sedimentation resulting from runoff from the rail corridor and associated drainage system.	
	Release/spill into downstream waterbodies.	Coal, diesel, lubricants and hydrocarbons.
Coal Storage Area	Uncontrolled drainage to downstream waterbodies during construction of the coal storage area.	Sediments, soluble salts, heavy metals, organic contaminants, fuels, oils, lubricants and low pH water.
	Uncontrolled drainage of runoff from access roads and construction areas to downstream waterbodies.	
	Spillage/overflow of site water to downstream waterbodies.	

Table 3.5 Potential surface water quality impacts

Project Site	Potential Impact Scenario	Potential Contaminant
	Release/spill into downstream waterbodies due to rupture of fuel tank (diesel/petrol).	Sediments, coal, diesel, lubricants and hydrocarbons.
Wharf Facilities and Ship loader Area	Uncontrolled drainage of sediment laden runoff to the south arm of the Hunter River during construction of the berths and wharf structure, excavation on or near the banks of the South Arm of the Hunter River and during piling operations.	Sediments, soluble salts, fuels, oils and grease.
	Uncontrolled drainage of runoff to the south arm of the Hunter River from access roads and wharf construction areas including excavation on or near the banks of the South Arm of the of the Hunter River.	
	Release/spill into South Arm of the Hunter River.	Sediments, coal, diesel, lubricants, hydrocarbons.

This identification of surface water flows was utilised to develop the monitoring programme defined in the OWMP which aim to ensure adjacent water bodies are not impacted by NCIG activities. The OWMP was approved by the Department of Planning (now NSW Department of Planning and Environment) as part of the Operations Environmental Management Plan (OEMP) respectively.

The surface water management strategies, as detailed in the OEMP, are:

- the separation of surface water runoff generated from within the active CET and Project construction areas from that generated from surrounding areas;
- containment and reuse of water onsite;
- the implementation of adequate water management controls to minimise the potential for impacts to off-site water resources such as adjacent wetland areas, Deep Pond and the Hunter River (Figure 10).

The management of erosion and sedimentation is outlined is Section 3.5.

3.3.2 Environmental Performance

Table 3.6 outlines the monitoring locations, frequency of monitoring and monitoring parameters for the Project in accordance with the OEMP and OWMP. These monitoring elements form the Surface Water Monitoring Program for the Project. Two new monitoring points 34 and 35 were added to EPL12693 for monitoring of discharge water in March 2016.

Table 3.6 Surface Water Monitoring Program

Monitoring Locations	Frequency	Parameters
Primary and secondary settling ponds, overflow pond.	Monthly	• pH; • Electrical conductivity (EC); • Turbidity; • Temperature.
	During period of heavy rainfall (i.e. more than 20 mm of rainfall in a 24 hour period).	• Water level.
Surface water monitoring sites.[1]	Monthly	• pH; • EC; • Turbidity; • Temperature.
Drainage, erosion and sediment control infrastructure.	Monthly	• Structural stability and effectiveness in controlling sediment migration.
Collection sumps	Weekly	• Level of collected sediment.
Discharge Points	Monthly during discharge (daily based on OWMP)	• pH; • Total Suspended Solids (TSS); • Oil and Grease.

[1] The location of monitoring sites is shown in Figure 12

A site drainage network was established to capture site runoff. The topography grades to the north and west of the Project site and the existing flow path for surface runoff was incorporated into the completed site surface profile.

The drainage network that was established for dredging activities was incorporated into the design of the permanent water management infrastructure on the site. This design involves stormwater draining from east to west in the coal stockpile area at which point it collects in an open drain and is directed to the north-west of the site (see Figure 21). Additional subsurface drainage was constructed as part of Stages 2AA and 2F, specifically beneath the extended stockpile area. Surface water captured in the construction area of the stockyard is redirected both to the east and west. Surface water is then captured in primary settling ponds across the north of the site where fines are allowed to settle. This water cascades from the primary ponds into a secondary settlement pond prior to collection in the clearwater pond where it is then pumped to water storage tanks and is then available for reuse on the site. This water resource is to be utilised primarily for dust suppression purposes across the site, but also wash-down and belt cleaning activities.

Within the design of the drainage network, stormwater from the wharf and rail areas of the site are also directed into the stockyard water management system. Stormwater collected on the wharf is accumulated in an on-site pond and then pumped across Cormorant Road. Stormwater captured inthe vicinity of the train unloading station is also pumped to the stockyard, with both sources eventually made available for reuse after treatment in the northern settlement ponds. This includes additional controls constructed as part of Dump Station 2. The existing surface water management controls in the rail loop and sidings allowed for the increased catchment capacity from Stages 2AA and 2F rail construction. Subsurface drainage from beneath Coal Stockpile Pads 4 and 5, and associated collection sumps were constructed as part of the Stage 2F construction works. Surface water drainage controls were also constructed at K10 wharf and the extension of the portside facility.

Improvements were made to Wharf Settling Basin 1 during the period. The basin was further compartmentalised to achieve a greater degree of settling before discharge to the stockyard. The improvement work can be seen in Figure 20.

Figure 20: Modifications to Wharf Settling Basin 1

Sampling of surface water ponds was also undertaken during the reporting period in accordance with the OWMP. The location of the sampling undertaken is illustrated in Figure 21 with the water quality results recorded detailed in Appendix 3.

Values for pH on site were slightly higher than the previous reporting period with a range of 7.47 to 10.01, although this is still considered to be a healthy range and within historical recording limits. The off-site water sources were less variable than onsite sampling locations (7.42 to 9.83), although this is also considered to be a healthy range and within the historical recording limits. Electrical conductivity (EC) was generally low onsite, with higher values reported at Swan Pond off-site. Dissolved Oxygen (DO), while being seasonally variable, was comparable between sites. Turbidity values were variable across all sites, which is likely due to discrete weather events (i.e. rainfall) and the settlement process within onsite ponds.

Biannual surface water sampling was completed by RCA in June and December 2015, with 10 surface water samples collected for analysis and comparison of the results to the trigger levels adopted in the Surface Water Monitoring Plan. The Surface Water Monitoring Program was originally developed in 2012 as an outcome of the Independent Environmental Audit (IEA), as precautionary measure to assess potential pollutants from the NCIG terminal, that were not investigated as part of monthly water quality monitoring measurements. Surface water samples were collected from operational locations, including the Trade Waste Pond, Wharf Sump, Hunter River Wharf, Rail Settling Basin (WT01) and Clear Water Pond; and from reference locations, including Deep Pond, Delta Pond, Pond I, Black Swan Pond and the Hunter River and compared to trigger values that were either site-specific trigger values or ANZECC triggers for protection of 95% Aquatic Species. Concentrations of TRH, PAHs, nitrate, ammonia and some heavy metals were below the trigger values (where available). Concentrations of phosphorous exceeded the marine trigger value at the majority of sampling locations, including the Hunter River (reference site). Concentrations of various metals, including aluminium, boron, copper, manganese, iron, molybdenum, nickel and zinc exceeded the trigger values (where available) at the Hunter River Wharf, Wharf Sump, Trade Waste Pond, Rail Settling Basin, Clearwater Pond (operational sites) and at Black Swan Pond, Delta Pond, Deep Pond, Pond I and the Hunter River (reference sites).

In accordance with the Surface Water Monitoring Program, NCIG commissioned a review of the surface water monitoring completed by Ramboll Environ in February 2016. This review followed on from the previous review completed in 2013. The 2016 review included an initial data screening to remove parameters with insufficient data (>60% non-detects), comparison of surface water quality against established (default) water quality triggers and calculation of site-specific trigger values for parameters that exceeded ANZECC (2000) 95% freshwater trigger values (aluminium, boron, zinc, total phosphorous, electrical conductivity, dissolved oxygen, pH and turbidity). Median concentrations of each parameter were then compared to the site-specific trigger values and a trend analysis of the Hunter River reference location completed. The surface water monitoring review recommended continuation of the six-monthly sampling regime given the low levels of detection of most parameters and continuation of the current suite of parameters (as revised in 2013) for another 12 months (two monitoring rounds) at which time the parameter list could be further refined to reflect site-specific water quality.

3.3.3 Reportable Incidents

During the reporting period, a discharge event occurred in January 2016. A factual report of the discharge event was compiled by RCA Laboratories in 'Report Compiled for Newcastle Coal Infrastructure Group Detailing the Analysis of Discharge Surface Waters January 2016'. The report indicates that water samples were collected during the period 6 to 18 January 2016, with samples collected from the SW1-D pond discharge point as well as other location across the NCIG site. Background surface water quality samples were also collected from the Hunter River. Water quality results were provided for pH, turbidity, total suspended solids and oil and grease. No concerns were raised in the factual report as discharge water quality parameters were below background water quality in the Hunter River. No further response was required.

3.3.4 Further Improvements

Further studies will be completed on NCIG's Surface Water Management System, including an updated Site Water Balance. NCIG are also looking to make additional improvements to manage sediment within the NCIG Surface Water Management System.

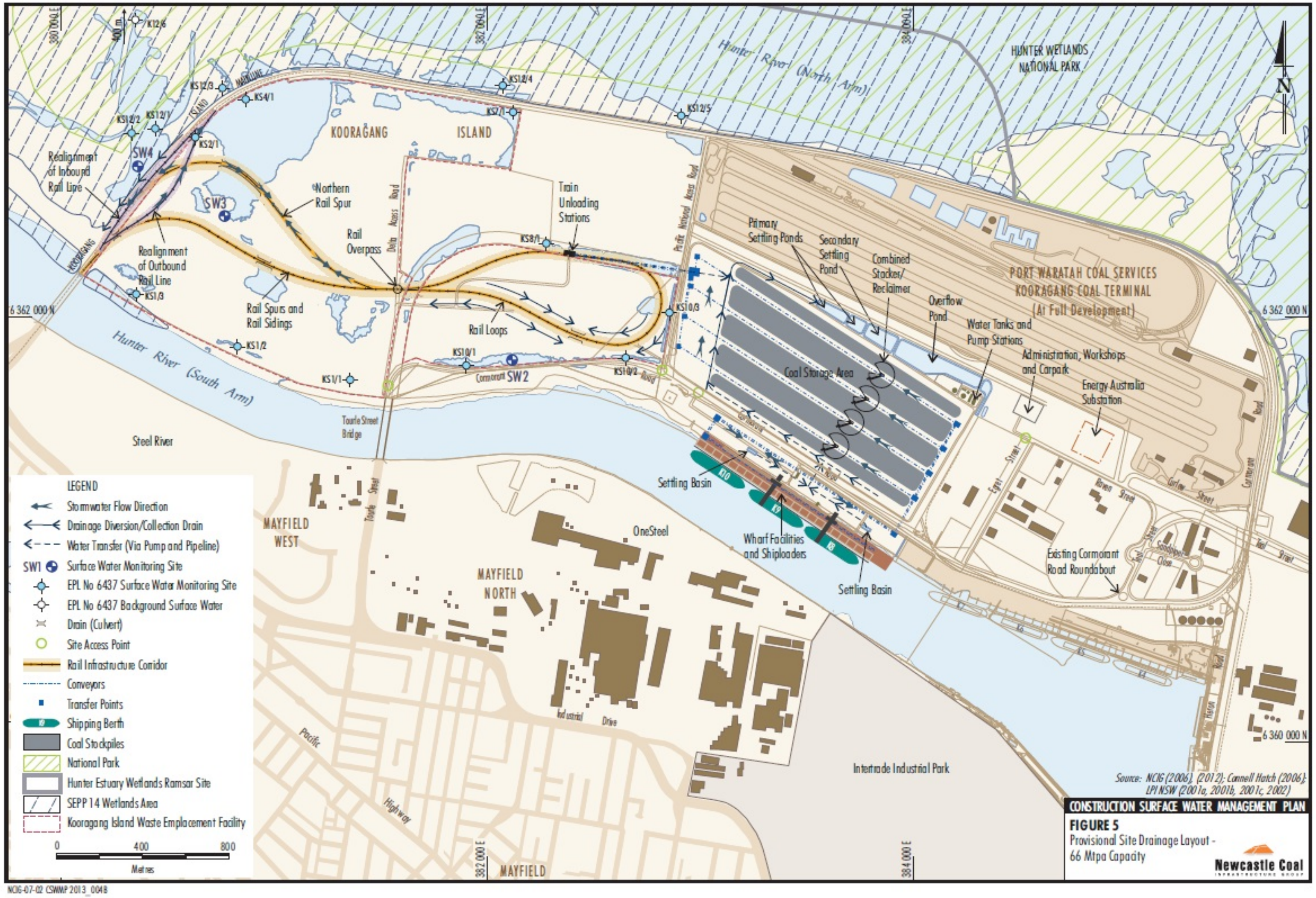

Figure 21: Permanent site drainage layout

3.4 Groundwater

3.4.1 Environmental Management Relating to EPL

A review of the groundwater monitoring program was undertaken by Ramboll Environ in April 2016 with the objective of developing a rationalised groundwater monitoring plan for future groundwater monitoring and management at the NCIG site.

This review built on the review of groundwater monitoring data completed in the previous reporting period with additional 2014 and 2015 data added to the database used for the 2014 review. This review consolidated the different data sets into a single database and screened the combined data. Following data screening, recommendations were made regarding monitoring locations, the analytical suite, monitoring frequency, site-specific trigger values, contingency program, sampling methodology and reporting requirements.

The Review included a rationalised groundwater monitoring plan for the OWMP, which identified appropriate monitoring locations, sampling and reporting methodology, refinement of the analytical suite, monitoring frequency, site-specific trigger values, a contingency program and reporting requirements.

3.4.2 Environmental Performance Relating to the EPL

Table 3.7 outlines the monitoring locations, groundwater monitoring parameters recorded, frequency of monitoring and groundwater criteria for the Project in accordance with Section M2.3 of EPL 12693.

Table 3.7 Summary of the Groundwater Monitoring Program (EPL)

Monitoring Parameter	Monitoring Sites	Frequency	Criteria
Al, Ammonia, Benzene, Co, Conductivity, Cu, Cyanide (Free), Cyanide (Total), Ethyl Benzene, Fe, m+p-Xylene, Mg, Mn, Ni, o-Xylene, pH, Phenol, K, Na, Toluene, Total PAH, TPH C6-9, TPH C10-36, Zn.	GW1 (Monitoring Point 1)	6 monthly	Refer EPL 12693
Ammonia, Benzene, Conductivity, Cyanide (Free), Cyanide (Total), Ethyl Benzene, m+p-Xylene, o-Xylene, pH, Phenol, Toluene, Total PAH, TPH C6-9, TPH C10-36.	K9/3S, K9/3N, K11/1S, K11/1 (Monitoring Points 20-23)	6 monthly	Refer EPL 12693
Al, Ammonia, Benzene, Co, Conductivity, Cu, Cyanide (Free), Cyanide (Total), Ethyl Benzene, Fe, m+p-Xylene, Mn, Ni, o-Xylene, pH, Phenol, K, Na, Toluene, Total PAH, TPH C6-9, TPH C10-36, Zn.	K11/3E, K11/3W, K11/2E, K11/2W, K9/4E, K9/4W, K9/2E, K9/2W, K10/4W, DM10 (Monitoring Points 24-33)	Only if Trigger Criteria is exceeded at Monitoring Points 20, 21, 22 or 23 and is confirmed through second monitoring round.	Refer EPL 12693

[1]The location of monitoring sites is shown on Figure 22.

A summary of the groundwater monitoring results recorded during the reporting period is provided in Appendix 4 and Table 3.8.

Table 3.8: Summary of Groundwater Monitoring Results (EPL)

Monitoring Sites	Dates of Sampling	Exceedances of EPL Requirements?	Exceedances of CEMP/ OWMP	Comments
GW1 (Monitoring Point 1)	7/12/15, 2/6/16	N/A	Cu, Mn, Zn	Review indicates insufficient data to complete trend analysis or develop site-specific trigger values currently. On-going monitoring recommended.
K9/3N (Monitoring Point 20)	7/12/15, 2/6/16	No	Mn	
K9/3S (Monitoring Point 21)	7/12/15, 2/6/16	No	Cu, Mn, Zn	
K11/1 (Monitoring Point 22)	7/12/15, 2/6/16	No	Mn, Zn	
K11/1S (Monitoring Point 23)	7/12/15, 2/6/16	No	pH, Mn	
K11/3E, K11/3W, K11/2E, K11/2W, K9/4E, K9/4W, K9/2E, K9/2W, K10/4W, DM10 (Monitoring Points 24-33).	Not required	N/A	N/A	Not required to be sampled as no exceedances of Trigger Values for Further Investigations (Section E1.1 of EPL 12693).

An assessment of the monitoring records found the following:

- that the Trigger Values For Further Investigation (as outlined in Section E1.1 of EPL 13693) were not exceeded at any of the required monitoring locations;
- that exceedences of criteria outlined in the OWMP (ANZECC (2000) trigger level for the protection of 95% of marine water species) occurred at Monitoring Points 1, 20, 21, 22 and 23, for manganese;
- The manganese exceedences are similar for the previous reporting period.

3.4.3 Environmental Management Relating to Flyover Construction

Additional groundwater monitoring requirements were introduced during the 2013/2014 reporting period for the construction of the rail flyover. Environmental Earth Sciences (EES) developed a Groundwater Management Plan in September 2013 to satisfy Conditions 2.45A and 2.45B of the Modification of the Minister's Approval MP06_0009. This plan includes the monitoring of bores BH19s/BH19d, BH21s/BH21d and BH23s/BH23d on a quarterly basis. It is noted that BH19s and BH19d were sampled in October 2013 but were found to be damaged in the next sampling round in January 2014 and wells BH20s and BH20d were substituted for the damaged wells. In addition, monitoring of surface water at Deep Pond and Swan Pond are required on a quarterly basis.

The final round of groundwater monitoring for the construction of the rail flyover was completed in July 2015. NCIG were in discussions with the EPA during the reporting period about incorporating groundwater monitoring from the rail flyover Groundwater Management Plan into the NCIG EPL.

3.4.4 Environmental Performance Relating to Flyover Construction

Table 3.9 outlines the monitoring locations, groundwater and surface water monitoring parameters recorded, frequency of monitoring and criteria for the flyover construction in accordance with Conditions 2.45A and 2.45B of the Modification of the Minister's Approval MP06_0009.

Table 3.9: Summary of the Groundwater Monitoring Program (Flyover)

Monitoring Parameter	Monitoring Sites	Frequency	Criteria
TRH (fraction C6-C40), BTEX, naphthalene, dissolved heavy metals(Al, As, Br, Cr, Cu, Fe, Mn, Ni, Pb, Zn), Biochemical Oxygen Demand (BOD)	BH20s/BH20d, BH21s/BH21d, BH23s/BH23d	3 monthly	Refer EES (2013) GMP
	Deep Pond, Swan Pond (surface water)		

[1]The location of monitoring sites is shown on Figure 22.

The area over which the rail flyover was constructed, known as KIWEF, comprises filling up to 11m bgs, including building rubble, coarse and fine coal washery reject, slag, fly ash, flue dust and liquid waste. Consequently, any interception of the groundwater table during Project construction activities is being managed. In response to groundwater conditions encountered on the project site the following groundwater management contingency measures were adopted for specific Project elements:

- a low permeability capping layer was incorporated into the rail embankment formation to minimise infiltration; and
- groundwater bores were established to monitor groundwater levels, and water quality along the rail infrastructure corridor.

The final groundwater monitoring event for construction of the rail flyover occurred in July 2015. Ramboll Environ closed out the rail flyover groundwater monitoring program in their Review of Groundwater Monitoring Program in April 2016. Ramboll Environ compared the results of each of the eight monitoring rounds to the site trigger levels and assessed these results against the contingency plan to be adopted as part of the Groundwater Management Plan. A review of the data indicated the following:

- No increasing trends in the concentrations of TRH, BTEX, PAHs or dissolved metals were identified in the monitored wells aside from an increasing trend in iron and manganese in BH20D. The EES (2013) Baseline Detailed Site Investigation – Site D1 – Kooragang Island, Newcastle, NSW indicates that the deep aquifer is likely to be in the manganese and ferric iron stages of reduction. As such, the increasing trend in manganese and iron concentrations in BH20D is likely to be associated with natural processes and not related to site activites;
- No significant changes in the nature of the contamination;
- No major changes in the depth to groundwater recorded at the wells over the eight sampling events;
- No trends indicating a significant reduction in the effectiveness of on-going natural attenuation (geo-chemical evolution) processes were identified;
- No changes to the potentially exposed receptors or their assessed risk were identified.

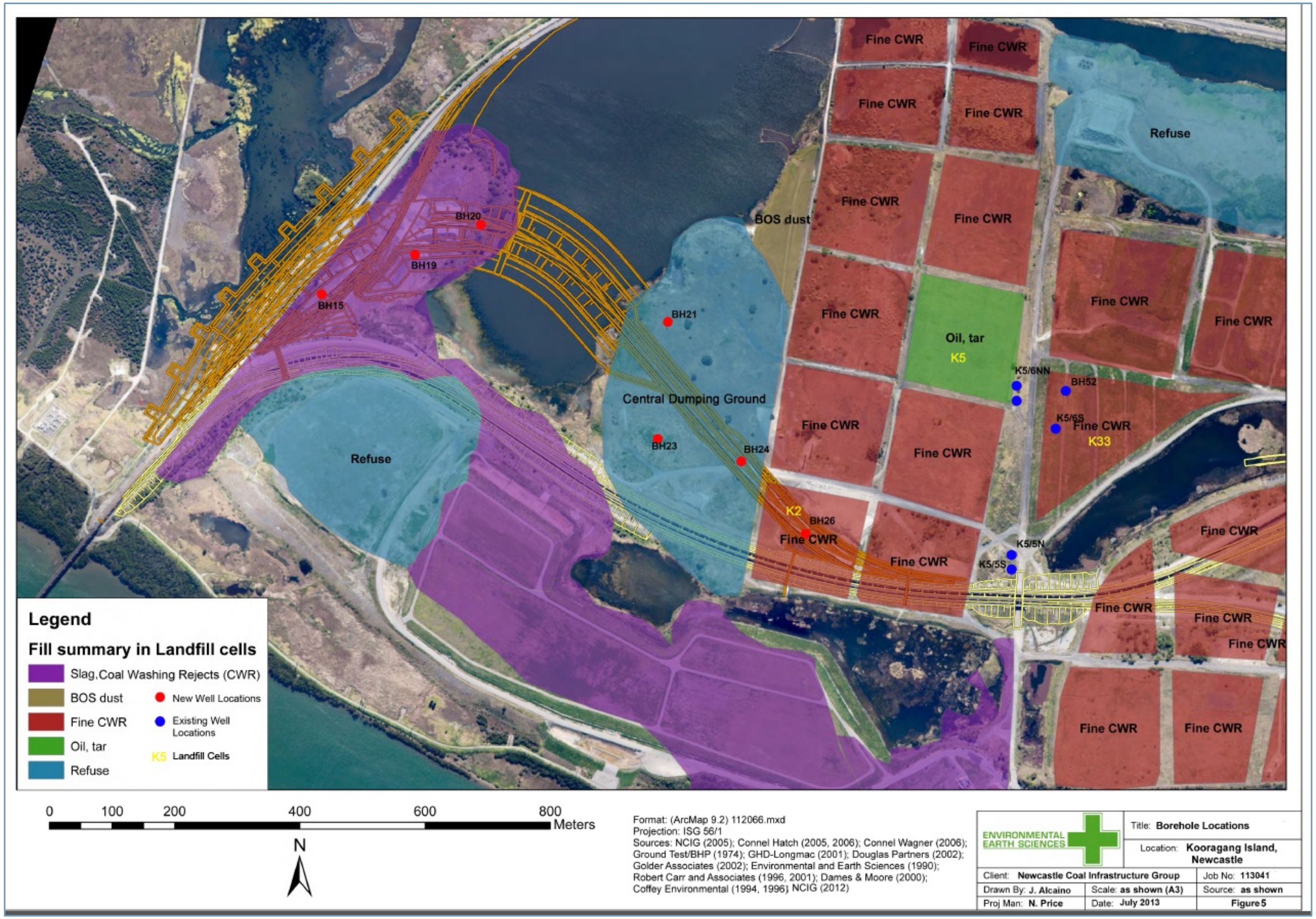

Figure 22: Location of Groundwater Monitoring Wells for Flyover

3.4.5 Reportable Incidents

No environmental incidents or complaints relating to groundwater quality conditions were made during the reporting period.

3.4.6 Further Improvements

NCIG are in the process of consolidating the groundwater monitoring program so that it is consistent with both the OWMP and the requirements of EPL 12693. Ramboll Environ completed a Review of Groundwater Monitoring Report in April 2016 with the objective of reviewing all existing groundwater monitoring plans and developing a rationalised groundwater monitoring plan for future groundwater monitoring and management at the NCIG site.

3.5 Erosion and Sediment Control

3.5.1 Environmental Management

In accordance with Condition 2.43, Schedule 2 of the PA 06_0009 NCIG took all reasonable measures to prevent soil erosion and the discharge of sediments and pollutants from the site during construction activities.

In accordance with Condition 2.42, Schedule 2 of the PA 06_0009 NCIG has designed and constructed surface water and stormwater management infrastructure on the site to accommodate a 1 in 100 annual recurrence interval (ARI) rainfall event.

All erosion, sediment and pollution control infrastructure is being maintained on the Site at or above design capacity during construction of the Project and will continue to be until such time as all ground disturbed by the works has been stabilised and rehabilitated so that it no longer acts as a source of sediment, in accordance with Condition 2.44, Schedule 2 of PA 06_0009.

All stockpiled construction materials have been managed to minimise erosion or dispersal of the materials in accordance with Condition 2.45 of PA 06_0009. All fill/preload material brought to the Project site is managed in a manner that minimises erosion and dispersal of those materials to the downstream waters (e.g. south arm of the Hunter River).

In accordance with Condition 2.49, Schedule 2 of PA 06_0009, all stormwater and surface water management infrastructure associated with the operation of the Project is lined with a low-permeability material to minimise potential leakage. Stormwater is reused onsite for beneficial purposes such as the wetting of coal to reduce dust emissions from the Site.

All grey wastewaters from the site are directed to sewer in accordance with a Trade Waste Licence, approved through Hunter Water Corporation, in accordance with Condition 2.51, Schedule 2 of PA 06_0009.

Erosion and sediment control measures and general surface water management measures for the Project are documented in the approved Construction Surface Water Management Plan (CSWMP) and the OWMP.

3.5.2 Environmental Performance

Table 3.10 outlines the monitoring locations, erosion and sediment control parameters recorded, frequency of monitoring and criteria for the Project in accordance with the CEMP. While construction of the NCIG Project was effectively completed prior to the reporting period, a number of erosion and sediment controls remained in-situ during the period until stabilisation of surfaces was achieved.

Table 3.10: Summary of the Erosion and Sediment Control Monitoring Program

Monitoring Parameter	Monitoring Sites	Frequency	Criteria
Structural stability and effectiveness in controlling sediment migration.	Drainage, erosion and sediment control infrastructure.	Monthly and following significant rainfall events (i.e. greater than 20 mm in 24 hours)	N/A

The management of erosion and sedimentation for the NCIG Project is detailed by the Erosion and Sediment Control Plan (ESCP), part of the Operations Water Management Plan. Activities that have the potential to cause or increase soil erosion at the Site have been identified and are primarily due to exposure of soils during construction activities.

The general erosion and sediment control principles adopted take into account the general recommendations for site drainage works presented in Managing Urban Stormwater: Soils and Construction – Volume 1 (Landcom, 2004) which underpin the goal of protecting adjacent wetland areas, Deep Pond and the Hunter River. These principles involve:

- Minimising surface disturbance and restricting access to undisturbed areas.
- Separation of runoff from disturbed and undisturbed areas where practicable.
- Construction of surface drains to facilitate the efficient transport of surface runoff or utilisation of existing stormwater systems.
- Construction of the site drainage network including perimeter bunds, internal bunds, primary settling ponds and hydraulically controlled discharge structures.
- Construction of primary and secondary settling ponds, site water pond and sediment dams to contain runoff up to specified design criterion.
- Installation of a silt curtain in the south arm of the Hunter River local to the disturbance area during construction of the shipping berth batters, wharf structure and during piling operations (in the River) that may create excessive material disturbance.
- Installation of silt curtains in Swan Pond and Deep Pond during construction of the Rail Flyover to contain mobilised sediments generated from ground disturbance.

In ensuring the erosion and sediment control principles are adhered to, development activities on the Project have been typically undertaken in the following order:

- Construction of sediment fences (down slope of disturbance areas) where required.
- Installation of silt curtains in identified water bodies, including the Hunter River, where required.

General construction works are only commenced once erosion and sediment control measures are in place. These measures may include:

- Construction of drainage diversions (typically upslope of disturbance areas) – these were only constructed where they significantly reduced the runoff catchment of disturbance areas and connected to the site drainage network where practicable.
- Construction of the primary and secondary settling ponds and a clearwater pond.
- Construction of collection drains (down slope of disturbance areas) where required to convey runoff to the site drainage network (including primary and secondary settling ponds and a site water pond).

ESCPs detailing specific erosion and sediment control measures, were developed in a progressive manner prior to the development of each Project component requiring land disturbance. This was undertaken through a risk assessment process associated with the individual task proposed and are modified as required to ensure that the goal of protecting water bodies from erosion and sedimentation is achieved.

Temporary erosion and sediment controls (e.g. silt fences and sediment control structures) were installed prior to the commencement of construction activities on the Project site. Routine (i.e. monthly) inspections of sediment control structures, as well as inspections following significant rainfall events (e.g. 20 millimetres (mm) or more in a 24 hour period), are conducted by NCIG personnel. During these inspections, sediment control structures were inspected for capacity, structural integrity and effectiveness. Any deficiencies identified by these inspections are assessed, prioritised and rectified in the appropriate timeframe.

A network of permanent stormwater structures has been constructed to manage runoff around the site. All long-term site water management structures are lined with low permeability materials (e.g. compacted clay) to minimise the potential for leakage. Water management structures are designed with sufficient capacity for a 1 in 100 year average recurrence interval (ARI) rainfall event.

During the reporting period, dewatering water was discharged from an excavation into a public drain. NCIG discussed the event with NSW EPA. As a result, NCIG developed a Dewatering and Sediment/Erosion Control Permit which is to be completed prior to any work (maintenance or construction) that requires dewatering and discharge or results in disturbance of ground surfaces greater than $10m^2$.

3.5.3 Reportable Incidents

No environmental incidents or complaints relating to erosion or sediment control were made during the reporting period.

3.5.4 Further Improvements

No scheduled improvement to erosion and sediment control is required for the next period as the construction of the permanent surface water management infrastructure on the terminal site was completed during this reporting period.

3.6 Land Contamination

3.6.1 Environmental Management

In accordance with Condition 2.53, Schedule 2 of PA 06_0009 NCIG engaged an appropriately qualified person to audit construction of the rail infrastructure over land used as part of the KIWEF against the commitments contained in the NCIG Project Environmental Assessment and supporting documents.

Prior to any excavation on the Project, a comprehensive surface and sub-surface soil sampling and analysis programme was undertaken in order to characterise the material to be excavated. The sampling programme was undertaken in accordance with the NSW EPA (2004b) *Guidelines for the Assessment, Classification and Management of Liquid and Non-Liquid Waste*. The aim of the programme was to identify the risk associated with contamination across the stockyard and rail areas and to determine the suitability of the site for the development of the NCIG project. The findings of this process were that there existed a manageable risk associated with contamination and that the site was suitable for the proposed development.

In accordance with Condition 2.54, Schedule 2 of PA 06_0009 NCIG did not direct any contaminated materials removed from the site to a waste management facility that was not lawfully permitted to accept the materials.

3.6.2 Environmental Performance

In accordance with Condition 2.53, Schedule 2 of the PA 06_0009 a Summary Report was provided by Ramboll Environ in August 2015, who audited the capping of the waste emplacement area during the flyover construction between October 2013 and June 2015. Specifically, Ramboll Environ was engaged to audit:

- Where rail loop modification works cross/ disturb landfill capping, the capping is established to the required specification, as presented below; and
- Where material is imported to site for use as capping materials, such material complies with the environmental specification.

The capping at the former waste emplacement area comprises:

- A seal bearing surface (subgrade);
- A 0.5m thick sealing layer with an effective permeability of not greater than $1x10^{-8}$m/s; and
- A drainage system along the rail corridor to maximise rainfall runoff and minimise infiltration.

The Summary Report concluded that Auditor review of compaction and survey records for all areas indicated that capping complied with Condition 2.53 of PA 06_0009 and that the consistent, ongoing management and record keeping, including the inspection/ test plan protocols and hold point records, undertaken by the main contractor, Aurecon-Hatch, throughout the project have given additional confidence that capping works have been undertaken in compliance with the Approval conditions.

3.6.3 Reportable Incidents

No environmental incidents or complaints relating to land contamination were made during the reporting period.

3.6.4 Further Improvements

There are no further improvements required for contamination management, as construction activities have ended.

3.7 Noise and Vibration

3.7.1 Environmental Management

In accordance with Condition 2.9, Schedule 2 of PA 06_0009 NCIG and its contractors minimised noise emissions from plant and equipment operated on the Project site as outlined in the *NSW Industrial Noise Policy* (EPA, 2000).

In accordance with Condition 2.13, Schedule 2 of the PA 06_0009, Stage 1 of the NCIG Terminal has been designed, constructed, operated and maintained to ensure that the noise contributions from the plant do not exceed the maximum allowable noise contributions specified in Table 3.12 below, at the locations and the time periods indicated.

In accordance with Condition 2.14, Schedule 2 of PA 06_0009, the monitoring of noise contributions was:

- Measured at the most affected point on or within the Site boundary at the most sensitive receiver to determine compliance with $L_{Aeq(15\ minute)}$ night noise limits.
- Measured at one metre from the dwelling façade to determine compliance with $L_{A1(1\ minute)}$ noise limits.
- Subject to the modification factors provided in Section 4 of the New South Wales Industrial Noise Policy (EPA, 2000), where applicable.

In accordance with Condition 2.15, Schedule 2 of PA 06_0009, NCIG has taken steps to ensure that trains operated on the Site meet noise performance criteria established. This includes construction of dedicated noise abatement berms directly adjacent the NCIG rail line and design and construction of the rail alignment to reduce noise from locomotive and wagon wheels.

Operations noise management measures are further detailed in the Operations Noise Management Plan (ONMP).

3.7.2 Environmental Performance

Table 3.11 outlines the monitoring locations, noise and vibration monitoring parameters recorded, frequency of monitoring and noise and vibration criteria for the Project in accordance with the ONMP.

Table **3.11**: Summary of the Noise and Vibration Monitoring Programme

Monitoring Parameter	Monitoring Sites	Frequency	Criteria
Attended and unattended noise monitoring	N1, N3, N5, N13 and N14[1].	Monthly for the first 3 months then quarterly.	See below.
Unattended continuous noise monitoring.	Selected locations.	Minimum period of one week per quarter.	See below.
Attended noise monitoring	**All static and mobile elements of terminal operations.**	Quarterly	See ONMP.

1 The location of monitoring sites is shown on Figure 14.

The noise impact assessment criteria as defined by the Project approval and EPL12693 are provided in Table 3.1216 and Table 17.

A Noise Audit Report was completed in October 2013 to confirm cumulative Stage 1, Stage 2AA and Stage 2F noise performance of the NCET as per Conditions 3.6 and 3.7 of PA 06_0009 Schedule 2.

Noise and vibration monitoring was undertaken by specialist acoustic consultants on a quarterly basis during the reporting period.

Table 3.12 Residential Noise Impact Assessment Criteria

Location	Site ID	Day, Evening Night At all times	Night 10.00 pm to 7.00am Monday to Saturday 10.00pm to 8.00 on Sundays and Public Holidays	
		$L_{Aeq(15\ minute)}$	$L_{Aeq(night)}$	$L_{A1(1\ minute)}$
Fern Bay West	N1	41	37	57
Fern Bay East	N17	39	36	55
Stockton West	N3	41	37	57
Stockton East	N16	38	35	56
Mayfield West	N5	45	40	55
Mayfield	N9	44	39	62
Carrington	N15	36	33	52

The maximum allowable noise conditions apply under:

a) wind speeds of up to 3m/s at 10 metres above ground level
b) temperature inversion conditions of up to 3 degrees (°C) pert 10 metres and 2 m/s at 10 metres above ground level.

Table 17 Industrial Noise Impact Assessment Criteria

Non-residential Location	Land use	Intrusive $L_{Aeq(15\ minute)}$			Acceptable Amenity $L_{Aeq(period)}$[1]			Maximum Amenity $LA_{eq(9\ hour)}$
		Day	Evening	Night	Day	Evening	Night	Night
Mayfield West	Commercial Steel River	Intrusive noise not applicable			65	65	65	70
Kooragang Island	Industrial	Intrusive noise not applicable			70	70	70	75
Mayfield North	Industrial	Intrusive noise not applicable			70	70	70	75
Any	School	Intrusive noise not applicable			External 45 when in use			50
Any	Hospital	Intrusive noise not applicable			External 50 when in use			55

Note 1: Daytime 0700 hours to 1800 hours, Evening 1800 hours to 2200 hours, Night-time 2200 hours to 0700 hours.

The monitoring undertaken principally consisted of:

- Unattended noise monitoring – two (2) Type EL316 environmental noise loggers were deployed at the nearest potentially affected receptors for a period of one week. The noise loggers were programmed to record statistical noise level indices continuously in 15 minute intervals, including LA_{max}, LA_1, LA_{50}, LA_{90}, LA_{99}, LA_{min} and LA_{eq}.
- Attended noise monitoring – operator attended noise survey was conducted at each noise logger location to assist in defining noise sources and the character of noise in the area and therefore to qualify unattended noise logging results. These measurements were conducted over 15 minute periods using a Bruel & Kjaer Type 2250 sound level meter.
- Vibration monitoring – In accordance with the CNMP, vibration monitoring was conducted during construction piling activities within 180m of adjacent industrial receivers (i.e. Blue Circle Southern). As mentioned, this did not take place during the monitoring period.

During the reporting period, off-site noise and on-site sound power monitoring was undertaken and reported per quarter, with reports for the quarter ending September 2015, December 2015, March 2016 and June 2016. These reports concluded that off-site noise monitoring indicated compliance was achieved at both selected residential and industrial locations under prevailing conditions.

A Noise Audit Report was completed in September 2015 to confirm noise performance for the construction of the rail flyover in compliance with Conditions 3.6, 3.7 and 3.8, Schedule 2 of PA 06_0009. The audit concluded that noise emissions from NCIG CET including the Rail Flyover Modification comply in full with all noise-related conditions set out in the Rail Flyover Modification Project Approval.

Following the completion of the rail flyover construction, NCIG submitted a request to the Department of Planning and Environment for review of operational noise monitoring from quarterly to biannually. A response had not been received before the end of the reporting period.

3.7.3 Reportable Incidents

No environmental incidents were reported relating to noise or vibration during the reporting period.

3.7.4 Further Improvements

No improvement to noise monitoring is required for the next period. Notwithstanding, NCIG implements a Continuous Noise Improvement Program. The program will continue to be implemented as part of ongoing NCIG operations.

3.8 Heritage

3.8.1 Environmental Management

The now OEH advised that as the Project construction site has been the subject of extensive disturbance over a period of more than 50 years, it considers that no Aboriginal heritage objects of significance will be present (DEC, pers. comm. 15 February 2007).

Notwithstanding, the management of items of Aboriginal cultural heritage significance during construction of the Project incorporated the following elements:

- During induction training, NCIG personnel were advised of their responsibility to advise management if they uncover any item that could be of Aboriginal heritage significance.
- If potential archaeological material is identified, construction activities proximal to the potential archaeological material will cease and OEH's North East Branch - Environment Protection and Regulation Division, Regional Archaeologist will be contacted to determine appropriate management requirements.
- If items of Aboriginal cultural heritage significance are salvaged on-site, they will be stored in a keeping place on-site for the duration of the Project.

- At the cessation of the Project, if any salvaged Aboriginal objects are stored on-site their ongoing management will be determined in consultation with the Aboriginal community and the OEH.

3.8.2 Environmental Performance

During the reporting period induction training was attended by all NCIG personnel. This training included information relating to aboriginal heritage and the potential identification of items of archaeological significance.

During the reporting period there were no items of potential Aboriginal cultural heritage significance identified.

3.8.3 Reportable Incidents

No incidents or complaints were reported relating to heritage during the reporting period.

3.8.4 Further Improvements

No improvement to heritage is required for the next period.

3.9 Ecology

3.9.1 Environmental Management

In accordance with Conditions 2.16 and 2.19, Schedule 2 of PA 06_0009 NCIG employed two qualified ecologists (Dr David Goldney and Dr Arthur White), approved by the Director-General, to undertake a pre-construction survey of areas affected by construction works for the presence of *Litoria aurea* (the Green and Golden Bell Frog) (see Figure 23). These ecologists also provided advice on the mitigation and management of impacts to listed threatened species that may be affected by the NCIG Project works.

Figure 23: The Green and Golden Bell Frog (Litoria aurea)

While Green and Golden Bell Frog individuals were not identified during the pre-construction survey, previous surveys have identified the presence of the species on the Project site. Therefore a management plan for the relocation of Green and Golden Bell Frog individuals was prepared in accordance with Condition 2.16, Schedule 2 of PA 06_0009. The Green and Golden Bell Frog Management Plan (GGBFMP) was developed in consultation with DECC (now OEH) and the Regional Land Management Corporation (now HDC). This plan has now been incorporated into the Ecological and Land Management Plan.

In accordance with Condition 2.17, Schedule 2 of PA 06_0009 NCIG has designed and constructed relevant rail infrastructure associated with the Project to include culverts, underpasses or other similar measures to permit the movement of *Litoria aurea* and other amphibian species under the NCIG rail infrastructure (see **Error! Reference source not found.**). The culverts and underpasses were installed to include suitable habitat for the Green and Golden Bell Frogs and to provide protection from predators in accordance with guidance provided by Dr Arthur White.

In accordance with Condition 2.18, Schedule 2 of PA 06_0009 all employees and contractors involved in construction of the Project are trained in site hygiene management in accordance with *Hygiene Protocol for the Control of Disease in Frogs* (NPWS, 2001) prior to the commencement of work.

A Compensatory Habitat and Ecological Monitoring Program (CHEMP) has also been prepared to guide the construction of Green and Golden Bell Frog habitat which suitably replaces habitat damaged or destroyed by construction works. This plan was initially submitted to DECCW (now EPA) and DoP (now NSW Planning and Environment) in 2008. Through discussions and agreed amendments, the first version of the CHEMP was approved by the then DoP on 16 November 2010. Details of compensatory habitat work completed in the period are given in Section 3.9.3.

A Vegetation Clearance Protocol (VCP) was also prepared to satisfy those commitments of the Project Environmental Assessment (EA) that relate to vegetation clearance during construction of the Project. This protocol has now been incorporated into the Ecological and Land Management Plan for any maintenance or construction works that may disturb native vegetation of important habitat.

3.9.2 Environmental Performance

The Green and Golden Bell Frog *Litoria aurea* is listed as Endangered under the *Threatened Species Conservation Act, 1995* (TSC Act) and Vulnerable under the EPBC Act. The Green and Golden Bell Frog is estimated to have disappeared from 90% of its former range within NSW.

Known and potential Green and Golden Bell Frog habitat is located across the Project site and surrounds. Disturbance to Green and Golden Bell Frog habitat occurred as a result of construction activities which primarily involved completely infilling Big Pond and partial disturbance of Ponds H, K and Q. Most of the known and potential Green and Golden Bell Frog habitat recorded across the Project site and surrounds (i.e. Ponds A, B, C, D, E, F, G, I, J, L, O, T, U, V, AA, AC, AD) has not however been directly disturbed by Project activities.

In order to minimise Project-related impacts on the Green and Golden Bell Frog the following management procedures were implemented in accordance with the GGBFMP:

- environmental induction training;
- site hygiene management;
- delineation of disturbance areas;
- pre-clearance surveys;
- Green and Golden Bell Frog relocation procedures; and
- construction works procedures.

All employees and contractors involved in the construction of the Project were informed about the presence and importance of the Green and Golden Bell Frog as a part of the site induction process. Similarly, operations employees and contractors are informed about the presence of the Green and Golden Bell Frog in areas adjacent to the Stage 1/2AA operations site, in particular the NCIG rail facility. Training was also provided on appropriate site hygiene practices in accordance with *Hygiene Protocol for the Control of Disease in Frogs* (NPWS, 2001) prior to the commencement of work.

All major ground disturbance activities were completed previously on the site. Areas of active earthworks continued to be delineated by fencing, however, in order to prevent the movement of amphibian species back into a construction area that had been previously cleared, these fencelines were regularly monitored for the presence of the Green and Golden Bell Frog to confirm that there were no individuals in the vicinity that may be at risk.

If individual frogs were identified on the site, and thought to be at potential risk of harm, they were captured and translocated in accordance with the Green and Golden Bell Frog Management Plan. Details of the individual Green and Golden Bell Frogs managed in accordance to this process are outlined in Table 3.13.

Table 3.13: Translocated Green and Golden Bell Frogs

Date	Quantity	Health	Size (cm)	Location identified	Location translocated
23/12/2015	1	Good	7	Gravel area immediately north of store	Overflow pond
23/12/2015	1	Dead	7	Security Exit Gate from Store to Raven St	NA
7/01/2016	1	Good	5	Administration Building Entrance	Pond I
21/01/2016	3	Good	6-7	TH11 Sump	Pond I
12/02/2016	3	Good	7-8	CV01 Mid-Point Sump	WT02

During the reporting period a total of nine (9) Green and Golden Bell Frogs were sighted on site and assessed as being at risk and subsequently translocated in accordance with the Green and Golden Bell Frog Management Plan. The majority of these animals were found near the main area of buildings at the NCIG site. All specimens were alive and in good condition, with the exception of one individual which was dead. The frogs were considered to be mostly adults and some juveniles, based on size.

Monitoring of the Green and Golden Bell Frog was conducted in areas adjacent to the NCIG Project site, particularly areas surrounding the NCIG Rail Facility, as shown in Figure 24. During the 2015/16 season, monitoring was conducted by the University of Newcastle. This was funded cooperatively by both NCIG and Port Waratah Coal Services (PWCS). This was to satisfy the requirements of the NCIG Project *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) Particular Manner Decision and to provide baseline data on areas proposed for the PWCS T4 Coal Export Terminal. The objective of the monitoring is to monitor the dynamics of the Green and Golden Bell Frog within habitat areas on Kooragang Island. The wetlands included in the survey all under the following categories:

- National Parks and Wildlife (NPWS): 40 wetlands in the Northern and Central Zone;
- Port Waratah Coal Services (PWCS): 22 wetlands in the Industrial Zone;
- NCIG: 3 wetlands in the Industrial Zone and 18 wetlands in the NCIG Compensatory Habitat;
- Hunter Development Corporation (HDC): 7 wetlands in the Industrial Zone;
- Wetlands previously managed by BHP, now managed by HDC: 3 wetlands in the Industrial Zone;
- Roads and Maritime Service (RMS): 3 wetlands in the Industrial Zone.

Wetland Overview - Kooragang Island survey area

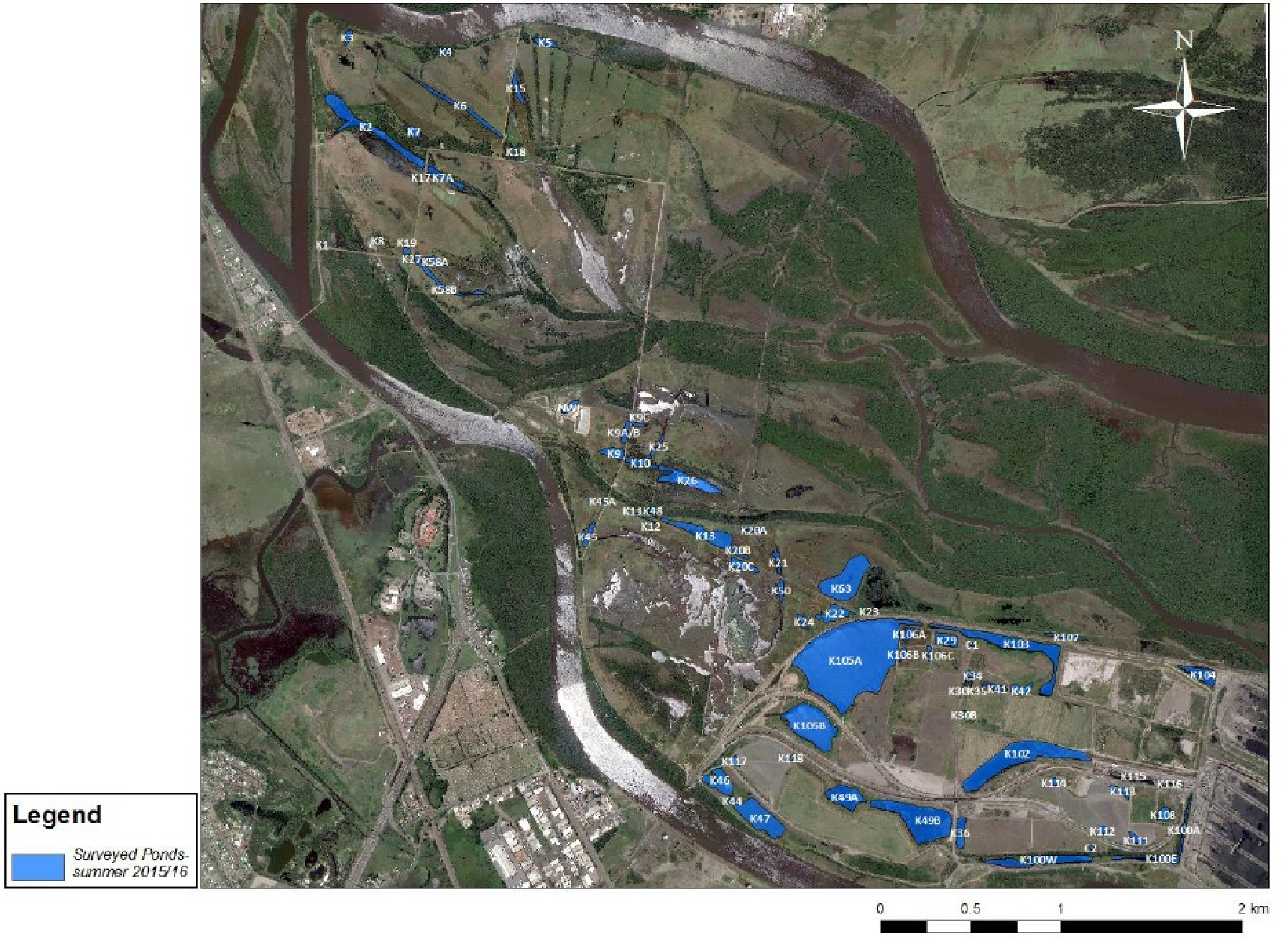

Figure 24: Green and Golden Bell Frog Surveyed Areas

Two methods were used to estimate the population per surveyed pond, namely Visual Encounter Surveys (VES) and Capture-Mark-Recapture (CMR) Surveys. Both these methods utilise recording of morphometrics of individuals surveyed, location and environmental conditions where individual locations were found and micro-chipping using Passive Induction Transponder (PIT) tags. Both surveys were conducted at night using survey teams of 2-6 people. Models for population estimates were generated for each surveyed pond using established statistical designs and computer-based modelling software (eg. MARK). These estimates were correlated with results of visual encounter surveys, using a number of assumptions and limiting factors, to generate population estimates for remaining ponds. A total of 78 wetlands were surveyed during the 2015/2016 breeding season, including 17 in the Northwest region of the island, 23 in the Central region and 38 in the Southern (Industrial Zone) region. Two rounds of surveys were completed, one in December to mid-January and the second from late January to February.

A summary of the results from the 2015/2016 surveys are as follows:

- From the surveys of the 78 wetlands (‘whole island’), 539 bell frogs were detected and modelling of the survey results estimated a population size between 1,000 and 2,200 bell frogs. An extra 184 bell frogs were detected at the NCIG Compensatory Habitat wetlands.
- Bell frogs were observed at 42 of the 78 wetlands, indicating the habitat quality of these wetlands is suitable to support the foraging and sheltering of bell frogs.
- The wetlands with the highest abundance of bell frogs are K104, C1, K22 and K23, which are located within the northern portion of the Industrial Zone.
- Breeding was recorded in seven of the 78 wetlands surveyed in the ‘whole island’ surveys. A large number of breeding pairs and tadpoles were observed in ponds K104 and K96, while only a few breeding pairs were observed in other ponds. Most breeding was associated with large summer rainfall in early to mid-January 2016.
- Six of the nine sites where breeding was observed involved brackish ephemeral wetland habitat that was not occupied by bell frogs prior to the summer rainfall. Adult male and female frogs migrated to these ponds following the rainfall and selected these ponds over nearby permanent wetlands.

Figure 25 below represents population estimates in the main pond site of K22-23 on Kooragang Island from the past five seasons.

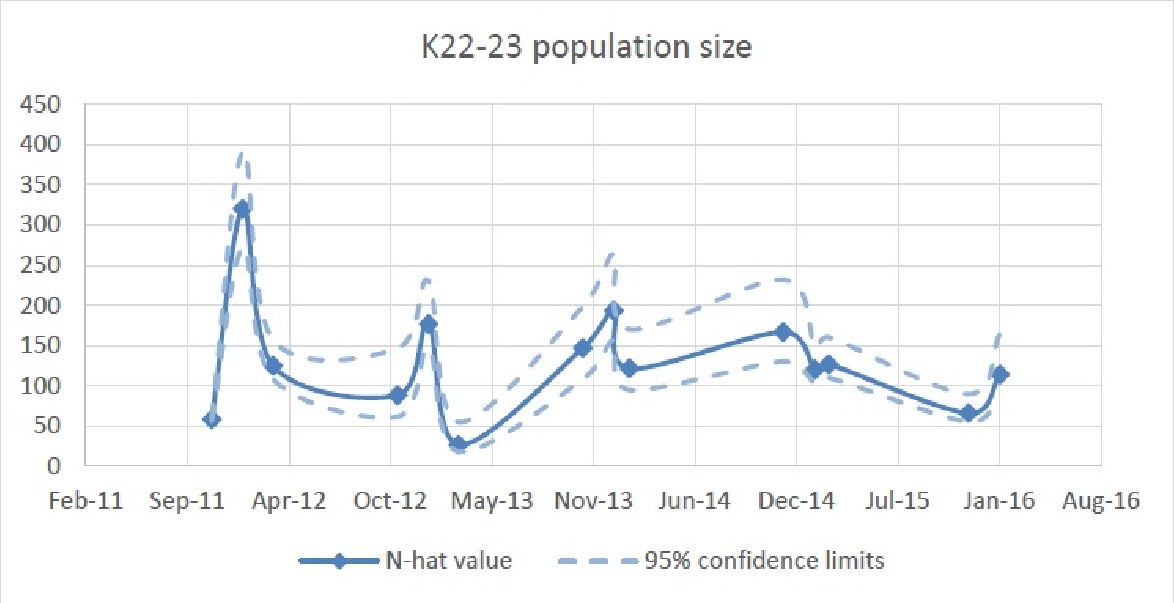

Figure 25: Population Size Estimates for GGBF from Ponds K22/23 on Kooragang Island between November 2011 and January 2016

A monitoring programme was also conducted during the reporting period to survey the utilisation of Deep Pond, adjacent to the NCIG rail infrastructure area, by bird species with the primary focus on shorebirds. This Avifauna Monitoring Programme was undertaken by the Hunter Bird Observers Club and the resulting information was provided to NCIG by way of agreement.

Prior to the construction of the rail flyover, one survey was completed for Deep Pond. The rail flyover, completed in August 2015, now separates Deep Pond into Deep Pond North and Deep Pond South. As such, from 2015 two monthly surveys have been completed.

The results of the monthly surveys conducted on Deep Pond North and Deep Pond South during the 2015 calendar year are illustrated by Table 3.14 and Table 3.15. The aim of the monitoring programme is to identify the pattern of usage of Deep Pond North and Deep Pond South by all birds over the annual cycle and determined the extent of any potential impact by the NCIG activities on this usage.

As this is the first year the shorebirds monitoring programme has been separated into Deep Pond North and Deep Pond South, no statistical comparison has been made to the 2014 results. Overall, there has been a slight decrease in the number of birds sing Deep Pond from 10,170 in 2014 to 9362 in 2015, likely due to high water levels in 2015.

Table 3.14: Avifauna 2015 Monitoring Results – Deep Pond North

Species	16/1/15	20/2/15	20/3/15	17/4/15	15/5/15	19/6/15	17/7/15	14/8/15	11/9/15	10/10/15	14/11/15	10/12/15	Total
Black Swan *Cygnus atratus*	36	120	41	62	2	3	8	15	17		24	40	368
Pacific Black Duck *Anas superciliosa*	5	10	101	9		2						2	129
Australasian Shoveler *Anas rhynchotis*	67	116	353	213			14						763
Grey Teal *Anas gracilis*	5	360	650	12									1027
Chestnut Teal *Anas castanea*	34	34	1310	4				7					1389
Pink-eared Duck *Malacorhynchus membranaceus*		160	309	260									729
Hardhead *Aythya australis*	7	10	21	23		2	4	1				3	71
Australasian Grebe Tachybaptus novaehollandiae		34	2		3			13	5	7		2	66
Hoary-headed Grebe *Poliocephalus poliocephalus*			39	87	11	9	8		3				157
Little Black Cormorant *Phalacrocorax sulcirostris*			3									4	7
Little Pied Cormorant *Microcarbo melanoluecos*			1										1
Great Cormorant *Phalacrocorax carbo*			1	1									2
Australian Pelican *Pelecanus conspicillatus*	24	23	21	17					1			14	100
White-faced Heron *Egretta novaehollandiae*				2	1								3
Little Egret *Egretta garzetta*				1								1	2
Eastern Great Egret *Ardea modesta*	1												1
Australian White Ibis *Threskiornis molucca*	53	4		3	1						1	1	63
Royal Spoonbill *Platalea regia*	9	3	33	5							3	6	59
Swamp Harrier *Circus approximans*			1										1
Purple Swamphen *Porphyrio porphyrio*			4										4
Eurasian Coot *Fulica atra*	300	10				220	200		182				912

Table 3.14: Avifauna 2015 Monitoring Results – Deep Pond North

Species	16/1/15	20/2/15	20/3/15	17/4/15	15/5/15	19/6/15	17/7/15	14/8/15	11/9/15	10/10/15	14/11/15	10/12/15	Total
Red-necked *Avocet Recurvirostra novaehollandiae*	10	520	611	361									1502
Black-fronted Dotterel *Elseyornis melanops*		2	3	26			1		1				33
Red-kneed Dotterel *Erythrogonys cinctus*			3										3
Masked Lapwing *Vanellus miles*			6										6
Silver Gull *Chroicocephalus novaehollandiae*		9											9
Spotless Crake *Porzana tabuensis*													
Black-winged Stilt *Himantopus himantopus*	101	35	444	19								55	654
Marsh Sandpiper *Tringa stagnatilis*	42	41	41										1
Musk Duck *Biziura lobata*			1		2		3						6
Black-tailed Godwit *Limosa Limosa*			8										8
Total 2015	**694**	**1491**	**4007**	**1105**	**20**	**236**	**240**	**36**	**210**	**7**	**28**	**130**	**8,204**

Table 3.15: **Avifauna 2015 Monitoring Results – Deep Pond South**

Species	16/1/15	20/2/15	20/3/15	17/4/15	15/5/15	19/6/15	17/7/15	14/8/15	11/9/15	10/10/15	No Survey	10/12/15	Total
Black Swan *Cygnus atratus*	17	2	2	2	6	8	2	7	4	43		30	123
Pacific Black Duck *Anas superciliosa*		2	33	13			28					12	88
Australasian Shoveler *Anas rhynchotis*	8			27								3	38
Grey Teal *Anas gracilis*	1			22								10	33
Chestnut Teal *Anas castanea*		3	22	18			2					30	75
Pink-eared Duck *Malacorhynchus membranaceus*					4								4
Hardhead *Aythya australis*												180	180
Australasian Grebe Tachybaptus novaehollandiae				15	7	2	7	1	4			5	41
Hoary-headed Grebe *Poliocephalus poliocephalus*					2		5					1	8
Little Pied Cormorant *Microcarbo melanoluecos*		2											2
Australian Pelican *Pelecanus conspicillatus*	1											6	7
White-faced Heron *Egretta novaehollandiae*			2					1					3
Little Egret *Egretta garzetta*				1									1
Australian White Ibis *Threskiornis molucca*	53												53
Royal Spoonbill *Platalea regia*	2		4										6
Purple Swamphen *Porphyrio porphyrio*	9	3	11	2									25
Eurasian Coot *Fulica atra*				11	73								84
Black-fronted Dotterel *Elseyornis melanops*	2	1	13				1						17
Red-kneed Dotterel *Erythrogonys cinctus*			2										2
Masked Lapwing *Vanellus miles*	2						2		1				5

Table 3.15: **Avifauna 2015 Monitoring Results – Deep Pond South**

Species	16/1/15	20/2/15	20/3/15	17/4/15	15/5/15	19/6/15	17/7/15	14/8/15	11/9/15	10/10/15	No Survey	10/12/15	Total
Black-winged Stilt *Himantopus himantopus*	41		5										46
Black-shouldered Kite *Elanus axillaris*							1						1
Musk Duck *Biziura lobata*						1							1
White-bellied Sea-Eagle *Haliaeetus leucogaster*							1						1
Whistling Kite *Haliastur sphenurus*							2						2
Northern Mallard (hybrid birds)							5						5
Total 2015	**136**	**13**	**96**	**111**	**93**	**11**	**53**	**12**	**9**	**45**	**NA**	**579**	**1158**

The Vegetation Clearance Protocol (VCP) was implemented to minimise impacts on threatened flora and fauna species within the Project area. The key components of the VCP are outlined below and include:

- Delineation of areas to be cleared of existing vegetation;
- Pre-clearance surveys;
- Managing impacts on fauna; and
- Vegetation clearance procedures.

In accordance with Condition 2.19A, verification of the extent of habitat disturbance at the western deviation (western side of the Kooragang Main Rail Line) was undertaken following the completion of the rail flyover. Verification was achieved through pre and post construction ecological surveys and confirmed by the approved project ecologist Dr Arthur White. The surveys indicated that the total area of land disturbed, including fresh water wetland, saltmarsh, mangrove forest, disturbed land and water bodies, complied with the defined limits of habitat disturbance for the flyover infrastructure works.

3.9.3 Compensatory Habitat and Ecological Monitoring Program

A number of works have been undertaken in relation to the CHEMP between July 2015 and June 2016. The following points highlight the major works undertaken and milestones achieved during this reporting period.

Consultative Board –Consultative Board meetings were held on 28 July and 15 December 2015. The purpose of the Consultative Board meetings are to provide information on the Compensatory Habitat planning works completed to date and provide guidance on works to be completed, particularly in the coming 12 months. The Board consists of representatives from NSW Planning and Environment, NSW Office of Environment and Heritage (National Parks and Wildlife Service), Hunter-Central Rivers Local Land Service, the University of Newcastle, the DoPI-Approved Ecologist for the NCIG Project, Hunter Bird Observers Club (HBOC) and NCIG. At each meeting, papers have been presented on a range of topics for the consideration and discussion of Board members. The topics discussed included updates on the following:

- Research areas and monitoring;
- Green and Golden Bell Frog Compensatory Habitat
- Compensatory Habitat Management;
- Migratory Shorebird habitat creation.

Research Areas and Monitoring – The NCIG Trial Site comprises 16 ponds constructed for a pond choice experiment for the green and golden bell frog reintroduction program. 8000 tadpoles and/or newly metamorphosed bell frags were introduced into the trial site in early 2013 and a further 12,000 tadpoles and/or newly metamorphosed bell frags were introduced in late 2013. These represent two cohorts, one that reached two years of age in the summer of 2014/15 and the second that reached one year of age in the summer of 2014/15.

The 16 ponds constructed are either shallow (0.5m) or deep (1.5m) and have varying salinity treatments, including control ponds with unmanipulated background salinity levels and artificially salted ponds.

An east coast low pressure system in late April brought extensive rainfall that caused localised flooding on Ash Island. All ponds, low lying areas between ponds and around the perimeter fencing became inundated, resulting in connectivity between the ponds. Ponds have remained completely charged since April 2015 as a result of high groundwater levels combined with periods of intermittent autumn and winter rain.

Gambusia, a pest fish, entered the NCIG Trial Site as a result of the localised flooding of Ash Island during the April 2015 east coast low. The July 2015 CHEMP Quarterly Report indicated that the predatory fish inhabited 10 of the 16 ponds at the site at that time. This increased to 13 of the 16 ponds, as reported in the December 2015 CHEMP Quarterly Report. Trials were completed in October 2015 to drain the ponds in an attempt to remove gambusia. Complete elimination of water and subsequently, fish from the drained ponds has been difficult to achieve as the ponds are generally unable to be completed drained in one day and groundwater and rainfall ingress prevents complete drying. As a result, some fish remained in the drained ponds as of December 2015.

Evening survey work ceased between April 2015 and October 2015, when low night time temperatures corresponded with a noticeable decline in the number of frogs detected. Evening surveys recommenced in mid-spring of 2015 with low detection of frogs. The December 2015 CHEMP Quarterly Report indicated that not more than 25 frogs had been detected in each survey period across the NCIG Trial Site since winter, compared with more than 40 frogs routinely detected in similar surveys in the preceding season. Population estimates from the NCIG Trial Site are included in Table 3.16. The population has declined dramatically in the past 12 months, despite natural breeding events that occurred within the NCIG Trial Site in January 2015. The cause of the population decline has yet to be quantified, however researchers hypothesise that disease and predation are the key threats to bell frog survival at the site and that escape from the site may also contribute to population decline.

Table **3.16**: Population Estimates at NCIG Trial Site

Year	No. of Tadpoles Introduced (Dec-Mar)	No. of Frogs* Estimated (Feb of each year)
2013	8000	
2014	12,000	750
2015	>7000 (natural breeding)	320
2016	-	21

The NCIG Trial Site research project will conclude in June 2016.

Green and Golden Bell Frog Compensatory Habitat – Monitoring of the Compensatory Habitat ceased during the winter months until December 2015. Major summer rainfall in early to mid-January 2016 resulted in a total that almost doubled the long-term monthly average. All of the wetlands of the Compensatory Habitat were fully charged and many of the 'permanent' and 'ephemeral' wetlands became interconnected. Significant overland and surface flow also connected the wetlands of the Compensatory Habitat to other wetlands in the local area. In addition to average temperatures above 20°C, these conditions were considered ideal for bell frog breeding.

Visual encounter surveys and aural surveys were conducted over the summer season. Adult frogs were detected in Stages 4, 5 and 7, with no adults detected in Stages 1, 2, 3 and 6. Demography of the adults collected show that the populations consists largely of first year males and females. First year females are not reproductive. No bell frog tadpoles were detected the surveys conducted across all the Compensatory Habitat area. Following the January rainfall, bell frog tadpoles and metamorphs were detected in two wetlands, K7A and K27, which are adjacent to the Compensatory Habitat Wetlands Stages 4 and 7 respectively. Breeding has been confirmed in these adjacent ephemeral wetlands.

A total of 10,718 captive-bred animals were introduced into the Compensatory Habitat during the 2015/16 season.

Compensatory Habitat Management – NCIG commenced monitoring and management of compensatory habitat in accordance with the approved Green and Golden Bell Frog Compensatory Habitat Management Plan in January 2015. Wetland Care Australia conducted the following work during the reporting period:

- Pond inspections, including visual inspections, photo points, water quality monitoring and monitoring for evidence of pests;
- Pond buffer zone transects;
- Vegetation transects;
- Fox baiting, including the establishment of 8 bait stations, installation of signage and notification to nearby properties. Baits are checked weekly with several baits taken to date;
- Manual weeding of pond buffers;
- Slashing around frog fence on Stage 1 and repairs to this fence;
- Weed sweep targeting priority weeds.

A modification was made to the NCIG Compensatory Habitat Management Plant address proposed shaping of bunds around aquatic habitat and use of agents (e.g. Rotenone or lime) to manage Gambusia. The purpose of the funding is to exclude constructed aquatic habitat from surrounding surface water during flood events, which carries Gambusia. For this to be effective, ponds would need to be pumped out (already allowed for in the management plan) and dosed with an agent, for example a piscicide, targeting Gambusia. This is required at the majority of the NCIG aquatic habitat has become infested with Gambusia during flood events in April 2015 and January 2016. NPWS determined the modification to be permissible providing the relevant regulatory approvals were obtained fur use of Rotenone.

Creation of bunds commenced at the Trial Site and Stage 7 in June 2016. Stages 1, 4 and 5 are scheduled to be completed in early July 2016. A photograph showing the complete bunding at Stage 7 is shown in Figure 26. This opportunity will also be used to create minor scrapings in mounds and elevated areas for marginal ephemeral aquatic habitat, observed to be favourable breeding habitat during the 2015/ 2016 season.

Figure 26: Creation of bunds around Stage 7 to control Gambusia

Shorebird Compensatory Habitat – The Office of Environment and Heritage provided a positive determination on the Review of Environmental Factors for migratory shorebird habitat creation at Area E, including the removal of 16Ha of mangroves in June 2015. The Determination included a number of conditions, including that habitat construction be restricted to times between May and October of any year to avoid residence time of migratory species using neighbouring ponds. For this reason, construction of the habitat commenced in May 2016. Between July 2015 and May 2016, NCIG conducted further testing and monitoring of the area, including detailed testing of Acid Sulfate Soils and migratory shorebird and benthic invertebrate monitoring.

Final signing of the Deed of Agreement for the Migratory Shorebird Habitat area was completed by the Minister for Environment on 11 March 2016. Following this, a site compound and security fences were erected in April 2016 and access tracks were improved in preparation for the commencement of mangrove removal in May. Between May and June 2016, approximately 70% of mangroves were removed. The extent of mangrove removal, including Phase 1 tree felling and Phase 2 trimming of stumps and pneumatophores is shown in Figure 27. Photographs of the mangrove removal works are shown in Figure 28 and Figure 29.

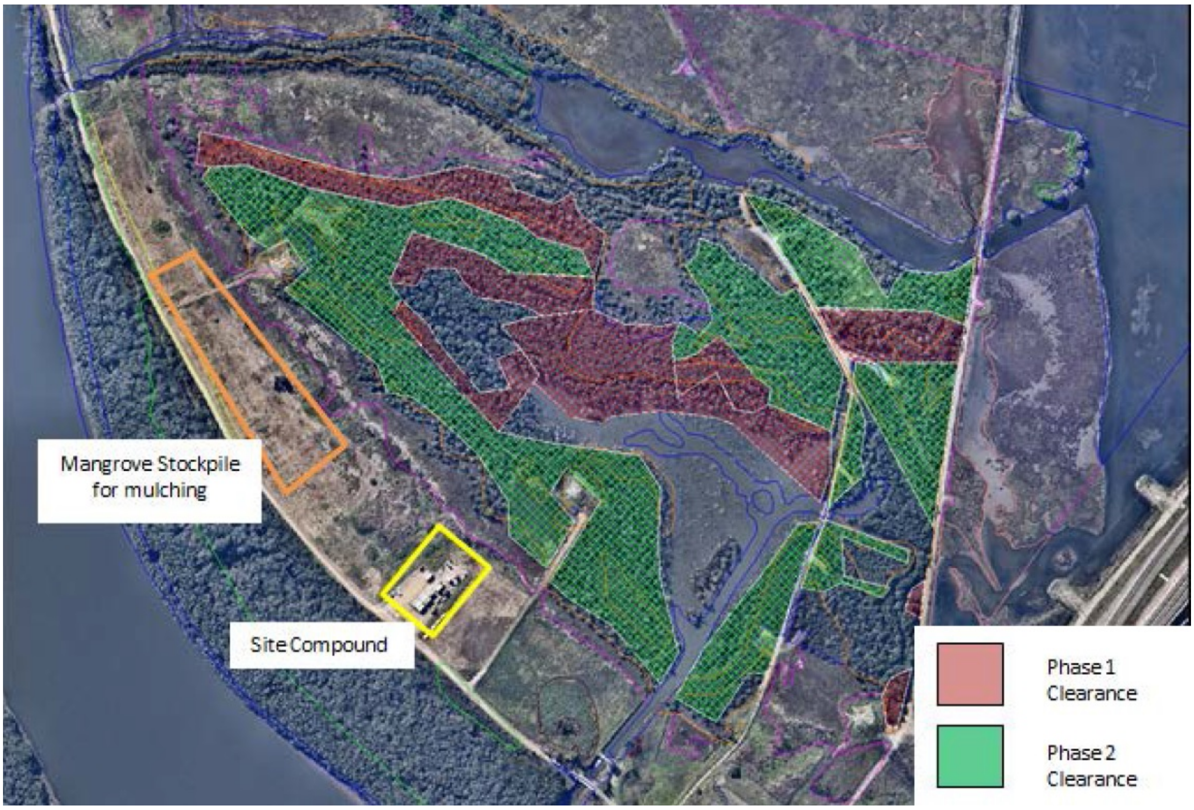

Figure 27: Mangrove Removal Works Area (current at 23 June 2016)

Figure 28: Long reach excavator removing mangroves with hydraulic sheer

Figure 29: Completed Phase 2 clearing area

3.9.4 Reportable Incidents

No incidents or complaints were reported relating to flora and fauna management during the reporting period.

3.9.5 Further Improvements

Works for 2016/ 2017 will include completion of the shorebird habitat, completion of bunds at the ponds in the Green and Golden Bell Frog Compensatory Habitat, results of Green and Golden Bell Frog monitoring (both in the Compensatory Habitat area and the Kooragang Island industrial area), management of Gambusia to improve breeding prospects and introduction of captive Green and Golden Bell Frogs.

3.10 Traffic Management

3.10.1 Environmental Management

PA 06_0009 contains a range of requirements that pertain to road transport (Conditions 2.21 to 2.37, Schedule 2). These requirements are addressed where relevant in the Construction Traffic Management Protocol.

3.10.2 Environmental Performance

The road improvements proposed to conform to the Conditions of the Project Approval for the construction phase of the CET are generally those permanent works that would be required during the future operation of the proposed coal loader.

Traffic management during the construction phase focussed on the immediate imposition of movement restrictions at key intersections to limit the potential for delays to traffic flows on Cormorant Road.

NCIG developed a Vehicle Traffic Management Plan (VTMP) in accordance with the Construction Traffic Management Protocol. The plan provided the approved traffic routes for NCIG construction traffic across the site. This plan also dictated the approved traffic routes for construction traffic on adjacent public roads, including the prevention of right-hand turns onto Cormorant Road from Egret Street, Pacific National Road and the NCIG Wharf Access Road intersection, in order to minimise any disruption to through traffic on this road. Each contractor on the NCIG project site also developed VTMPs to ensure that construction traffic is adequately managed on internal and external roads.

There were no road improvements performed during the reporting period. It is noted that NCIG have been working in consultation with Roads and Maritime Services (RMS) on the design of the Cormorant Road duplication where this interacts with NCIG operations.

In addition to the above, a Vehicle Traffic Management Plan has been developed for operational vehicles which came into effect at the commencement of NCIG operational activities.

3.10.3 Reportable Incidents

No incidents or complaints were reported relating to traffic management during the reporting period.

3.10.4 Further Improvements

No improvement to traffic management is required for the next period.

3.11 Waste Management

3.11.1 Environmental Management

Measures to avoid and minimise the generation of wastes and promote waste re-use and recycling have been adopted during construction of the Project and include:

- waste avoidance – practices were developed that reduce the amount of waste on-site, via selective purchasing procedures and the use of bulk purchasing, where practicable;
- material reuse – reuse of recyclable or reusable materials where practicable; and

- recycling – materials such as metals, oil, timber, plastics, glass and paper were recycled where practicable.

In accordance with Conditions 2.54 and 2.56, Schedule 2 of the PA 06_0009, all waste materials removed from the site were directed to a waste management facility lawfully permitted to accept the materials.

In accordance with Condition 2.57, Schedule 2 of the PA 06_0009, waste was not received at the site during the reporting period. In addition, NCIG complied with the requirements of EPL No. 6437 as it relates to the on-going management of the Kooragang Island Waste Emplacement Facility.

During the reporting period, NCIG introduced a new Materials Management Area Procedure for the handling, reuse and disposal of non-standard wastes such as rail ballast, clean spoil or mixed spoil. A trial was completed on the separation of coal fines from used rail ballast so the fines could be recycled as a saleable product.

3.11.2 Environmental Performance

The principles of waste management, being waste avoidance, material reuse and recycling have been adopted by NCIG and all construction contractors on the site during the reporting period. The focus of this process has been the avoidance of waste, however the recycling of waste products was also actively pursued with paper, aluminium, steel, plastics, timber and glass being the primary materials collected. Recycled concrete has also been incorporated into the pavement design for the rail and stockyard areas as a means of improving reuse of waste materials.

A 12,000 litre (L) waste oil tank was installed prior to operations to enable the collection and storage of waste hydrocarbons during NCIG operational activities, before being removed by licensed waste transporters on a periodic basis. A purpose built oil/water separator system has also been installed at the workshop and truck washdown areas, which is inspected and maintained on a regular basis during operations.

A Waste Management Plan has been developed and incorporated into the environmental management system for the operations of the NCIG Terminal. Waste volumes are tracked on a monthly basis, with the assistance of NCIG's waste management contractor.

During the reporting period there was no waste material stored, treated, processed or reprocessed or disposed of on the Kooragang Island Waste Emplacement Facility that would constitute a breach of the conditions of EPL 6437.

3.11.3 Reportable Incidents

No incidents or complaints were reported relating to waste management during the reporting period.

3.11.4 Further Improvements

No improvement to waste management is required for the next period. A Waste Management Plan has been incorporated into the environmental management system for the operational site. This will be developed on an ongoing basis.

3.12 Community Relations

3.12.1 Environmental Management

During Project construction the following complaints handling system was implemented which remains in place during Project operations:

- In accordance with Conditions 6.2, Schedule 2 of the PA 06_0009, NCIG established a telephone number, postal address and email address prior to the commencement of construction for community complaints and enquiries. Current details are provided below:
  - 24-hour complaints telephone hotline: 1800 016 304
  - Postal address for written complaints: PO Box 644
Newcastle NSW 2300

    - Email address for electronic complaints: enquiries@ncig.com.au
- In accordance with Condition 6.2, Schedule 2 of PA 06_0009, the community were informed of the phone, email and postal addresses via the NCIG website (www.ncig.com.au), notices in local newspapers and signage adjacent to the Project.
- In accordance with Conditions 6.3, Schedule 2 of PA 06_0009, NCIG recorded all complaints received in a Complaints Register.
- In accordance with Condition 6.4 of PA 06_0009, NCIG established and maintained a website for the provision of electronic information associated with the Project including all relevant Management Plans.

3.12.2 Environmental Performance

The general structure of Complaint Response Procedure is shown on Figure 30. Upon receiving a complaint all details relating to the issue of concern were recorded in the Complaints Register including:

- the date and time, where relevant, of the complaint;
- the means by which the complaint was made (telephone, mail or email);
- any personal details of the complainant that were provided, or if no details were provided, a note to that effect;
- the nature of the complaint; and
- a record of any operational or meteorological conditions that may have potentially contributed to the complaint.

Within two working days of a complaint being registered, an initial response was provided to the complainant and a preliminary assessment commenced to determine likely causes of the complaint using relevant available information (i.e. climatic conditions, environmental monitoring results and current construction activities). Table 3.17 provides a summary of the complaints received during the reporting period. In every case the investigation of the complaint determined that the issue of concern was not as a result of an exceedence of relevant Project Approval or EPL criteria.

The outcome of the complaints handling process was recorded in the Complaints Register, including:

- action taken by NCIG in relation to the complaint, including all follow-up contact with the complainant; and
- details of the finding of the investigation and the reason(s) why no action was taken.

Every effort was made to ensure that the concerns of the complainant were addressed in a manner that resulted in a mutually acceptable outcome.

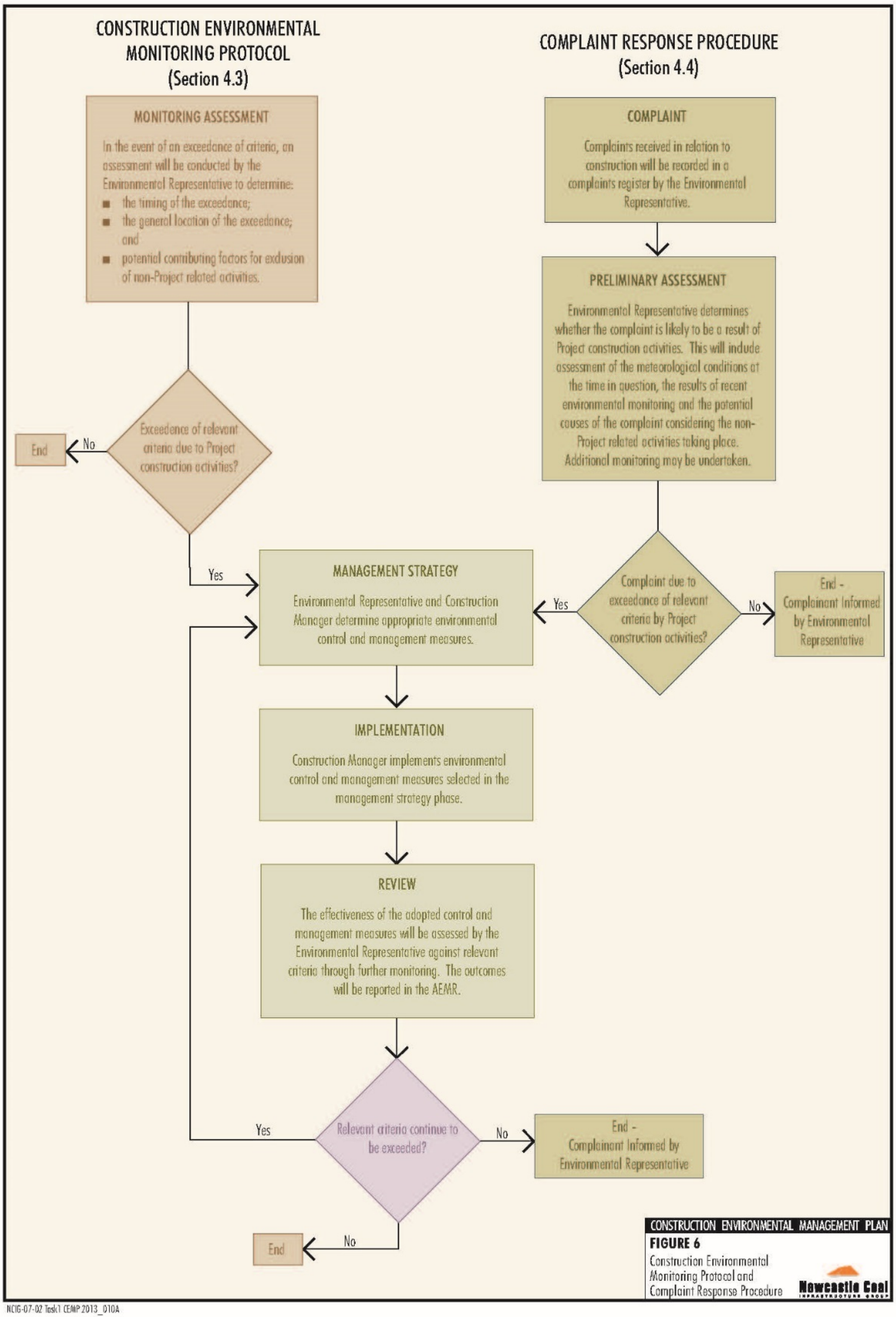

Figure 30: Complaint Response Procedure

Table **3.17**: Community Complaints register summary

Date of complaint	Environmental concern raised	Issue	Action taken
12-July-15	Dust	A Boral employee made a complaint to the wharf security guard that his car had been covered in water from NCIG sprays. Security reported that the vehicle did not appear to be covered in coal slurry/ dust, likely only to be water.	Boral employee was offered to visit NCIG site to meet with NCIG HSEC staff. Boral employee did not attend.
3-Sept-15	Damage to car	Community member received chip to windscreen on Cormorant Road, believed to be a metal object from CV12/13 gantry. Chip worsened over following days and complainant contacted Wharf Security for compensation.	Complainant requested NCIG pay for windscreen repair. Request was denied on lack of evidence.
18-Dec-15	Sediment	During dewatering of an open excavation to repair a leaking pipe, the HSEC manager observed inadequate sediment controls in place and instructed that the work be stopped to rectify this. At the same time, an EPA officer approached the work area and made similar comments.	Appropriate containment measures were installed and the work area cleaned before the workmen left site. Incident actions were closed out in **Pulse** (incident management system) for dewatering of excavations.
4-Feb-16	Damage to car	Member of the public claimed their vehicle had received damage to the windscreen from a falling object while travelling under the CV12/13 conveyor gantry along Cormorant Road.	Advised complainant that an investigation would be carried out in the area, including an inspection of the gantry area, security camera footage, operations and maintenance activities. Followed up results of investigation with complainant on 12 February 2016.
11-Mar-16	Odour/ discolouration	Complaint was received from a Tenambit resident, concerned that odour and discolouration of surfaces at his property was caused by the Aurizon development at Hexham.	Spoke to complainant on the phone and advised the NCIG was unrelated to the Aurizon Hexham development. Advised complainant to contact Maitland Council, EPA or Hunter Water Corporation (adjacent water treatment works).
2-May-16	Noise	Received complaint from Warabrook resident about train noise disrupting sleep.	Resident complained of train noise in 2015 and also about dust from coal trains. Offered to visit house and take dust samples. Offer accepted and house visit completed on 3 May 2016. A dust sample was collected from the exterior of the house and sent to CSIRO for analysis.

NCIG participated in stakeholder consultation during the reporting period, in particular with regards to management of residual coal in the rail corridor and other industrial forums regarding air quality management from coal trains. As part of this, NCIG participated in an industry monitoring of residual coal in the rail network – see Figure 31. Stakeholder engagement on air quality from the rail corridor continues.

Figure 31: Residual coal monitoring on NCIG rail siding

NCIG has developed an initiative titled the Community Support Program (CSP). This process involves engagement with local community groups and providing support to community based events and projects. The Program seeks applications on a six monthly basis from community groups that are seeking support for their endeavours. NCIG would undertake an assessment process and provide primarily financial support to these community events and projects. NCIG participated with the community groups in these project and events wherever possible. Through this process groups within the Fern Bay, Stockton, Mayfield and greater Newcastle area were assisted by NCIG. For example, NCIG assisted Harry's House Stockton (see Figure 44), a retreat for families with children living with cancer or for families grieving the loss of a child to cancer, in the 2014/15 reporting period.

The chronology of community liaison held during the reporting period is outlined in Table 3.18 below.

Table 3.18: Community Liaison Summary

Date	Type
September 2015	Community Support Program – submissions called, 17 successful applicants.
March 2016	Community Support Program – submissions called, 19 successful applicants.
April 2016	Community Newsletter

3.12.3 Reportable Incidents

No incidents were reported relating to community relations during the reporting period. Complaints received during the period are detailed in the section above.

3.12.4 Further Improvements

An increase in community relations and stakeholder engagement activities is planned for the next period, e.g. Community Open Day, additional newsletters, Corporate Sustainability Reporting (CSR), update of the NCIG Community Engagement Strategy.

3.13 Environmental Monitoring Program

An Environmental Monitoring Programme was implemented to monitor the environmental performance of the Project during construction and operation in accordance with the PA 06_0009, environmental licences and other statutory conditions. The programme was established and implemented at the commencement of construction works.

The Environmental Representative was responsible for the implementation of the construction environmental monitoring programme and is responsible for ensuring that adequate environmental monitoring is maintained throughout the Project construction.

The details of the monitoring undertaken are provided in the previous sections, however, an overview Operations Environmental Management Plan (OEMP), is provided in Table 3.19.

Table **3.19**: Operations Environmental Monitoring Program

Monitoring Focus	Monitoring Sites	Frequency	Criteria
Meteorology			
Temperature, relative humidity, net solar radiation rainfall, wind speed and direction and sigma theta (rate of change of wind direction).	Project automated meteorological station[1].	Continuously monitored and the data averaged over 15 minute periods.	N/A
Erosion and Sediment Control			
Structural stability and effectiveness in controlling sediment migration.	Drainage, erosion and sediment control infrastructure.	Monthly and following significant rainfall events (i.e. greater than 20 mm in 24 hours).	N/A
Noise			
Attended and unattended noise monitoring.	Fern Bay, Stockton, Mayfield, Carrington per Section 4.2 ONMP.	Quarterly.	See Section 3.7.2.
Attended noise monitoring in case of complaint.	Reference locations proximal to the Project[1].	At the commencement of operation.	
Air Quality			
Dust monitoring.	DG1, DG2, DG3, DG4, DG5, DG6[1].	Monthly	See Section 3.2.2
	HVAS1, HVAS2, HVAS3, HVAS4.	Every 6 days	
	BAM1, BAM2, BAM3, BAM4.	Continuous	
	PWCS	Through regular consultation.	
Surface Water			
pH, electrical conductivity (EC), total dissolved solids (TDS) and total suspended solids (TSS).	Secondary settling ponds[4].	Monthly.	See Section 3.3.2
	Surface water monitoring sites[4].	Monthly.	

Water level.	Primary and secondary settling ponds[4].	Following heavy rainfall (i.e. more than 20 mm of rainfall in a 24 hour period).	
Drainage, erosion and sediment control.	All areas of NCIG	Monthly.	
Groundwater			
pH, EC, TDS, TSS, sulfate, polycyclic aromatic hydrocarbons (PAH), As III, Cd, Cu, Pb, Hg, Zn, Cr VI, Mn and Ni (refer Table 5).	GW1, K9/3S, K9/3N, K11/1S, K11/1.[1].	6 Monthly.	See Section 3.4.2 and 3.4.4
Groundwater level.		6 Monthly	

1 The location of monitoring sites is shown on Figure 12.

2 Dust deposition will be analysed in accordance with AS/NZS 3580.10.1-2003 Methods for Sampling and Analysis of Ambient Air- Determination of Particulate Matter – Deposited Matter – Gravimetric Method.

3 PM_{10} will be monitored in accordance with the Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales (EPA,2001).

4 The location of monitoring sites in detailed in the OWMP (Appendix C) and Figure 4.

4. COMPLIANCE AUDITS

Audits were undertaken in relation to NCIG Construction activities which considered the compliance status of the Project for the reporting period. These reviews were conducted to meet the requirements of Condition 5.1 of development Approval 06-009 a) as outlined below:

5.1 The Proponent shall develop and implement a Compliance Tracking Program to track compliance with the requirements of this approval. The Program shall include, but not necessarily limited to:

a) provisions for periodic review of the compliance status of the project against the requirements of this approval;

c) a program for independent auditing at least annually, or as otherwise agreed by the Director-General, in accordance with ISO19011:2002, Guidelines for Quality and/or Environmental Management Systems Auditing.

The details and outcomes of the audits conducted are illustrated below:

December 2015

An independent environmental audit of the NCIG Coal Export Terminal was undertaken by Trevor Brown and Associates in December 2015. This review was undertaken to confirm the ongoing compliance of the NCIG project against the requirements of the Project Approval (06_0009). This review determined that the Coal Export Terminal continues to be operated in compliance with the conditions of the Project Approval granted for this project. The Audit also indicated that with the high levels of compliance, the frequency of audits required under Project Approval 06-009 Condition 5.1(c) could be reduced to every 3 years (this would be consistent with the standard audit condition currently applied in Project Approval conditions under the *Environmental Planning and Assessment Act 1979*.

Compliance Tracking Program Updated April 2016

A Compliance Tracking Program was set up for the NCIG CET in accordance with Condition 5.1, Schedule 2 of PA 06_009. The Compliance Tracking Program was updated in April 2016. The Compliance Tracking Program indicated that project compliance has been achieved for each condition of the Project Approval.

5. STANDARDS

A gap audit of NCIG's Environmental Management System (EMS) against ISO14001 in May 2015 was undertaken by Jacobs Group (Australia). The audit included a desktop review of EMP documentation, a site visit, a review meeting, a report with a rating system to demonstrate adherence with the ISO14001 requirements and priority assigned to the recommendations identified in the audit.

The audit identified several recommendations for the NCIG EMS, to achieve compliance with the ISO14001 standard (both 2004 and draft 2015).

NCIG are currently implementing actions from the May 2015 gap audit and a re-audit of the gap audit will be undertaken in August 2016.

6. ACTIVITIES PROPOSED IN NEXT AEMR PERIOD

Significant activity is proposed to be undertaken in the next AEMR period in accordance with the Project Approval and environmental management and monitoring programmes. The principle elements are:

- Continued operation and maintenance of the full 66Mtpa Coal Export Terminal.
- Internal planning for optimisation of existing plant to provide additional capacity, if required in the future.
- Review of monitoring locations in EPL12693.
- Monitoring of carry-back coal from coal wagons.
- Commence MERI of the migratory shorebird habitat at Area E.
- Further development and continuous improvement of the NCIG Environmental Management System.
- Review of the NCIG Community Engagement Strategy

7. REFERENCES

Avifauna Research & Services (April 2015) NCIG Shorebird Compensatory Habitat Monitoring, Pre-Construction Period Jan-Mar 2015

EES (2013) Groundwater Management Plan – Site D1 – Kooragang Island, Newcastle, NSW

Hunter Bird Observers Club (2015) Deep Pond (Kooragang Island) Avifauna Data Summary 2015

Jacobs (May 2016) NCIG CET Stockpile Emission Calculations

NCIG (July 2015) Compensatory Habitat and Ecological Monitoring Program – Quarterly Report

NCIG (December 2015) Compensatory Habitat and Ecological Monitoring Program – Quarterly Report

NCIG (April 2016) Compensatory Habitat and Ecological Monitoring Program – Quarterly Report

NCIG (April 2016) Project Approval (06_0009) Modification Approval (MOD2 06_0009) Compliance Tracking Program, Revision L

NCIG (July 2016) Compensatory Habitat and Ecological Monitoring Program – Quarterly Report

Ramboll Environ (February 2016) NCIG Surface Water Monitoring Data Review 2016

Ramboll Environ (April 2016) Review of Groundwater Monitoring Program

RCA (July 2015) Report Compiled for Newcastle Coal Infrastructure Group Detailing the Analysis of Discharge Surface Waters June 2015

RCA (January 2016) Report Compiled for Newcastle Coal Infrastructure Group Detailing the Analysis of Discharge Surface Waters December 2015

RCA (August 2015) Groundwater and Surface Water Monitoring, Kooragang Island, Newcastle

RCA (February 2015) Groundwater and Surface Water Monitoring, Kooragang Island, Newcastle

SLR (August 2015) NCIG Construction Noise and Vibration, Project Completion – Summary Report

SLR (September 2015) Newcastle Coal Export Terminal, Off-site Noise and On-site Power Monitoring, Quarter Ending June 2014

SLR (October 2015) Newcastle Coal Export Terminal, The High Capacity Optional Inlet Rail Spur and Rail Siding (Modification 2) Condition 3.6 – Noise Audit Report

SLR (February 2016) Newcastle Coal Export Terminal, Off-site Noise and On-site Power Monitoring, Quarter Ending December 2015

SLR (April 2015) Newcastle Coal Export Terminal, Off-site Noise and On-site Power Monitoring, Quarter Ending March 2015

Trevor Brown and Associates (December 2015) Independent Environmental Audit, NCIG Coal Export Terminal, Kooragang Island

University of Newcastle (May 2016) Kooragang Island Green and Gold Bell Frog Survey 2015-2016

8. LIMITATIONS

Ramboll Environ Australia Pty Ltd (Ramboll Environ) prepared this report in accordance with the scope of work as outlined in our proposal to NCIG dated July 2016 and in accordance with our understanding and interpretation of current regulatory standards.

The conclusions presented in this report represent Ramboll Environ's professional judgment based on information made available during the course of this assignment and are true and correct to the best of Ramboll Environ's knowledge as at the date of the assessment.

Ramboll Environ did not independently verify all of the written or oral information provided to Ramboll Environ during the course of this investigation. While Ramboll Environ has no reason to doubt the accuracy of the information provided to it, the report is complete and accurate only to the extent that the information provided to Ramboll Environ was itself complete and accurate.

This report does not purport to give legal advice. This advice can only be given by qualified legal advisors.

8.1 User Reliance

This report has been prepared exclusively for NCIG and may not be relied upon by any other person or entity without Ramboll Environ Australia's express written permission.

APPENDIX 1
METEOROLOGICAL (OTHER THAN RAINFALL) SUMMARY

Table A1.1 Meteorological statistics by month									
	Wind speed			Sigma theta			Solar radiation		
Month	Monthly average m/s	Hourly min m/s	Hourly max m/s	Monthly average -	Hourly min -	Hourly max -	Monthly average W/m²	Hourly min W/m²	Hourly max W/m²
July 2015	3.8	0.4	12.2	16.9	3.6	49.3	100.1	10.5	454.7
August 2015	3.4	0.2	10.7	17.3	3.5	55.8	126.8	7.7	549.3
September 2015	3.0	0.2	8.3	22.0	3.2	57.8	158.2	7.8	696.8
October 2015	3.0	0.2	7.0	22.7	4.4	60.0	210.3	6.8	831.8
November 2015	3.1	0.1	11.3	22.6	7.4	68.5	209.9	6.2	864.5
December 2015	5.0	-1.4	12.3	20.4	0.1	74.2	238.0	5.3	898.0
January 2016	6.2	1.4	15.3	23.3	5.9	64.0	213.9	5.8	912.3
February 2016	6.1	1.4	15.9	16.5	0.0	55.0	232.8	5.8	824.5
March 2016	2.9	0.5	7.5	18.5	0.1	54.7	217.0	0.0	854.3
April 2016	2.5	0.4	6.5	19.7	6.8	53.2	149.3	0.0	668.8
May 2016	3.8	0.5	12.7	13.4	3.3	50.9	124.4	0.0	529.7
June 2016	4.5	0.5	16.1	13.3	3.2	47.8	93.8	0.0	455.8

*Instrument failure

Table A1.2 Meteorological statistics by month

	Monthly average	Hourly min	Hourly max	Monthly average	Hourly min	Hourly max	Number of hours when $T_{10} > T_2$.	
	°C	°C	°C	°C	°C	°C	Hours	% of month
July 2015	12.2	5.5	19.4	11.8	5.1	18.7	24	3
August 2015	14.2	5.8	25.8	13.7	5.3	25.4	25	3
September 2015	16.1	8.8	27.5	15.6	8.5	26.7	8	1
October 2015	21.1	14.0	34.9	20.5	13.2	34.2	8	1
November 2015	22.2	15.2	39.2	21.6	14.8	39.0	0	0
December 2015	28.5	15.8	65.3	22.0	2.5	35.6	0	0
January 2016	23.7	16.5	37.7	*	*	*	*	*
February 2016	24.7	19.4	37.4	*	*	*	*	*
March 2016	23.1	16.0	29.3	22.3	3.6	27.9	0	0
April 2016	20.8	13.0	31.4	20.1	11.9	30.3	0	0
May 2016	17.3	6.2	26.2	16.8	5.7	25.9	21	3
June 2016	14.2	5.5	19.9	13.7	5.0	19.0	0	0

*Instrument failure

APPENDIX 2
DUST DEPOSITION MONITORING RESULTS

Table A2.2 Meteorological statistics by month

Month	Limit	DG1 (Fern Bay)	DG2 (Stockton)	DG3 (KI*)	DG4 (Mayfield)	DG5 (Mayfield West)	DG6 (Sandgate)
Jul-15	4	0.8	NS***	4.1	0.5	0.9	2.1
Aug-15	4	0.8	NS***	0.6	1	1.1	3.4
Sep-15	4	0.7	1.3	3.7	0.6	1.5	1.2
Oct-15	4	1.2	1.4	8.1	1.3	2.7	2.4
Nov-15	4	0.8	0.9	46.9	1.5	2.0	3.8
Dec-15	4	0.9	0.8	6.3	0.8	1.5	7.6
Jan-16	4	0.5	0.5	**	1.7	1.6	1.6
Feb-16	4	0.6	1.1	1.7	1.4	1.9	1.4
Mar-16	4	0.8	0.6	1.2	1.1	1.3	1.3
Apr-16	4	0.5	1	0.9	1.4	1.5	0.6
May-16	4	0.6	1.7	0.9	0.9	1.0	2.0
Jun-16	4	0.7	0.9	0.9	0.5	0.8	1.4

*KI – Kooragang Island

**Insect and bird droppings

***NS – No Sample

APPENDIX 3
SURFACE WATER MONITORING RESULTS

Table A3.1 Meteorological statistics by month

	pH	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
SW1(a)	Pond 1	8.16	8.72	8.5	8.52	8.04	8.34	8.08	7.93	8.45	8.98	8	7.92
SW1(b)	Pond 2	8.17	8.74	8.64	8.65	8.12	8.45	8.11	8.4	8.49	8.94	7.91	7.99
SW1(c)	Pond 3	8.11	8.71	8.61	8.51	8.16	8.24	8.09	8.5	8.55	8.97	8	8.2
SW1(d)	Clearwater	7.95	8.66	8.8	8.64	8.16	8.39	7.73	8.34	8.47	8.92	8.32	7.92
SW2	Black Swan Pond	7.54	8.44	8.78	8.74	9.31	10.01	7.44	7.64	8.9	8.95	8.05	8.21
SW3	Deep Pond	8.08	9.26	9.24	9.83	8.28	9.23	7.47	8.9	8.07	9.35	7.78	8.53
SW4	Swan Pond	7.62	8.56										

Table A3.2 Meteorological statistics by month

	EC (mS/cm)	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
SW1(a)	Pond 1	2.5	2.93	2.09	2.61	1.11	2.83	638	823	2610	2610	2030	1250
SW1(b)	Pond 2	1.93	2.42	2.08	2.08	1.58	2.69	612	1860	2650	2320	1730	650
SW1(c)	Pond 3	1.08	2.19	1.96	1.33	1.49	2.2	597	1660	2520	1670	1600	818
SW1(d)	Clearwater	1.32	2.49	3.35	1.26	2.04	2.85	317	991	2790	1930	2310	1410
SW2	Black Swan Pond	2.23	2.14	2.44	1.84	1.99	2.07	376	2420	1830	2870	2610	2170
SW3	Deep Pond	1.59	1.59	1.61	1.59	1.73	2.78	538	1390	2960	2040	1750	2030
SW4	Swan Pond	27.6	47.6										

Table A3.3 Meteorological statistics by month

	Turbidity (NTU)	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
SW1(a)	Pond 1	67	98	876	68	>1000	275	303	594	91	110	111	312
SW1(b)	Pond 2	38.9	49	133	23	122	69	395	218	33	21	38	622
SW1(c)	Pond 3	46	91	100	59	98	508	271	40	50	45	26	363
SW1(d)	Clearwater	33.3	88	167	22	145	84	515	53	22	130	120	146
SW2	Black Swan Pond	5.8	14	3	2	2	13	20	27	50	42	13	15
SW3	Deep Pond	6.3	39	5	36	121	20	66	15	32	190	50	22
SW4	Swan Pond	11.2	15										

Table A3.4 Meteorological statistics by month

	Water Temp (°C)	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
SW1(a)	Pond 1	11.9	12.9	18.1	26.9	23	30.6	23	24.2	27.1	26.2	22.5	16.9
SW1(b)	Pond 2	12.3	13.5	16.8	26.5	22	27.1	22	24.7	27.8	25.6	20.9	16.3
SW1(c)	Pond 3	12.5	13.3	16.8	26.1	22	27.7	20	25.4	28	25.8	21.1	15.7
SW1(d)	Clearwater	12	13.1	17.6	28.9	22	31	20	25.4	27.4	26.6	23	15.5
SW2	Black Swan Pond	11.3	14.2	18.2	27	21	24.2	20	24.4	27.1	23.9	21.8	15.2
SW3	Deep Pond	11.5	13.7	17.4	27.1	22	28.9	20	24.5	25.9	25.6	23.9	17.2
SW4	Swan Pond	12	13.1										

APPENDIX 4
GROUNDWATER MONITORING RESULTS

Cells with a green shade indicate that the trigger level associated with this result has not been exceeded

Cells with a yellow shade indicates that the LOR is greater than the trigger value,and although undected by the laboratory could exceed criteria

Cells with a red shade indicate that the trigger level associated with this result has been exceeded

Indicates no guideline specified(site specific or ANZECC)

ID = Insufficient data to provide trigger value

	Reporting Units	95% Marine Waters ANZECC Trigger Level		EP Licence Trigger Level (Site specific)	13/06/2013	2/12/2013	6/06/2014	1/12/2014	18/06/2015	7/12/2015	2/06/2016
		Sourced from CEMP	Sourced from OWMP								
EPA Point Number					1	1	1	1	1	1	1
Sample Number					06136902001	12136902001	061410481001	121410481001	061510481007	121510481019	061610481017
Date of Sampling					13/06/2013	2/12/2013	6/06/2014	1/12/2014	18/06/2015	7/12/2015	2/06/2016
Time of Sampling					11:05	13:15	11:10	11:20	10:35	11:20	11:56
Sampler					K. Hawes	K. Hawes	K. Hawes	K. Hawes	K. Hawes/C. South	K. Hawes/C. South	K. Hawes/C. South
Groundwater Level	metres				1.32	1.49	1.57	1.57	1.29	1.50	1.47
Temperature	°C				19.4	20.5	17.5	21.8	19.0	24.2	20.7
Analyte											
pH	pH units	7.0-8.5	7.0-8.5		7.8	7.95	7.2	7.2	7.7	7.48	7.47
EC	µS/cm				11410	9900	11160	9980	11800	12400	12100
TDS	mg/L				7082	7288	7327	7052	6606	6578	6955
TSS	mg/L				33	42	21	38	26	29	14
Metals - Dissolved											
Al	mg/L		ID		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.005
Cd	mg/L	0.0055			0.0002	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Co	mg/L		0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	mg/L		0.0013		0.004	0.003	<0.001	<0.001	0.002	<0.001	<0.001
Pb	mg/L	0.0044			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mn	mg/L	0.08	0.08		0.03	0.132	0.004	0.39	0.009	0.341	0.23
Ni	mg/L	0.07	0.07		0.002	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Zn	mg/L	0.015	0.015		0.046	0.038	0.022	0.016	0.042	<0.005	<0.005
Fe	mg/L		ID		<0.05	<0.05	<0.05	0.15	<0.05	<0.05	0.014
As III	µg/L	ID			<1	<1	<1	<2	<2	<0.5	<0.5
Hg	mg/L	0.0004			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Hexavalent Cr	mg/L	0.0044			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.004
Cations - Dissolved											
Mg	mg/L		ID		151	119	115	107	109	117	100
Na	mg/L		ID		2800	1920	2220	2150	2070	2150	1900
K	mg/L		ID		173	114	130	128	113	111	130

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Cells with a red shade indicate that the trigger level associated with this result has been exceeded											
Indicates no guideline specified (site specific or ANZECC)											
ID = Insufficient data to provide trigger value											
	Reporting Units	**95% Marine Waters ANZECC Trigger Level**		**EP Licence Trigger Level (Site specific)**	13/06/2013	2/12/2013	6/06/2014	1/12/2014	18/06/2015	7/12/2015	2/06/2016
		Sourced from CEMP	**Sourced from OWMP**								
PAH											
Polynuclear Aromatic Hydrocarbons - 16 analytes	µg/L		ID		<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<1
TPH											
C6-9 Fraction	µg/L				<20	<20	<20	<20	<20	<20	<40
C10-14 Fraction	µg/L				<50	<50	<50	<50	<50	<50	<50
C15-28 Fraction	µg/L				<100	<100	<100	<100	<100	<100	<200
C29-36 Fraction	µg/L				<50	<50	<50	<50	<50	<50	<200
BTEX											
Benzene	µg/L				<1	<1	<1	<1	<1	<1	<0.5
Toluene	µg/L				<2	<2	<2	<2	<2	<2	<0.5
Ethyl Benzene	µg/L				<2	<2	<2	<2	<2	<2	<0.5
m+p Xylene	µg/L				<2	<2	<2	<2	<2	<2	<1
o Xylene	µg/L				<2	<2	<2	<2	<2	<2	<0.5
Cyanide											
Free	µg/L				<4	<4	<4	<4	<4	<4	<4
Total	µg/L				<4	<4	<4	<4	<4	<4	<4
Ammonia	µg/L				50	470	20	630	140	2450	1700
Phenol	µg/L				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5
Sulfate	mg/L				638	628	571	547	484	622	640

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Cells with a red shade indicate that the trigger level associated with this result has been exceeded

Indicates no guideline specified(site specific or ANZECC)

ID = Insufficient data to provide trigger value

	Reporting Units	95% Marine Waters ANZECC Trigger Level		EP Licence Trigger Level (Site specific)	13/06/2013	2/12/2013	6/06/2014	1/12/2014	18/06/2015	7/12/2015	2/06/2016
		Sourced from CEMP	Sourced from OWMP								
EPA Point Number					20	20	20		20	20	20
Sample Number					06136902002	12136902002	061410481002	121410481002	061510481008	121510481020	061610481018
Date of Sampling					13/06/2013	2/12/2013	6/06/2014	1/12/2014	18/06/2015	7/12/2015	2/06/2016
Time of Sampling					12:55	15:15	10:20	11:45	11:05	11:55	8:40
Sampler					K. Hawes	K. Hawes	K. Hawes	K. Hawes	K. Hawes/C. South	K. Hawes/C. South	K. Hawes/C. South
Groundwater Level	metres				2.57	2.62	2.80	2.90	2.57	2.80	2.70
Temperature	°C				20.3	21.0	18.5	22.0	20.5	22.5	19.4
Analyte											
pH	pH units	7.0-8.5	7.0-8.5		7.5	7.77	7.47	7.41	7.61	6.95	6.89
EC	µS/cm				7560	6560	7390	5950	6620	24800	22600
TDS	mg/L				4376	4575	4088	3921	3687	14208	13596
TSS	mg/L				44	27	1152	142	160	13	21
Metals - Dissolved											
Al	mg/L		ID		0.02	<0.01	0.03	0.02	0.02	<0.01	0.011
Cd	mg/L	0.0055			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Co	mg/L		0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	mg/L		0.0013		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pb	mg/L	0.0044			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mn	mg/L	0.08	0.08		0.541	0.49	0.234	0.528	0.397	0.73	1.9
Ni	mg/L	0.07	0.07		<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001
Zn	mg/L	0.015	0.015		<0.005	0.01	0.005	<0.005	0.008	<0.005	<0.005
Fe	mg/L		ID		0.14	<0.05	<0.05	<0.05	0.06	0.08	0.022
As III	µg/L	ID			<1	<1	<1	<2	<1	<0.5	<0.5
Hg	mg/L	0.0004			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Hexavalent Cr	mg/L	0.0044			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.004
Cations - Dissolved											
Mg	mg/L		ID		109	90	70	130	62	439	370
Na	mg/L		ID		1890	1340	1310	1910	1200	4620	4200
K	mg/L		ID		113	58	64	87	59	177	220

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Indicates no guideline specified (site specific or ANZECC)											
ID = Insufficient data to provide trigger value											
	Reporting Units	95% Marine Waters ANZECC Trigger Level		EP Licence Trigger Level (Site specific)	13/06/2013	2/12/2013	6/06/2014	1/12/2014	18/06/2015	7/12/2015	2/06/2016
		Sourced from CEMP	Sourced from OWMP								
PAH											
Polynuclear Aromatic Hydrocarbons - 16 analytes	µg/L		ID	1	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<1
TPH											
C6-9 Fraction	µg/L			20	<20	<20	<20	<20	<20	<20	<40
C10-14 Fraction	µg/L			50	<50	<50	<50	<50	<50	<50	<50
C15-28 Fraction	µg/L			100	<100	<100	<100	<100	<100	<100	<200
C29-36 Fraction	µg/L			50	<50	<50	<50	<50	<50	<50	<200
BTEX											
Benzene	µg/L			700	<1	<1	<1	<1	<1	<1	<0.5
Toluene	µg/L			180	<2	<2	<2	<2	<2	<2	<0.5
Ethyl Benzene	µg/L			5	<2	<2	<2	<2	<2	<2	<0.5
m+p Xylene	µg/L			75	<2	<2	<2	<2	<2	<2	<1
o Xylene	µg/L			350	<2	<2	<2	<2	<2	<2	<0.5
Cyanide											
Free	µg/L			4	<4	<4	<4	<4	<4	<4	<4
Total	µg/L			81.1	<4	<4	<4	<4	<4	<4	<4
Ammonia	µg/L				3580	510	100	3300	4970	3220	3300
Phenol	µg/L			400	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5
Sulfate	mg/L				400	433	312	350	289	1300	1100

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Indicates no guideline specified(site specific or ANZECC)

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	Reporting Units	95% Marine Waters ANZECC Trigger Level		EP Licence Trigger Level (Site specific)	11/12/2012	13/06/2013	2/12/2013	6/06/2014
		Sourced from CEMP	Sourced from OWMP					
EPA Point Number					21	21	21	21
Sample Number					12126902003	06136902003	12136902003	061410481003
Date of Sampling					11/12/2012	13/06/2013	2/12/2013	6/06/2014
Time of Sampling					12:10	12:40	15:25	10:05
Sampler					K.Hawes	K. Hawes	K. Hawes	K. Hawes
Groundwater Level	metres				2.13	2.00	2.00	1.98
Temperature	°C				21.0	19.3	21.5	18.0
Analyte								
pH	pH units	7.0-8.5	7.0-8.5		7.6	7.6	7.89	7.32
EC	µS/cm				11890	8960	7520	7790
TDS	mg/L				10400	4770	5003	4708
TSS	mg/L				18985	4350	2902	1960
Metals - Dissolved								
Al	mg/L		ID		<0.01	0.02	0.01	<0.01
Cd	mg/L	0.0055			<0.0001	0.0003	0.0003	<0.0001
Co	mg/L		0.001		<0.001	<0.001	<0.001	<0.001
Cu	mg/L		0.0013		<0.001	0.004	0.012	<0.001
Pb	mg/L	0.0044			<0.001	<0.001	<0.001	<0.001
Mn	mg/L	0.08	0.08		0.842	0.39	0.328	0.279
Ni	mg/L	0.07	0.07		<0.001	0.002	0.005	<0.001
Zn	mg/L	0.015	0.015		<0.005	0.013	0.102	<0.005
Fe	mg/L		ID		0.13	0.05	<0.05	<0.05
As III	µg/L	ID			<5	<1	<1	<1
Hg	mg/L	0.0004			<0.0001	<0.0001	<0.0001	<0.0001
Hexavalent Cr	mg/L	0.0044			<0.01	<0.01	<0.01	<0.01
Cations - Dissolved								
Mg	mg/L		ID		211	139	83	80
Na	mg/L		ID		2820	2380	1270	1490
K	mg/L		ID		129	129	55	72

	1/12/2014	18/06/2015	7/12/2015	2/06/2016
EPA Point Number	21	21	21	21
Sample Number	121410481003	061510481009	121510481021	061610481019
Date of Sampling	1/12/2014	18/06/2015	7/12/2015	2/06/2016
Time of Sampling	12:10	11:15	12:05	8:45
Sampler	K. Hawes	K. Hawes/C. South	K. Hawes/C. South	K. Hawes/C. South
Groundwater Level	2.20	1.80	2.00	1.97
Temperature	22.0	19.3	25.7	19.6
Analyte				
pH	7.47	7.99	7.70	7.71
EC	8100	4030	6990	6720
TDS	5345	2372	4423	3295
TSS	2460	3150	1807	1096
Metals - Dissolved				
Al	0.01	0.08	<0.01	<0.005
Cd	<0.0001	0.0001	<0.0001	<0.0001
Co	<0.001	<0.001	<0.001	<0.001
Cu	0.002	0.005	<0.001	<0.001
Pb	<0.001	<0.001	<0.001	<0.001
Mn	0.425	0.113	0.285	0.46
Ni	0.001	0.002	0.001	<0.001
Zn	0.025	0.009	<0.005	<0.005
Fe	<0.05	<0.05	<0.05	0.067
As III	<2	<1	1.9	1
Hg	<0.0001	<0.0001	<0.0001	<0.0001
Hexavalent Cr	<0.01	<0.01	<0.01	<0.004
Cations - Dissolved				
Mg	102	37	80	82
Na	2010	800	1330	1500
K	119	38	69	96

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Indicates no guideline specified(site specific or ANZECC)

ID= Insufficient data to provide trigger value

	Reporting Units	95% Marine Waters ANZECC Trigger Level		EP Licence Trigger Level (Site specific)	11/12/2012	13/06/2013	2/12/2013	6/06/2014	1/12/2014	18/06/2015	7/12/2015	2/06/2016
		Sourced from CEMP	Sourced from OWMP									
PAH												
Polynuclear Aromatic Hydrocarbons - 16 analytes	µg/L		ID	1.1	<0.5	<0.5	<1.0	<1.0	<0.5	<0.5	<0.5	<1
TPH												
C6-9 Fraction	µg/L			20	<20	<20	<20	<20	<20	<20	<20	<40
C10-14 Fraction	µg/L			50	<50	<50	<50	<50	<50	<50	<50	<50
C15-28 Fraction	µg/L			100	<100	<100	<100	<100	<100	<100	<100	<200
C29-36 Fraction	µg/L			50	<50	<50	<50	<50	<50	<50	<50	<200
BTEX												
Benzene	µg/L			700	<1	<1	<1	<1	<1	<1	<1	<0.5
Toluene	µg/L			180	<5	<2	<2	<2	<2	<2	<2	<0.5
Ethyl Benzene	µg/L			5	<2	<2	<2	<2	<2	<2	<2	<0.5
m+p Xylene	µg/L			75	<2	<2	<2	<2	<2	<2	<2	<1
o Xylene	µg/L			350	<2	<2	<2	<2	<2	<2	<2	<0.5
Cyanide												
Free	µg/L			4	<4	<4	<4	<4	<4	<4	<4	<4
Total	µg/L			21.8	7	<4	<4	<4	<4	<4	<4	6
Ammonia	µg/L				2420	1610	1170	1300	2050	690	1130	1700
Phenol	µg/L			400	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5
Sulfate	mg/L				935	538	380	386	494	263	373	300

exceeded												
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Cells with a red shade indicate that the trigger level associated with this result has been exceeded												
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ID = Insufficient data to provide trigger value												
	Reporting Units	**95% Marine Waters ANZECC Trigger Level**		**EP Licence Trigger Level (Site specific)**	13/06/2013	2/7/13 *Retest*	2/12/2013	6/06/2014	1/12/2014	18/06/2015	7/12/2015	2/06/2016
		Sourced from CEMP	**Sourced from OWMP**									
EPA Point Number					22	22	22	22	22	22	22	22
Sample Number					06136903004	07136902001	12136902004	061410841004	121410481004	061510481010	121510481022	061610481020
Date of Sampling					13/06/2013	2/07/2013	2/12/2013	6/06/2014	1/12/2014	18/06/2015	7/12/2015	2/06/2016
Time of Sampling					12:10	14:55	16:00	9:55	12:50	12:23	14:55	12:35
Sampler					K. Hawes	C. South	K.Hawes	K.Hawes	K. Hawes	K. Hawes/C. South	K. Hawes/C. South	K. Hawes/C. South
Groundwater Level	metres				1.49	1.41	1.30	1.53	1.89	1.21	1.86	1.54
Temperature	°C				19.2	22	18	16	19.25	18.1	21.4	19.5
Analyte												
pH	pH units	7.0-8.5	7.0-8.5		7.3	Retest analysis conducted due to TPH C10-C14 Fraction result from June 2013 sampling. Only TPH analysis conducted on this event.	8.25	7.24	7.48	7.60	7.68	7.55
EC	µS/cm				854		879	1016	1116	843	821	801
TDS	mg/L				504		550	606	718	470	530	571
TSS	mg/L				208		850	470	162	910	895	69
Metals - Dissolved												
Al	mg/L		ID		0.04		<0.01	<0.01	<0.01	<0.01	<0.01	<0.005
Cd	mg/L	0.0055			<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Co	mg/L		0.001		<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	mg/L		0.0013		<0.001		0.009	<0.001	<0.001	<0.001	<0.001	<0.001
Pb	mg/L	0.0044			<0.001		0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mn	mg/L	0.08	0.08		0.17		1.16	0.391	0.724	0.155	0.25	0.27
Ni	mg/L	0.07	0.07		0.001		0.001	0.002	<0.001	<0.001	<0.001	<0.001
Zn	mg/L	0.015	0.015		0.046		0.006	0.032	0.007	0.005	<0.005	0.01
Fe	mg/L		ID		0.19		<0.05	0.11	0.23	0.18	<0.05	0.007
As III	µg/L	ID			<1		<1	<1	<2	<1	<0.5	<0.5
Hg	mg/L	0.0004			<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Hexavalent Cr	mg/L	0.0044			<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.004
Cations - Dissolved												
Mg	mg/L		ID		15		12	10	13	12	12	11
Na	mg/L		ID		85		52	49	122	62	62	41
K	mg/L		ID		12		4	5	9	8	6	6.8

[illegible] exceeded

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Cells with a red shade indicate that the trigger level associated with this result has been exceeded

Indicates no guideline specified(site specific or ANZECC)

ID= Insufficient data to provide trigger value

	Reporting Units	95% Marine Waters ANZECC Trigger Level – Sourced from CEMP	95% Marine Waters ANZECC Trigger Level – Sourced from OWMP	EP Licence Trigger Level (Site specific)	13/06/2013	2/7/13 *Retest*	2/12/2013	6/06/2014	1/12/2014	18/06/2015	7/12/2015	2/06/2016
PAH												
Polynuclear Aromatic Hydrocarbons - 16 analytes	µg/L		ID	2.2	<0.5		<1.0	<0.5	<0.5	<0.5	<0.5	<1
TPH												
C6-9 Fraction	µg/L			20	<20	<20	<20	<20	<20	<20	<20	<40
C10-14 Fraction	µg/L			50	130	<50	<50	<50	<50	<50	<50	<50
C15-28 Fraction	µg/L			100	<100	<100	<100	<100	<100	<100	<100	<200
C29-36 Fraction	µg/L			50	<50	<50	<50	<50	<50	<50	<50	<200
BTEX						Retest analysis conducted due to TPH C10-C14 Fraction result from June 2013 sampling						
Benzene	µg/L			700	<1		<1	<1	<1	<1	<1	<0.5
Toluene	µg/L			180	<2		<2	<2	<2	<2	<2	<0.5
Ethyl Benzene	µg/L			5	<2		<2	<2	<2	<2	<2	<0.5
m+p Xylene	µg/L			75	<2		<2	<2	<2	<2	<2	<1
o Xylene	µg/L			350	<2		<2	<2	<2	<2	<2	<0.5
Cyanide												
Free	µg/L			4	<4		<4	<4	<4	<4	<4	<4
Total	µg/L			16.6	<4		<4	<4	<4	<4	<4	<4
Ammonia	µg/L				0.11		250	140	350	70	200	210
Phenol	µg/L			400	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0	<0.5
Sulfate	mg/L				32		75	76	63	46	38	43

exceeded

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Indicates no guideline specified (site specific or ANZECC)

ID = Insufficient data to provide trigger value

	Reporting Units	95% Marine Waters ANZECC Trigger Level		EP Licence Trigger Level (Site specific)	13/06/2013	2/7/13 *Retest*	2/12/2013	6/06/2014	1/12/2014	18/06/2015	7/12/2015	2/06/2016
		Sourced from CEMP	Sourced from OWMP									
EPA Point Number					22	22	22	22	22	22	22	22
Sample Number					06136903004	07136902001	12136902004	061410841004	121410481004	061510481010	121510481022	061610481020
Date of Sampling					13/06/2013	2/07/2013	2/12/2013	6/06/2014	1/12/2014	18/06/2015	7/12/2015	2/06/2016
Time of Sampling					12:10	14:55	16:00	9:55	12:50	12:23	14:55	12:35
Sampler					K. Hawes	C. South	K.Hawes	K.Hawes	K. Hawes	K. Hawes/C. South	K. Hawes/C. South	K. Hawes/C. South
Groundwater Level	metres				1.49	1.41	1.30	1.53	1.89	1.21	1.86	1.54
Temperature	°C				19.2	22	18	16	19.25	18.1	21.4	19.5
Analyte												
pH	pH units	7.0-8.5	7.0-8.5		7.3	Retest analysis conducted due to TPH C10-C14 Fraction result from June 2013 sampling. Only TPH analysis conducted on this event.	8.25	7.24	7.48	7.60	7.68	7.55
EC	µS/cm				854		879	1016	1116	843	821	801
TDS	mg/L				504		550	606	718	470	530	571
TSS	mg/L				208		850	470	162	910	895	69
Metals - Dissolved												
Al	mg/L		ID		0.04		<0.01	<0.01	<0.01	<0.01	<0.01	<0.005
Cd	mg/L	0.0055			<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Co	mg/L		0.001		<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	mg/L		0.0013		<0.001		0.009	<0.001	<0.001	<0.001	<0.001	<0.001
Pb	mg/L	0.0044			<0.001		0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mn	mg/L	0.08	0.08		0.17		1.16	0.391	0.724	0.155	0.25	0.27
Ni	mg/L	0.07	0.07		0.001		0.001	0.002	<0.001	<0.001	<0.001	<0.001
Zn	mg/L	0.015	0.015		0.046		0.006	0.032	0.007	0.005	<0.005	0.01
Fe	mg/L		ID		0.19		<0.05	0.11	0.23	0.18	<0.05	0.007
As III	µg/L	ID			<1		<1	<1	<2	<1	<0.5	<0.5
Hg	mg/L	0.0004			<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Hexavalent Cr	mg/L	0.0044			<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.004
Cations - Dissolved												
Mg	mg/L		ID		15		12	10	13	12	12	11
Na	mg/L		ID		85		52	49	122	62	62	41
K	mg/L		ID		12		4	5	9	8	6	6.8

exceeded

Cells with a yellow shade indicates that the LOR is greater than the trigger value,and although undected by the laboratory could exceed criteria

Cells with a red shade indicate that the trigger level associated with this result has been exceeded

Indicates no guideline specified(site specific or ANZECC)

ID= Insufficient data to provide trigger value

	Reporting Units	95% Marine Waters ANZECC Trigger Level – Sourced from CEMP	95% Marine Waters ANZECC Trigger Level – Sourced from OWMP	EP Licence Trigger Level (Site specific)	13/06/2013	2/7/13 *Retest*	2/12/2013	6/06/2014	1/12/2014	18/06/2015	7/12/2015	2/06/2016
PAH												
Polynuclear Aromatic Hydrocarbons - 16 analytes	µg/L		ID	2.2	<0.5		<1.0	<0.5	<0.5	<0.5	<0.5	<1
TPH												
C6-9 Fraction	µg/L			20	<20	<20	<20	<20	<20	<20	<20	<40
C10-14 Fraction	µg/L			50	130	<50	<50	<50	<50	<50	<50	<50
C15-28 Fraction	µg/L			100	<100	<100	<100	<100	<100	<100	<100	<200
C29-36 Fraction	µg/L			50	<50	<50	<50	<50	<50	<50	<50	<200
BTEX												
Benzene	µg/L			700	<1	Retest analysis conducted due to TPH C10-C14 Fraction result from June 2013 sampling	<1	<1	<1	<1	<1	<0.5
Toluene	µg/L			180	<2		<2	<2	<2	<2	<2	<0.5
Ethyl Benzene	µg/L			5	<2		<2	<2	<2	<2	<2	<0.5
m+p Xylene	µg/L			75	<2		<2	<2	<2	<2	<2	<1
o Xylene	µg/L			350	<2		<2	<2	<2	<2	<2	<0.5
Cyanide												
Free	µg/L			4	<4		<4	<4	<4	<4	<4	<4
Total	µg/L			16.6	<4		<4	<4	<4	<4	<4	<4
Ammonia	µg/L				0.11		250	140	350	70	200	210
Phenol	µg/L			400	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0	<0.5
Sulfate	mg/L				32		75	76	63	46	38	43

APPENDIX 5
CHEMP QUARTERLY REPORTS AND MINUTES

Newcastle Coal
INFRASTRUCTURE GROUP

Compensatory Habitat and Ecological Monitoring Program – Quarterly Report

DATE: *27 July 2015*

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APPROVAL: Nathan Juchau

INTRODUCTION

This report provides an update of activities relating to the NCIG Compensatory Habitat and Ecological Monitoring Program since the previous Quarterly Report from 30 April 2015. The report aims to provide information on key components of the program and how these are being implemented. An update will be provided to members of the Consultative Board every 3 months, in the form of a Quarterly report and presentations (every 6 months) coinciding with Board Meetings.

1. Research Area Ponds and Associated Monitoring (Alex Callen)

The 16 pond environment at the NCIG trial site ('the trial site') provides a pond choice experiment for a green and golden bell frog reintroduction program using a 2x2 replicated factorial design with pond depth and salinity as treatments to determine pond preference and the potential for passive chytrid management. Pond depth treatments were; deep – permanent water (1.5m); and shallow – ephemeral water (0.5m). Salinity treatments comprised artificially salted ponds - to 3‰ using naturally derived sea salt and control ponds where background salinity levels remained unmanipulated ('not dosed'). Some deep control ponds have been influenced by background salinity from groundwater intrusion.

The reintroduction program involved two primary release periods of bell frog propagules as tadpoles and metamorphs. Between February and March 2013 8,000 tadpoles and/or newly metamorphosed bell frogs were introduced into the trial site (see previous reports for details and outcomes). A further 12,000 tadpoles and/or newly metamorphosed bell frogs were released to the site between December 2013 and February 2014 (see previous reports for details and outcomes).

The bell frog population within the trial site results from the growth and development of these introduced animals, and represent two cohorts, one that reached two years of age in the summer of 2014/15 and the second that reach one year of age in the summer of 2014/2015. This is an important aspect of the reintroduction program as female bell frogs are presumed not to reach sexual maturity (under conditions applying in mid-latitudinal, temperate, coastal environments) until at least two years of age, which means natural recruitment (that is, breeding within the population) cannot occur until year two of the program. Survival of adults into the first potential breeding season (the summer of 2014/15) in the presence of disease and predation was crucial and it was for this reason that the second cohort was released – to provide a dynamic age class that would close the gap on recruitment that would occur in a reintroduction for this species, thus providing a greater chance of adult survival to breeding.

This report provides an update about trial site activities since the Summer 2014-15 quarterly report.

1.1. Climate and site conditions

Evening survey work ceased 9 April 2015 with a noticeable decline in the number of frogs detected, corresponding with minimum nighttime temperatures dropping to below 15°C. The region experienced the full force of an east coast low pressure system in late April that brought extensive rainfall which caused localized flooding on Ash Island. The storm completely charged all ponds with low lying areas between ponds and around the fence perimeter becoming inundated, resulting in connectivity between ponds. Ponds have remained completely charged since that time as a result of high groundwater levels combined with periods of intermittent autumn and winter rain.

1.1.1. Climate and site conditions

Mean pond depth before and after the April rainfall is depicted for deep and shallow ponds at the NCIG Trial Site (Figure 1-1). Deep ponds had a mean depth of 116 cm (SE±5.0) prior to the rainfall events toward the end of April, and shallow ponds had a mean depth of 46.6cm (SE±3.4), indicating ponds were near to total water holding capacity prior to the storms. All ponds were fully charged post-storm and have maintained full capacity with deep ponds having a mean depth of greater than 135cm and shallow ponds having a mean depth of greater than 60cm.

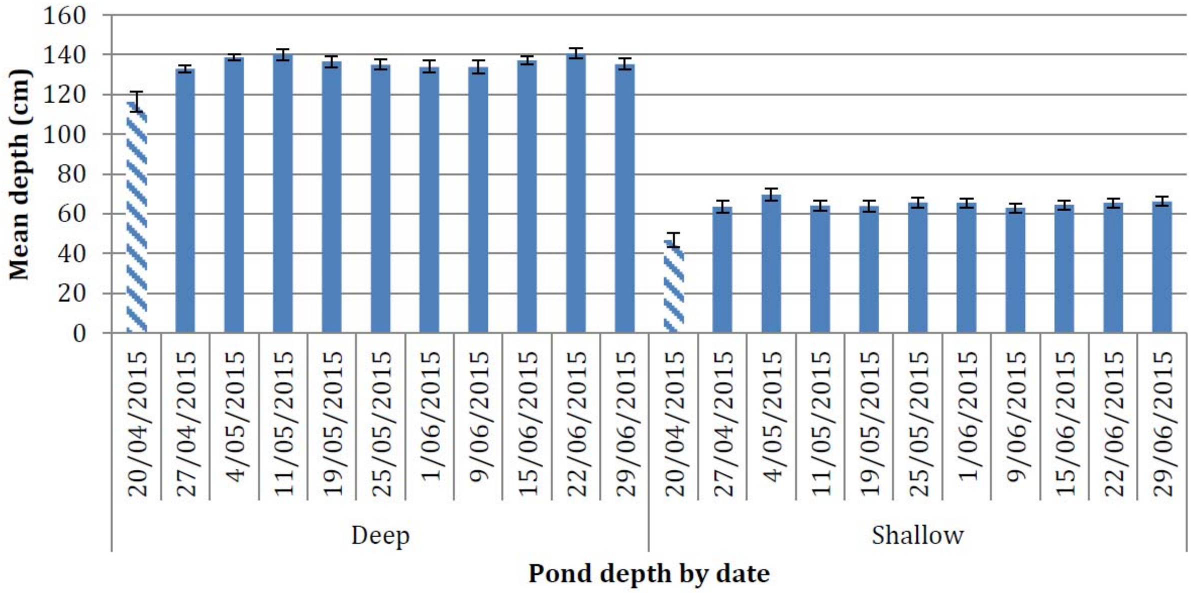


Figure 1-1 Mean pond depth for deep and shallow ponds at the NCIG trial site between April and June 2015. Patterned bars represent mean pond depths just prior to the storm. Deep ponds were created to a depth of 150cm and shallow ponds to a depth of 50cm. Bars represent means and whiskers represent standard errors.

1.1.2. Pond salinity

Treatment ponds were originally dosed to achieve a salinity threshold of 3‰ and have not been re-dosed with marine-derived sea salt since April 2014. Natural environmental conditions (evaporation and rainfall) reduced the dosing concentration and this was exacerbated by the rainfall resulting from the East Coast Low in April. Mean salinities of all pond treatments have been markedly diluted as a result of the rainfall to less than 0.6‰ across all treatment types (Figure 1-2). Salinity concentrations are expected to remain low until such time as pond water levels drop as a result of increased evaporation due to warmer air temperatures.

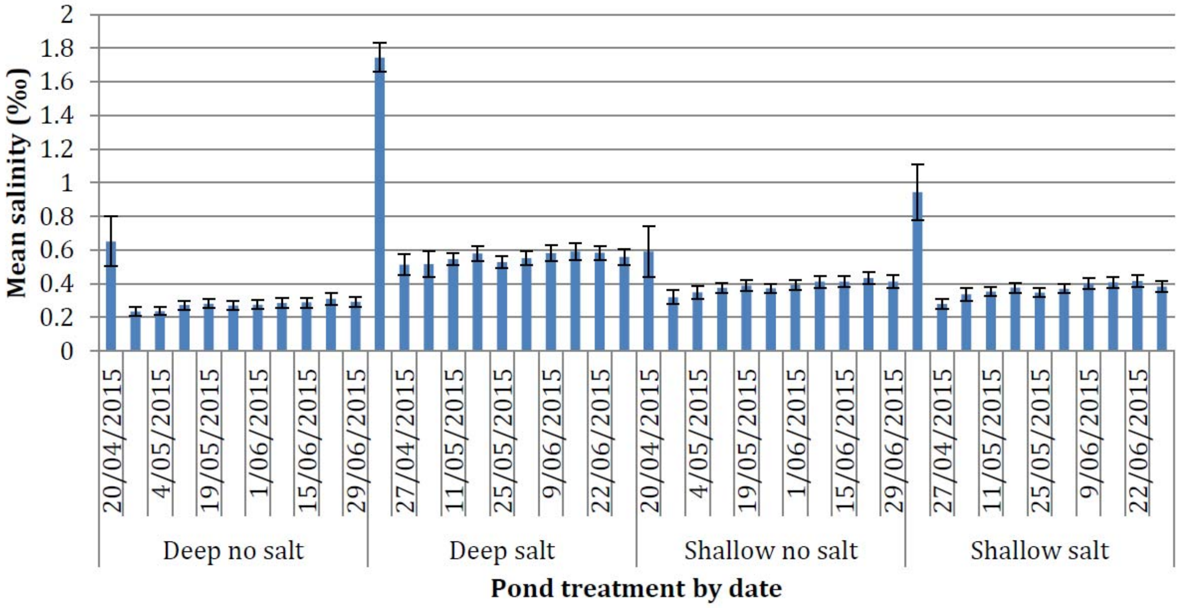


Figure 1-2 Mean salinity (‰) in pond water by treatments at the NCIG trial site between April and June 2015. Treatments are Deep (1.5m), Shallow (0.5m), Salt (dosed with sea salt), No salt (not dosed with sea salt). Bars represent means and whiskers represent standard errors. Original salt dose target for treatment ponds was 3‰.

1.2. Bell frog research

1.2.1. Pond preference through visual encounter surveys

Visual encounter surveys of all 16 ponds occurred until there was a noticeable decline in the number of frogs detected, corresponding with minimum nighttime temperatures dropping to below 15°C. Frogs were consistently observed to occupy all ponds at the trial site irrespective of treatment depth or salinity concentration.

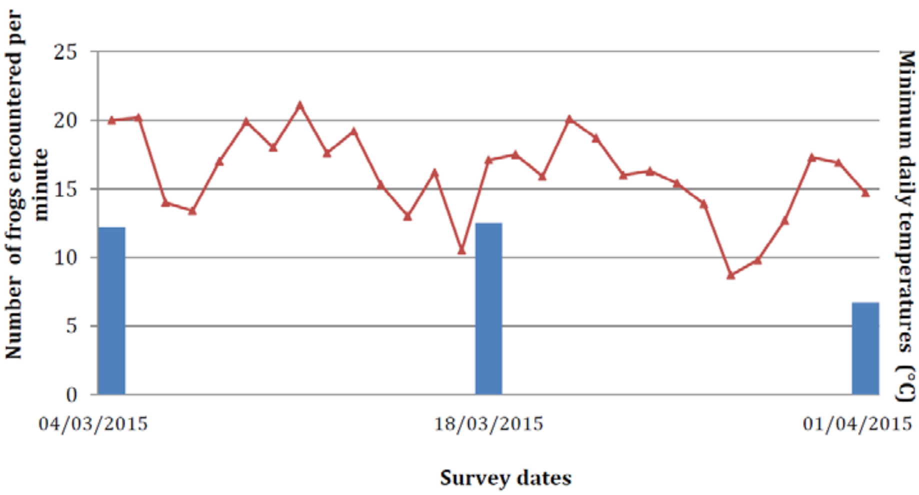


Figure 1-3 Results of visual encounter surveys with data presented as the mean number of frogs encountered across the site March through to early April 2015. Bars represent means and whiskers represent standard errors. The line represents minimum daily temperatures (°C).

1.2.2. Tadpoles

The late onset of breeding at the NCIG trial site has caused a proportion of tadpoles to overwinter. Morphometrics and infection status of these tadpoles is routinely monitored to track growth and infection load over the cooler months and into spring.

1.2.3. Gambusia

Gambusia entered the site as a result of localised flooding of Ash Island during the April East Coast Low. As a result of the interconnectedness of some of the ponds at the site, the predatory fish now inhabits 10 of the 16 ponds at the site. Discussions between the University, NCIG and NSW National Parks are ongoing regarding management options. Of the six ponds containing bell frog tadpoles from summer breeding, four of these now contain gambusia.

2. Behavoural Ecology Research

The behavioural ecology research project has paused during the cooler winter months due to a drop in bell frog activity. In addition, post-graduate scientist, Sean Doody, has resigned from the research position funded by NCIG. NCIG is now in discussions with the University of Newcastle regarding the prospects of continuing the behavioural research program in the 2015/16 season. It is proposed that this research will focus on dispersal of the species during rain/storm events.

3. Annual Green and Golden Bell Frog Monitoring

Monitoring of the Green and Golden Bell Frog in the industrial area of Kooragang Island was conducted by the University of Newcastle for the 2014/15 season. This monitoring took place over three (3) month-long monitoring campaigns in approximately November, January and March. The results are summarised in the points below (*please note, the Kooragang Island GGBF monitoring does not include monitoring events recorded inside the NCIG GGBF Compensatory Habitat site*):

- K22/23 Ponds (northern side of Kooragang Main Rail Line) had high variation in population estimate throughout the season. However, the annual estimate is consistent with previous years. Breeding has taken place in these ponds each season for the past four years.
- K29 Pond (emplacement cell, southern side of Kooragang Main Rail Line) has had a steady population estimate for the last four seasons. However, no breeding has been recorded in this pond since 2011.
- Rail Loop Pond (emplacement cell inside the NCIG Rail Loop) had two breeding events in 2012/13 and 2013/14. However, no breeding was observed in the last season. This has contributed to a fluctuating population estimate.

- A significant breeding event was recorded at K104 Pond (northern extent of Windmill Road) in February 2015.
- Breeding also occurred in one of the two clusters of artificial ponds constructed by PWCS on the proposed T4 land.
- 10 bell frogs were found in the BHPB Wetland, which is more than have been found in previous seasons. However, this is still considered to be a small number for a large wetland.
- Bell frogs were found in 48.3% of surveyed ponds during the 2014/15 season, which is similar to previous seasons. However, the ponds in which bell frogs are found change from year to year (a phenomenon observed at the Sydney Olympic Park population).
- Movement of individual frogs were primarily focusses within the K22/23 pond area, with no movements recorded across the Kooragang Main Rail Line, unlike previous seasons.
- Overall, bell frogs bred in 6 ponds of those surveyed, and were heard calling in 4 ponds of those surveyed.
- The Kooragang Island / Ash Island GGBF population is small and is highly susceptible to environmental conditions and stochastic events.

A version of the monitoring report is not provided as part of this report, as it has not yet been finalised. It is expected to be finalised in the coming weeks after both PWCS and NCIG provide feedback to the draft.

4. Breeding Program

The breeding pairs at the University of Newcastle were once again used for producing new progeny, this time to release into the NCIG Compensatory Habitat, as opposed to the Trial Site. As of June 2015, 4204 tadpoles and 436 metamorphs were released into ponds in Stage 1 (both KWRP-constructed ponds and NCIG fenced ponds) and Stage 4. These animals were closely monitored in baskets and after full release for health and survival. Release in the compensatory habitat was facilitated by an addendum to the current Translocation Proposal for the NCIG Research Area (trial ponds). Approximately 300 tadpoles remain at the university breeding facility and will be released when the weather warms.

Costs for managing the breeding individuals are currently assumed by both NCIG and PWCS. PWCS did not utilise the breeding facility during the 2014/15 season.

5. Green and Golden Bell Frog Compensatory Habitat

5.1. Green and Golden Bell Frog Population

Breeding during the 2014/15 season in the NCIG Green and Golden Bell Frog Compensatory Habitat was reported in the previous Quarterly Report. In the interim, monitoring of the compensatory habitat has ceased during the winter months. NCIG will have a dedicated resource from the University of Newcastle to monitor the compensatory habitat starting in the 2015/16 season.

5.2. Compensatory Habitat Management

Since confirming a breeding event in January/February 2015, a subsequent storm event in April caused Ash Island, including the NCIG Compensatory Habitat area, to experience significant flooding. The constructed habitat and NCIG Research Area (trial site) avoided significant damage from the event, with only a minor section of fencing around Stage 1 requiring repair. Due to high water levels and associated connectivity, Mosquito Fish (Gambusia holbrookii) has now been introduced into several of the constructed ponds, including the Research Area. NCIG is working with the University of Newcastle to identify the best method to drain ponds to manage Gambusia across the landscape.

It should be noted that draining of ponds will not commence until NPWS have approved the NCIG Green and Golden Bell Frog Compensatory Habitat Management Plan, which has been submitted as an Addendum to the current REF for the compensatory habitat area. An updated version of the plan is currently with NPWS for approval, after comments were provided by NPWS. It is expected that this will be approved in the coming weeks.

6. Shorebird Compensatory Habitat

6.1. Land Security

In-principle support of the Migratory Shorebird offset at Area E from the Environment Minister remains the current status from the government regarding land security. A signed Deed of Agreement between the Minister and NCIG is a step closer, now Determination has been given by OEH for migratory shorebird habitat creation, including mangrove removal (see below). This process will be further facilitated by updating the Compensatory Habitat and Ecological Monitoring Program (CHEMP) to include details of the mangrove removal process and other provisions of the REF, and subsequent approval of the updated CHEMP by Department of Planning and Environment. A s151 Licence will also be issued by NPWS for Area E with signing of the Deed of the Agreement.

6.2. Approvals

The Review of Environmental Factors (REF) for migratory shorebird habitat creation at Area E, including removal of 16 Ha of mangroves, has been positively determined by the Office of Environment and Heritage (OEH). The Determination has been provided with a number of conditions, which NCIG is expected to comply with. These conditions include restricting timing of habitat construction between May and October of any year, to avoid residence time of migratory species using neighbouring ponds. For this reason, construction of habitat is now scheduled to commence in May 2016. In the interim, NCIG will be conducting further testing and monitoring of the area, including detailed testing of Acid Sulfate Soils (ASS), and migratory shorebird and benthic invertebrate monitoring. Monitoring will be coordinated with LLS – KWRP to avoid duplicating monitoring efforts, where they are already required for the current Area E Hydrological Management MERI Plan.

In parallel with the above approval, NCIG has also sought third party advice on the requirement for a Part 7 Permit from Department of Primary Industries (DPI) – Fisheries for removal of mangroves. This advice has found that the requirement for a Part 7 Permit is absolved by the current Part 3A Major Project Approval for the NCIG CET, which includes conditions to provide migratory shorebird habitat. The relevant (now repealed but still effective) part of the *Environmental Planning and Assessment Act 1979*, makes Part 3A approvals exempt to a number of other departmental approvals and permits, including a DPI Part 7 Permit. Once the updated CHEMP has been provided to and approved by the Department of Planning and Environment, removal of mangroves may proceed, in effect, as part of the approved of the NCIG CET Project.

7. Shorebird Monitoring

7.1. Overview

Monitoring of Area E for shorebird usage continued throughout the latest quarter. Monitoring took place each month on 9 April, 5 May and 18 June. For background information, please refer to the previous NCIG Quarter 1, 2015 CHEMP Report.

7.2. Methods

Surveys were conducted along pre-determined transects at the project site as well as at reference sites in the Hunter River Estuary (Table 7-1). Survey date, time, tide height, weather, abundance and behaviour of birds were recorded, along with any observed disturbances.

Table 7-1. Survey sites

Location	Subsite
Area E: Project site	Fish Fry Flats Fish Fry Creek Wader Creek
Area E: Reference sites	Wader Pond Swan Pond
Hunter River Estuary	Milham's Pond Phoenix Flats Hexham Swamp Kooragang Dykes Stockton Sandspit & Channel

7.3. Results

A total of 17 species of shorebirds were observed during the April-June 2015 survey period, including 7 resident and 10 migratory species (Tables 7-2 and 7-3). However, no birds were observed using the Area E Project site, with species only recorded in the neighbouring reference sites. The most abundant species recorded across the Area E reference sites was the resident Red-necked Avocet, with a peak count of 1,410 at low tide – see Appendix A. The only migratory species sighted at Area E was the Sharp-tailed Sandpiper.

Monitoring of shorebirds at the project site and reference sites will continue on a monthly basis during the “off-peak” migratory bird season (April- August 2015), increasing to fortnightly from September with the return of key migratory species. Detailed survey results are provided in an appendix.

Table 7-2. All shorebird species observed in Area E, Apr-Jul 2015

Species	Project Area	Reference Area	EPBC listing	TSC listing
Black-winged Stilt	No	Yes		
Red-necked Avocet	No	Yes		
Black-fronted Dotterel	No	Yes		
Sharp-tailed Sandpiper	No	Yes	Migratory	

Table 7-3. All shorebird species observed in other Hunter Estuary locations, Apr-Jul 2015

Species	EPBC listing	TSC listing
Pied Oystercatcher		Endangered
Sooty Oystercatcher		Vulnerable
Black-winged Stilt		
Red-necked Avocet		
Pacific Golden Plover	Migratory	
Red-capped Plover		
Black-fronted Dotterel		
Red-kneed Dotterel		
Black-tailed Godwit	Migratory	Vulnerable
Bar-tailed Godwit	Migratory	
Eastern Curlew	Migratory	
Grey-tailed Tattler	Migratory	
Red-necked Stint	Migratory	
Sharp-tailed Sandpiper	Migratory	
Curlew Sandpiper	Migratory	Endangered
Red Knot	Migratory	
Terek Sandpiper	Migratory	Vulnerable

8. NCIG Compensatory Habitat Schedule

A copy of the NCIG Compensatory Habitat Schedule of Works for Migratory Shorebirds is not provided as part of this report. The timing of works is currently being redeveloped, subject to the Determination conditions provided by OEH.

Appendix A – NCIG Shorebird Compensatory Habitat Monitoring (Avifauna Research and Services)

9/04/15

Low Tide	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Area E
	NW Pond	Wader Creek	Fish Fry Creek	Fish Fry Flat	Little Fish Fry Flat	Wader Creek Lagoon	Swan Pond South	Swan Pond Main	Wader Pond
Black-winged Stilt	0	0	0	0	0	0	52	18	190
Common Greenshank	0	0	0	0	0	0	0	0	0
Eastern Curlew	0	0	0	0	0	0	0	0	0
Masked Lapwing	0	0	0	0	0	0	2	0	2
Pacific Golden Plover	0	0	0	0	0	0	0	0	0
Red-necked Avocet	0	0	0	0	0	0	64	1308	320
Sharp-tailed Sandpiper	0	0	0	0	0	0	0	0	4

High Tide	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Hunter Estuary	Hunter Estuary	Hunter Estuary	Hunter Estuary	Hunter Estuary	Hunter Estuary	Hunter Estuary
	NW Pond	Wader Creek	Fish Fry Creek	Fish Fry Flat	Little Fish Fry Flat	Wader Creek Lagoon	Swan Pond South	Swan Pond Main	Wader Pond	Stockton Sandspit	Stockton Channel	Kooragang Dykes	Fern Bay/northern arm sandflat	Hexham Swamp	Milham Pond	Phoenix flat
Bar-tailed Godwit	0	0	0	0	0	0	0	0	0	0	0	126	0	0	0	0
Black-fronted Dotterel	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	1
Black-tailed Godwit	0	0	0	0	0	0	0	0	0	0	0	37	0	0	0	0
Black-winged Stilt	0	0	0	0	0	0	57	14	140	118	0	169	0	850	0	0
Common Greenshank	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Curlew Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eastern Curlew	0	0	0	0	0	0	0	0	0	12	0	0	0	0	13	0
Grey-tailed Tattler	0	0	0	0	0	0	0	0	0	0	6	0	26	0	0	0
Marsh Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Masked Lapwing	0	0	0	0	0	0	0	4	0	0	0	8	0	18	2	0
Pacific Golden Plover	0	0	0	0	0	0	0	0	0	25	5	98	0	0	0	0
Pied Oystercatcher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-capped Plover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Red-kneed Dotterel	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
Red-necked Avocet	0	0	0	0	0	0	30	1112	150	650	0	0	0	0	0	0
Red-necked Stint	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0
Sharp-tailed Sandpiper	0	0	0	0	0	0	0	0	0	0	0	1685	0	50	0	0
Sooty Oystercatcher	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Terek Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0

5/05/15													
Low Tide	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Area E				
	NW Pond	Wader Creek	Fish Fry Creek	Fish Fry Flat	Little Fish Fry Flat	Wader Creek Lagoon	Swan Pond South	Swan Pond Main	Wader Pond				
Black-fronted Dotterel	0	0	0	0	0	0	3	0	0				
Black-winged Stilt	0	0	0	0	0	0	5	130	0				
Common Greenshank	0	0	0	0	0	0	0	0	0				
Eastern Curlew	0	0	0	0	0	0	0	0	0				
Masked Lapwing	0	0	0	0	0	0	2	2	1				
Pacific Golden Plover	0	0	0	0	0	0	0	0	0				
Red-necked Avocet	0	0	0	0	0	0	57	565	380				
Sharp-tailed Sandpiper	0	0	0	0	0	0	0	0	0				
High Tide	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Hunter Estuary	Hunter Estuary	Hunter Estuary	Hunter Estuary
	NW Pond	Wader Creek	Fish Fry Creek	Fish Fry Flat	Little Fish Fry Flat	Wader Creek Lagoon	Swan Pond South	Swan Pond Main	Wader Pond	Stockton Sandspit	Stockton Channel	Kooragang Dykes	Phoenix flat
Bar-tailed Godwit	0	0	0	0	0	0	0	0	0	0	0	1	0
Black-tailed Godwit	0	0	0	0	0	0	0	0	0	0	0	0	0
Black-winged Stilt	0	0	0	0	0	0	0	150	0	120	0	17	0
Common Greenshank	0	0	0	0	0	0	0	0	0	0	0	0	0
Curlew Sandpiper	0	0	0	0	0	0	0	0	0	1	0	0	0
Eastern Curlew	0	0	0	0	0	0	0	0	0	0	0	15	0
Grey-tailed Tattler	0	0	0	0	0	0	0	0	0	0	0	0	0
Marsh Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	0
Masked Lapwing	0	0	0	0	0	0	0	1	2	0	0	0	2
Pacific Golden Plover	0	0	0	0	0	0	0	0	0	0	0	0	0
Pied Oystercatcher	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-necked Avocet	0	0	0	0	0	0	35	469	1100	380	0	0	0
Sharp-tailed Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	0
Sooty Oystercatcher	0	0	0	0	0	0	0	0	0	0	0	7	0

18/06/15												
Low Tide	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Hunter Estuary		
	NW Pond	Wader Creek	Fish Fry Creek	Fish Fry Flat	Little Fish Fry Flat	Wader Creek Lagoon	Swan Pond South	Swan Pond Main	Wader Pond	Hexham Swamp		
Black-fronted Dotterel	0	0	0	0	0	0	0	0	1	0		
Black-winged Stilt	0	0	0	0	0	0	6	27	4	188		
Common Greenshank	0	0	0	0	0	0	0	0	0	0		
Eastern Curlew	0	0	0	0	0	0	0	0	0	0		
Masked Lapwing	1	0	0	0	0	0	0	12	14	4		
Pacific Golden Plover	0	0	0	0	0	0	0	0	0	0		
Red-necked Avocet	0	0	0	0	0	0	10	1410	17	322		
Sharp-tailed Sandpiper	0	0	0	0	0	0	0	0	0	0		
High Tide	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Area E	Hunter Estuary	Hunter Estuary	Hunter Estuary
	NW Pond	Wader Creek	Fish Fry Creek	Fish Fry Flat	Little Fish Fry Flat	Wader Creek Lagoon	Swan Pond South	Swan Pond Main	Wader Pond	Stockton Sandspit	Stockton Channel	Kooragang Dykes
Bar-tailed Godwit	0	0	0	0	0	0	0	0	0	73	0	97
Black-tailed Godwit	0	0	0	0	0	0	0	0	0	0	0	0
Black-winged Stilt	0	0	0	0	0	0	8	0	6	56	0	140
Common Greenshank	0	0	0	0	0	0	0	0	0	0	0	0
Curlew Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0
Eastern Curlew	0	0	0	0	0	0	0	0	0	10	0	14
Grey-tailed Tattler	0	0	0	0	0	0	0	0	0	0	0	0
Marsh Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0
Masked Lapwing	0	0	0	0	0	0	0	2	12	0	0	2
Pacific Golden Plover	0	0	0	0	0	0	0	0	0	1	0	0
Pied Oystercatcher	0	0	0	0	0	0	0	0	0	4	0	4
Red-capped Plover	0	0	0	0	0	0	0	0	0	2	0	0
Red Knot	0	0	0	0	0	0	0	0	0	1	0	0
Red-necked Avocet	0	0	0	0	0	0	4	314	1	2200	0	2
Sharp-tailed Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0

Newcastle Coal
INFRASTRUCTURE GROUP

Compensatory Habitat and Ecological Monitoring Program – Quarterly Report

DATE: *14 December 2015*

AUTHOR: Philip Reid, Alex Callen (Uni of Newcastle), Phil Straw (Avifauna), Tim Mouton (Wetland Care Australia)

APPROVAL: Nathan Juchau

INTRODUCTION

This report provides an update of activities relating to the NCIG Compensatory Habitat and Ecological Monitoring Program since the previous Quarterly Report from 21 October 2015. The report aims to provide information on key components of the program and how these are being implemented. An update will be provided to members of the Consultative Board every 3 months, in the form of a Quarterly report and presentations (every 6 months) coinciding with Board Meetings.

1. Research Area Ponds and Associated Monitoring (Alex Callen)

1.1. Overview

The 16 pond environment at the NCIG trial site ('the trial site') provides a pond choice experiment for a green and golden bell frog reintroduction program using a 2x2 replicated factorial design with pond depth and salinity as treatments to determine pond preference and the potential for passive chytrid management. Pond depth treatments were; deep – permanent water (1.5m); and shallow – ephemeral water (0.5m). Salinity treatments comprised artificially salted ponds - to 3‰ using naturally derived sea salt and control ponds where background salinity levels remained unmanipulated ('not dosed'). Some deep control ponds have been influenced by background salinity from groundwater intrusion.

The reintroduction program involved two primary release periods of bell frog propagules as tadpoles and metamorphs. Between February and March 2013 8,000 tadpoles and/or newly metamorphosed bell frogs were introduced into the trial site (see previous reports for details and outcomes). A further 12,000 tadpoles and/or newly metamorphosed bell frogs were released to the site between December 2013 and February 2014 (see previous reports for details and outcomes).

The bell frog population within the trial site results from the growth and development of these introduced animals, and represent two cohorts, one that reached two years of age in the summer of 2014/15 and the second that reach one year of age in the summer of 2014/2015. This is an important aspect of the reintroduction program as female bell frogs are presumed not to reach sexual maturity (under conditions applying in mid-latitudinal, temperate, coastal environments) until at least two years of age, which means natural recruitment (that is, breeding within the population) cannot occur until year two of the program. Survival of adults into the first potential breeding season (the summer of 2014/15) in the presence of disease and predation was crucial and it was for this reason that the second cohort was released – to provide a dynamic age class that would close the gap on recruitment that would occur in a reintroduction for this species, thus providing a greater chance of adult survival to breeding.

This section provides an update about trial site activities since the Winter 2015 report.

1.2. Site conditions

Evening survey work ceased 9 April 2015 with a noticeable decline in the number of frogs detected, corresponding with minimum nighttime temperatures dropping to below 15°C. These surveys recommenced in early October, at least one month later than in previous years, due to the cooler than average evening spring temperatures. Several heavy rainfall events has kept ponds at full capacity since the April east coast low and ephemeral depressions that connect some ponds have only recently dried.

1.2.1. Pond depth and salinity

All ponds have remained at near or full capacity since April with deep ponds having a mean depth of greater than 135cm and shallow ponds having a mean depth of greater than 45cm. This excludes ponds 6, 9, 10 and 14 which have been drained as part of a gambusia control program and are now gradually replenishing with groundwater ingress and rainfall.

Treatment ponds were originally dosed to achieve a salinity threshold of 3‰ and have not been re-dosed with marine-derived sea salt since April 2014. Salinity concentrations fluctuate in response to natural environmental conditions (evaporation and rainfall) with periods of heavy rainfall in April, October and November diluting the dosing concentration to averages of less than 1‰ for both shallow and deep ponds, irrespective of salinity treatments. Salinity concentrations are expected to remain low until such time as pond water levels drop as a result of increased evaporation due to warmer air temperatures. The exceptions to these mean salinities are ponds 6, 9, 14 (shallow) and 10 (deep) as these ponds have been drained in an attempt to control gambusia. These ponds were all dosed with salt as part of the trial and the shallow ponds currently have a mean salinity of 2.2‰ and pond 10 has a mean salinity of 3.8‰.

1.2.2. Tadpoles

The late onset of breeding at the NCIG trial site caused a proportion of tadpoles to overwinter. Morphometrics and chytrid infection status of these tadpoles was monitored to track growth and infection load over the cooler months and into spring. Infection was not detected in tadpoles through winter, however it was detected in late October in tadpoles removed from ponds where draining for gambusia occurred. Metamorphs have not been detected in any ponds since evening surveys recommenced in October.

1.2.3. Gambusia

Gambusia entered the site as a result of localised flooding of Ash Island during the 2015 April East Coast Low. As a result of the interconnectedness of some of the ponds at the site, the predatory fish now inhabits 13 of the 16 ponds at the site, including four of the six ponds containing bell frog tadpoles from summer breeding. Trials to drain ponds to remove gambusia commenced in late October. Water was pumped from the ponds through a fine sieve structure to prevent mastication of soft-bodied organisms such as the fish and tadpoles. As water levels dropped, dipnets were used to catch fish and tadpoles. Tadpoles were weighed, measured and swabbed before being released to gambusia-free ponds, and fish were euthanised in an ice slurry.

Complete elimination of both water and fish from drained ponds has proven to be logistically challenging. Ponds are generally unable to be completely drained in one day, and rainfall and groundwater ingress prevents complete drying. As a result, some fish remain in the drained ponds.

1.3. Bell frog research

1.3.1. Pond preference

Preliminary modelling (generalised additive mixed modelling) on the first two years of data suggests that frogs do not exhibit a preference for ponds in relation to salinity concentrations but that there may be a slight preference for ponds with permanent water. Further analysis will incorporate detectability as a function of vegetation density to explore the relationship between pond depth and frog occupancy to validate this finding.

1.3.2. Detection of frogs

Evening surveys recommenced mid-Spring, with low detection of frogs. The numbers of frogs detected have not increased substantially as ambient air temperatures continue to warm and only one gravid (sexually mature) female has been detected within the site. Males have been observed to call in up to three ponds, singly or in twos and threes, in both gambusia-infested and gambusia free ponds. Not more than 25 frogs have been detected in each survey period across the site since Winter, compared with more than 40 frogs routinely detected in similar surveys in the preceding season.

2. Annual Green and Golden Bell Frog Monitoring

Monitoring of the industrial area of Kooragang Island is commencing in December 2015. This will include three monitoring events conducted throughout the season, and will take place at multiple water bodies across the industrial part of Kooragang Island and some areas of Ash Island (southern end near the Kooragang Main Rail Line). The 2015/16 monitoring will be jointly-funded by

NCIG, Port Waratah Coal Services and the Hunter Development Corporation, due to potential impacts from future capping of the former Kooragang Island Waste Emplacement Facility (KIWEF).

3. Breeding Program

Captive bred tadpoles have been released into Stage 5 of the NCIG GGBF Compensatory Habitat (Pond 16) during the week of 1 December 2015. These are the only ponds of the compensatory habitat that are not infested with gambusia. Water quality of ponds were confirmed as suitable and tadpoles in baskets have shown 100% survival. Tadpoles were confirmed as free of chytrid.

NCIG will continue to utilise the breeding facility during the 2015/16 season, with tadpoles and metamorphs intended to be released into other GGBF Compensatory Habitat ponds where suitable. This means that some ponds are planned to be pumped down to remove Gambusia, eg. smaller ponds such as Ponds 2 and 3 – Stage 1, Pond 10 – Stage 4 and Ponds 12 and 13 – Stage 6. Costs for managing the breeding individuals are currently assumed by both NCIG and PWCS. PWCS will not utilise the breeding facility during the 2015/16 season.

4. Green and Golden Bell Frog Compensatory Habitat

4.1. Green and Golden Bell Frog Population

No active monitoring of the Compensatory Habitat was conducted during the reporting period. The University of Newcastle has chosen a suitable candidate for the PhD position to conduct monitoring and research of the Green and Golden Bell Frog Compensatory Habitat. This student is expected to commence by the end of December 2015.

4.2. Compensatory Habitat Management

The NCIG has commenced monitoring and management of compensatory habitat in accordance with the approved Green and Golden Bell Frog Compensatory Habitat Management Plan. Work during the reporting period has been conducted by Wetland Care Australia (WCA) and includes:

- Pond inspections, including visual inspections, photo points, water quality monitoring and monitoring for evidence of pests
- Pond buffer zone transects
- Vegetation transects
- Fox baiting, including establishment of 8 bait stations, installation of signage and notification to nearby properties. Baits are checked weekly with several baits taken to date.
- Manual weeding of pond buffers

An observation was also made by WCA of an adult Bell Frog in Stage 1 during the reporting period – see Figure 1. A copy of the monitoring and maintenance report is provided in Appendix A.

Figure 1 – Green and Golden Bell Frog observed at Pond 1, Stage 1.

NCIG has requested a proposal from WCA to commence pumping a selection of ponds to assist in control of Gambusia, as mentioned in Section 5. It is planned that these ponds will be utilised for further releases of captive-bred bell frogs during the season, pending success of Gambusia management, and may also require filling with potable water where needed.

5. Shorebird Compensatory Habitat

5.1. Land Security and Approvals

NCIG received approval of the revised CHEMP from the Department of Planning and the Environment (DPE) on 7 December 2015. This updated version includes changes requested by DPE after an initial review on 11 November 2015. The approved CHEMP is a critical document in facilitating the removal of mangroves and the creation of migratory shorebird habitat at Area E, Ash Island.

The Section 151 Licence and Deed of Agreement have been updated by NCIG following the approval of the CHEMP and have been signed by the NCIG Board of Directors. A copy of these documents have been sent through to NPWS for final agreement and signing by the NSW Minister for the Environment.

6. Shorebird Monitoring

6.1. Overview

Monitoring of Area E for shorebird usage continued throughout the latest quarter, from October to 3 December (Appendix B). Monitoring is currently conducted fortnightly dring the 'peak' season. Monitoring of Area E commenced in April 2015.

6.2. Methods

Surveys were conducted along pre-determined transects at the project site as well as at reference sites in the Hunter River Estuary (Table 7-1). Survey date, time, tide height, weather, abundance and behaviour of birds were recorded, along with any observed disturbances.

Table 7-1. Survey sites

Location	Subsite
Area E: Project site	Fish Fry Flats Fish Fry Creek Wader Creek
Area E: Reference sites	Wader Pond Swan Pond
Hunter River Estuary	Milham's Pond Phoenix Flats Hexham Swamp Kooragang Dykes Stockton Sandspit & Channel

6.3. Results

A total of 22 species of shorebirds were observed during the October to first week in December 2015 survey period, including 7 resident and 15 migratory species (Table 7-2). The most abundant species recorded across Area E reference sites was the resident Black-winged Stilt, with a peak count of 1,407 at high tide and 1,489 at low tide. The most common migratory species sighted adjacent to Area E included the included Bar-tailed and Black-tailed Godwit, Common Greenshank and Marsh Sandpiper; while the Hunter Estuary subsites supported higher numbers of most migratory shorebirds including Sharp-tailed Sandpiper, Whimbrel, Eastern Curlew, Curlew Sandpiper, Pacific Golden Plover, Bar-tailed and Black-tailed Godwit, Common Greenshank and Marsh Sandpiper.

Shorebirds were typically observed feeding and roosting in response to tidal fluctuation, although there was little variation in total abundance of shorebirds present between high and low tides at Area E. No disturbances were noted during this survey period.

As expected prior to the restoration works, no shorebird species were recorded at the project site (Fish Fry Flats, Fish Fry and Wader Creeks) prior to the removal of mangroves. Small numbers of waterbirds were present, including Teals, Cormorants and Egrets.

Nocturnal surveys commenced on 25 September and will be carried out fortnightly throughout the peak season, Nocturnal surveys found quite different usagae of wetland sites by shorebirds compared with diurnal sites.

Monitoring of shorebirds at the project site and reference sites will continue on a monthly basis during the “off-peak” migratory bird season (April-August 2015), increasing to fortnightly from September 2015 – March 2016 with the return of key migratory species.

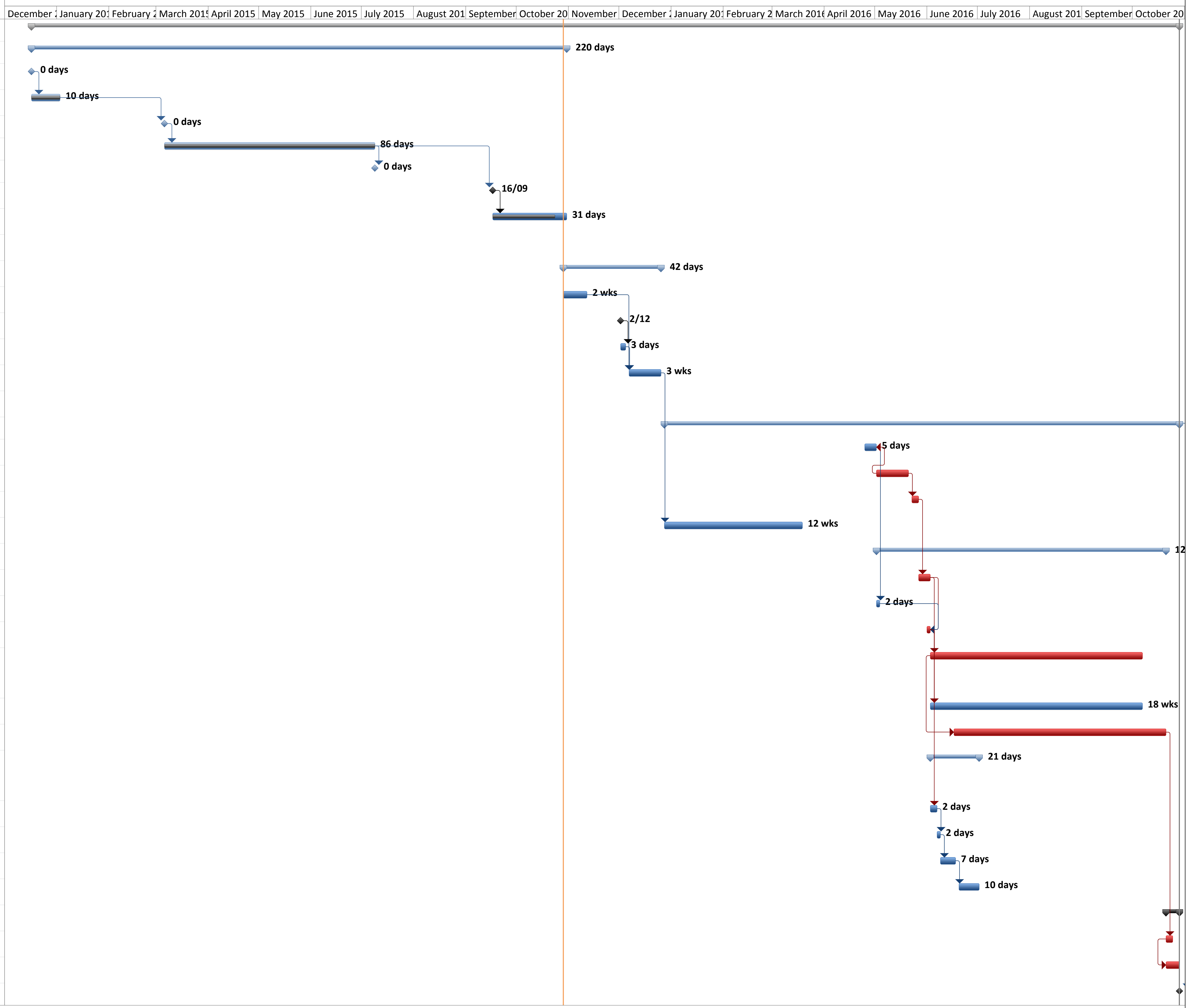
Table 7-2. All shorebird species observed in other Hunter Estuary locations, Oct-Dec 2015

Species	EPBC listing	TSC listing
Pied Oystercatcher		Endangered
Sooty Oystercatcher		Vulnerable
Black-winged Stilt		
Red-necked Avocet		
Pacific Golden Plover	Migratory	
Red-capped Plover		
Black-fronted Dotterel		
Red-kneed Dotterel		
Black-tailed Godwit	Migratory	Vulnerable
Bar-tailed Godwit	Migratory	
Whimbrel	Migratory	
Eastern Curlew	Migratory	
Terek Sandpiper	Migratory	Vulnerable
Grey-tailed Tattler	Migratory	
Common Greenshank	Migratory	
Marsh Sandpiper	Migratory	
Ruddy Turnstone		
Great Knot		
Red Knot		
Red-necked Stint	Migratory	
Sharp-tailed Sandpiper	Migratory	
Curlew Sandpiper	Migratory	Endangered

7. NCIG Compensatory Habitat Schedule

A copy of the NCIG Compensatory Habitat Schedule of Works for Migratory Shorebirds is provided as part of this report. This has been updated to reflect construction timing in accordance with the REF conditions.

ID	Task Mode	Task Name	Duration	Start	Finish
0		**Shorebirds Compensatory Habitat**	**480 days**	**Wed 17/12/14**	**Fri 28/10/16**
1		**Project Approval**	220 days	Wed 17/12/14	Fri 30/10/15
2		Submit REF	0 days	Wed 17/12/14	Wed 17/12/14
3		OEH REF Preliminary Review	10 days	Wed 17/12/14	Fri 2/01/15
4		Resubmit REF addressing comments	0 days	Thu 5/03/15	Thu 5/03/15
5		Review of REF (inc. consultation)	86 days	Fri 6/03/15	Wed 8/07/15
6		REF Approval	0 days	Wed 8/07/15	Wed 8/07/15
7		Submit revised CHEMP	0 days	Wed 16/09/15	Wed 16/09/15
8		Approval of CHEMP	31 days	Thu 17/09/15	Fri 30/10/15
9					
10		**Land Tenure**	42 days	Thu 29/10/15	Fri 25/12/15
11		NCIG Finalise and sign Deed of Agreement	2 wks	Thu 29/10/15	Wed 11/11/15
12		Obtain s 151 license from NPWS	0 days	Wed 2/12/15	Wed 2/12/15
13		NCIG to sign s 151 license	3 days	Wed 2/12/15	Fri 4/12/15
14		Minister for the Environment to Execute Deed	3 wks	Mon 7/12/15	Fri 25/12/15
15					
16		**Construction**	**220 days**	**Mon 28/12/15**	**Fri 28/10/16**
17		Mobilise to site	5 days	Mon 25/04/16	Mon 2/05/16
18		Establish Exclusion Zones	15 days	Mon 2/05/16	Fri 20/05/16
19		Sediment Control	4 days	Mon 23/05/16	Thu 26/05/16
20		Procure smart Gate and Seed control Structure	12 wks	Mon 28/12/15	Fri 18/03/16
21		**Mangrove Removal**	**124 days**	**Mon 2/05/16**	**Thu 20/10/16**
22		Adjust Water levels	5 days	Fri 27/05/16	Thu 2/06/16
23		Adapt / Mod existing wader pond drainage	2 days	Mon 2/05/16	Tue 3/05/16
24		Mobilise and Establish Plant	2 days	Wed 1/06/16	Thu 2/06/16
25		Mechanical Mangrove Removal (2 crews @ 1250m2/d each)	18 wks	Fri 3/06/16	Thu 6/10/16
26		Manual Mangrove Removal	18 wks	Fri 3/06/16	Thu 6/10/16
27		Mulching	18 wks	Fri 17/06/16	Thu 20/10/16
28		**Construction of Smart Gate and Seed Control Structure**	**21 days**	**Fri 3/06/16**	**Fri 1/07/16**
29		Construct internal coffer dam	2 days	Fri 3/06/16	Mon 6/06/16
30		Construct external coffer dam	2 days	Tue 7/06/16	Wed 8/06/16
31		Install Smart Gates	7 days	Thu 9/06/16	Fri 17/06/16
32		Install mangrove seed screen	10 days	Mon 20/06/16	Fri 1/07/16
33		**Demobilise**	**6 days**	**Fri 21/10/16**	**Fri 28/10/16**
34		Demobilise plant	2 days	Fri 21/10/16	Mon 24/10/16
35		Remove all fencing and water controls	6 days	Fri 21/10/16	Fri 28/10/16
36		**Project Completion**	**0 days**	**Fri 28/10/16**	**Fri 28/10/16**



Task		Summary		External Milestone		Inactive Summary	
Split		Project Summary		Inactive Task		Manual Task	
Milestone		External Tasks		Inactive Milestone		Duration-only	
Manual Summary Rollup		Finish-only		Critical Split			
Manual Summary		Deadline		Progress			
Start-only		Critical					

Project: Shorebirds Compensator
Date: Thu 29/10/15

Appendix A – NCIG GGBF Compensatory Habitat Project, Monitoring and Maintenance Report, October 2015 (Wetland Care Australia).

wetlandcare australia

NCIG GGBF Compensatory Habitat Project

Monitoring and Maintenance Report

October 2015

Version	Author	Date	Review	Date
1	T. Mouton	9-11-2015	L. Duff	12-11-2015

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Specialising in wetland management and rehabilitation since 1991

Introduction

The Newcastle Coal and Infrastructure Group (NCIG) developed a 78ha Compensatory Habitat and Ecological Monitoring Program (CHEMP), to offset areas lost as a result of the NCIG CET. The compensatory habitat comprises 18 constructed ponds. WetlandCare Australia has prepared a Green and Golden Bell Compensatory Habitat Management Plan (GGBF CHMP) based on requirements contained in the CHEMP, which sets out the methodology of site management and monitoring requirements for the ponds. The GGBF CHMP has been approved by the Office of Environment and Heritage, and forms part of the NCIG project approval.

This report contains a monthly summary of site works and monitoring results undertaken as part of the GGBF CHMP.

Works Undertaken

The program of monitoring and maintenance works commenced on the 12th October 2015. The following works were undertaken this period:

Monitoring

- Pond inspections and monitoring, involving:
  - Visual inspection of pond condition and structure
  - Photo points established at each pond
  - Water quality monitoring
  - Monitoring for evidence of pest species (feral animals and noxious weeds)

  Results from these inspections and management recommendations are contained in Appendix A. Photo points are contained in Appendix E.
- Monitoring transects were established within pond buffers, and the first round of vegetation monitoring undertaken over three days between 21/10/15-29/10/15. Vegetation transect data is contained in Appendix D.

Maintenance

- Fox baiting commenced on the 13/10/2015, which included establishment of 8 bait stations, installation of signage and notifications to surrounding properties. Bait stations were checked three times during this period (weekly). Fox baiting records are contained in Appendix C.
- Manual weeding was undertaken in pond buffers by a CVA Better Earth team (9 volunteers and 1 supervisor), over a period of 3 days (28-30 November 2015).

Appendix B contains the schedule of works undertaken during October, and works forecast for the following month in November.

Key Outcomes

Monitoring

Water Quality

- Salinity (Target range 0-4 ppt tadpoles; 0-6 ppt frogs)
  - All ponds were within the acceptable salinity range for frogs.
  - Pond 11 was just above the salinity range for tadpoles at 4.47 ppt.
- pH (Target range 4-9)
  - Pond pH ranged between 7 – 10.
  - 6 ponds (3,5,6,11,17,18) had a pH greater than 9, pond 5 being the highest at 10.05.
  - This could be due to residual lime still present in pond substrates buffering pond pH.
- DO (Target range 4-17)
  - Dissolved oxygen levels were all within the acceptable range.
- Depth
  - Water levels in the majority of ponds were in excess of their design depth.
  - The ponds ranged in depth from 0.6m – 2m+
- Temperature (Target range 16-31^{0}C tadpoles; 4-35^{0}C frogs)
  - Pond temperatures were all within the acceptable range.

Vegetation Transects

- Native vegetation coverage and density within the buffers was generally poor overall, with bare ground and weeds dominating coverage in many ponds. Ponds of particular concern are 8, 9, 17, 18.
- Ponds 1, 2, 4, 10, 11, 14 had well developed vegetation structure in buffers and emergent zone.

Pest Species

- Gambusia were observed in 16/18 ponds.
- Ponds 15 and 16 were Gambusia free.
- Small infestations of Alligator Weed were observed in ponds 1 and 5. A moderate infestation was observed in the macrophyte trench adjacent to Pond 1.
- A small infestation of Sharp Rush was observed in pond 4.

Other Observations

One Green and Golden Bell Frog was observed opportunistically during monitoring (see Photo 1). This was an adult located in Pond 1 within emergent Typha and Eleocharis, and was observed calling.

Photo 1 - GGBF observed in Pond 1

Maintenance

<u>Fox Baiting</u>

- 6 baits were taken during the period. Observations from tracks indicate that they were taken by a fox on all occasions.
- High activity was recorded at Station 6, with 3 out of 3 baits taken.
- 2 out of 3 baits were taken at Station 7, and 1 out of 3 at Station 1.
- 2 signs were damaged/taken and replaced.

<u>Weed Control</u>

- Manual weeding was undertaken in pond buffers, with the exception of ponds 1, 2, 3, 10 and 11. Vegetation transect monitoring determined that weeding was not required at these ponds, as native vegetation and macrophyte coverage was sufficient to prevent significant weed invasion. Weeding focused on removal of invasive grasses and annual weeds on the pond banks and around native macrophytes.
- Alligator Weed spraying within the macrophyte trench was programmed for this period, however adverse weather conditions prevented this from happening. This will be undertaken during the next period (November 2015).

Discussion & Recommendations

The pH in ponds exceeding 9 should be monitored closely during the next monitoring round, to assess if additional management is required. If pH still exceeds acceptable levels, further advice may be required to determine suitable management.

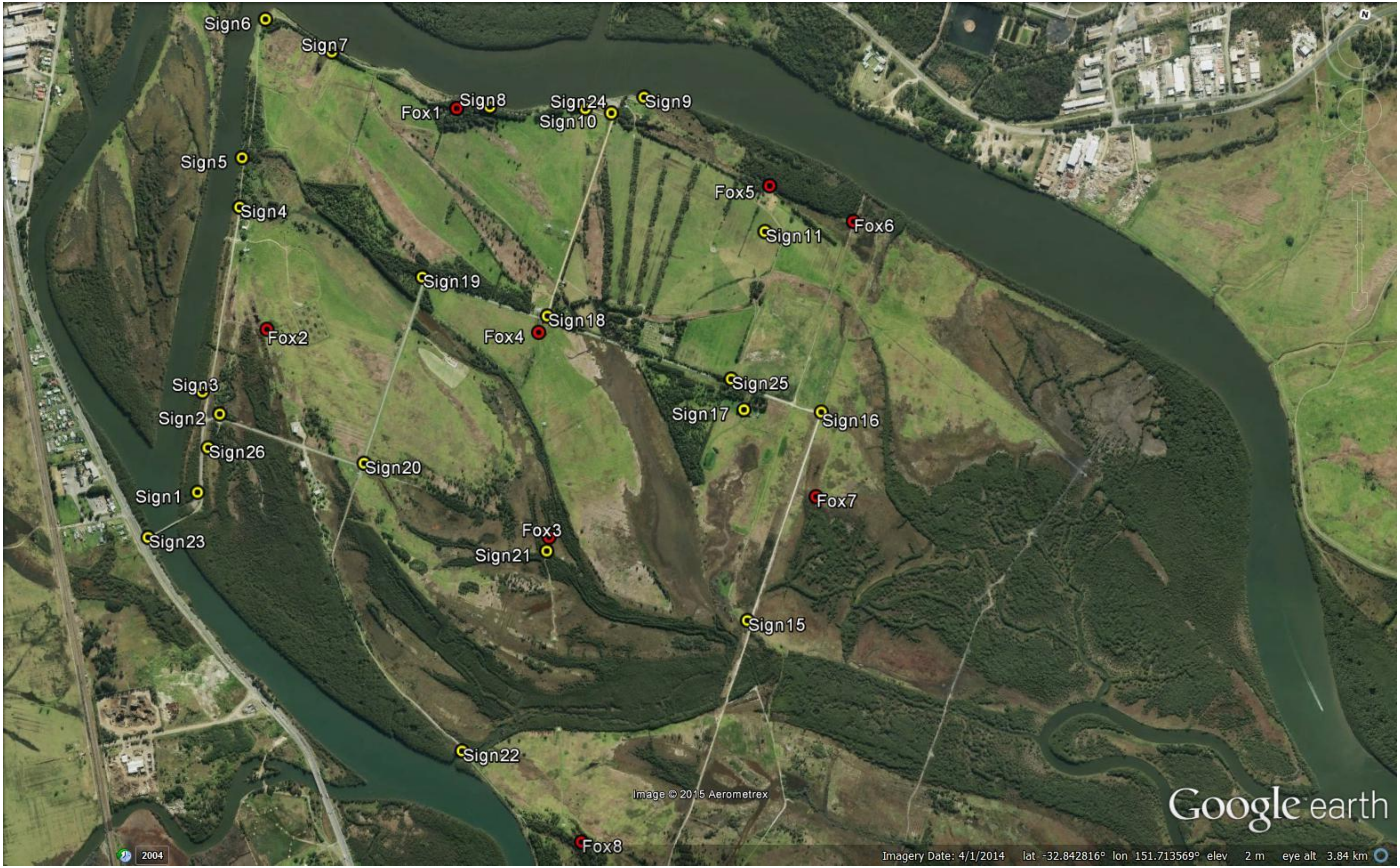
Additional planting of macrophytes should be undertaken within the buffers and banks of ponds 8, 9, 17 and 18. Improving the condition of macrophyte and buffer vegetation will increase stability on pond banks, and quality of habitat. It will also assist in improving water quality, in particular oxygenating the pond water and reducing algal blooms.

Further investigation into Gambusia management is required, to determine the feasibility of active measures such as dewatering ponds to remove Gambusia. Passive measures such as macrophyte planting will increase vegetation coverage and refuge areas of tadpoles and frogs.

Removal of Alligator Weed and Sharp Rush in ponds 1, 4 and 5 will be undertaken mid-November during the next weed control session.

Photo Point Locations

Fox Control Sites & Signage




Fox8
Sign14
Sign13
Sign12
Image © 2015 Aerometrex
Google earth
2004
Imagery Date: 4/1/2014 lat -32.865440° lon 151.721582° elev 2 m eye alt 3.84 km

Appendix A – Monitoring Results

Date	21/22 & 28/29 October 2015
Breeding Season (Oct-Dec)?	**Yes** / No
Name of Inspector/s	Tim Mouton, Will McCaffrey
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds
WEATHER	Overcast/Wet during WQ monitoring, Sunny/warm during vegetation transect monitoring
Temperature	21.8 – 33.5
Total rainfall over preceding 3 days	1.8 mm
Total rainfall over preceding month	11.8 mm

WATER QUALITY INSPECTION

Parameter	**Target Range**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Target Condition	Permanent ponds wet	**Wet**			**Wet**	**Wet**	**Wet**		**Wet**			**Wet**		**Wet**			**Wet**		
Wet/Dry		Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet
Design Depth m		1.4	0.2	0.4	1.4	1.4	1.2	0.6	1.0	0.2	0.4	1.0	0.2	1.2	0.4	0.6	2.2	0.4	0.2
Measured Depth m		>1.5	0.7	>1.5	0.6	>1.5	>1.5	>1.5	>1.5	1.1	>1.5	>1.5	1.2	1.25	1.25	0.6	>2.0	1	0.7
Temp ^{0}C	T: 16-31 F: 4-35	26.1	26.3	25.9	26.8	25.3	24.3	23.7	24.9	25.1	25.1	24.5	28.9	28.3	31.2	30.1	28.4	27.4	30
pH	4-9	8.96	8.08	9.16	8.45	10.05	9.01	8.05	7.96	7.75	7.53	9.08	8.13	8.28	8.58	8.52	8.6	9.45	9.45
Salinity uS/cm		3950	2720	2682	3296	3650	746	358	1003	4520	3598	6990	567	812	670	370	707	4459	4940
Salinity ppt	T < 4 F < 6	2.53	1.74	1.72	2.11	2.34	0.48	0.23	0.64	2.89	2.3	4.47	0.36	0.52	0.43	0.24	0.45	2.85	3.16
DO mg/L	4-17	14.4	5.05	11.71	4.99	7.41	4.87	5.79	5.25	5.48	6.13	5.6	6.17	5.17	7.9	7.3	5.84	8.58	6.41
Turbidity NTU	Not critical	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% Open Water	Min. 30% Max 70%	80	60	90	65	90	90	99	99	100	90	70	98	60	80	95	90	60	95
Meets Targets	Y/N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Action Required	Y/N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y

☞ **See Over**

WATER QUALITY ACTION				
POND	**Action Required**	**Due Date**	**Completion Date**	**Signed**
3,5,6,11,17,18	pH in ponds exceeding 9 should be monitored closely during the next monitoring round, to assess if additional management is required. If pH still exceeds acceptable levels, further advice may be required to determine suitable management.	19/11/15		
1,3,5,6,7,8,9,10, 12,14,15,16,18	Ponds are above the maximum acceptable level of open water percentage. This can be addressed by additional macrophyte planting (refer to Vegetation Actions below).	19/11/15		

NB: All vegetation work eg. removing macrophytes/in-fill planting should be recorded on the Vegetation Inspection Sheet

Date	Breeding Season (Oct-Dec) **Yes** / No			**Name of inspector/s** Tim Mouton, Will McCaffrey	
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds				
POND STUCTURE INSPECTION					
POND	**Is there evidence of leakage?**	**Is there evidence of erosion/sedimentation?**	**Action Required?**	**Define action**	**Date Complete**
1.	No	No	No		
2.	No	No	No		
3.	No	No	No		
4.	No	No	No		
5.	No	No	No		
6.	No	No	No		
7.	No	No	No		
8.	No	No	No		
9.	No	Yes	No	Sediment accumulation observed within pond, likely due to erosion from exposed banks/buffer. Banks and buffer need additional vegetation – see Vegetation Action below	
10.	No	No	No		
11.	No	No	No		
12.	No	No	No		
13.	No	No	No		
14.	No	No	No		
15.	No	Yes	No	Water turbid, no obvious signs of erosion. Take turbidity sample next monitoring period if still evident.	
16.	No	No	No		
17.	No	No	No		
18.	No	No	No		

All Actions Complete: Signed ________________ Date ________

Date	Breeding Season (Oct-Dec) **Yes** / No		Name of inspector/s Tim Mouton, Will McCaffrey			
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds					
POND NATIVE VEGETATION INSPECTION						
POND	**Emergent Vegetation % Cover of water body**	**Emergent Vegetation Density**	**Emergent vegetation Condition**	**Buffer Width**	**Buffer Density (Weed + Native)**	**Buffer Density (Native) %**
Target	**40-70% Cover of water body**	**> 50%**	**Good**	**1.5 m**	**> 50% total veg cover**	**> 50% native cover**
1.	20	60	Good	> 1.5m	96.8	40.9
2.	40	80	Good	< 1m	88.4	57
3.	10	10	Poor	< 1m	76	24
4.	35	80	Very Good	> 1.5m	73.7	39
5.	10	20	Average	1.5m	81	11.4
6.	10	30	Average	1.5m	77.8	37
7.	1	2	Very Poor	1.5m	79.8	13.5
8.	1	1	Very Poor	2-2.5m	73	6.3
9.	0	0	Very Poor	1.5m	70	4
10.	10	95	Very Good	> 1.5m	90.8	56.3
11.	15	85	Good	> 1.5m	97.6	57.1
12.	2	15	Poor	1-1.5m	87.8	28.9
13.	40	60	Good	> 1.5m	78.2	32.1
14.	20	80	Very Good	> 1.5m	89.5	48
15.	5	5	Average	2-2.5m	66.1	13.9
16.	10	5	Average	1.5m	97.3	34.2
17.	0	0	Very Poor	1-2m	81.4	0
18.	5	5	Very Poor	0.5-1m	66.7	0

POND NATIVE VEGETATION ACTION REQUIRED			
POND	**Action Required**	**Due Date**	**Completion Date**
8, 9, 17, 18	Additional planting of macrophytes should be undertaken, within buffers and pond banks.	TBD	

COMMENTS:

All Actions Complete: Signed ________________ Date ________

WEEDS	Alligator Weed Density Class	Juncus acutus Density Class	Blackberry Density Class	Action Required	Date Action Complete
POND				**See Maintenance Guidelines in NCIG GGBF CH POM**	
1.	2			1 very small patch coming under frog fence from access track. Manual removal required during next programmed weed control session.	
2.					
3.					
4.		2		1 small tussock present at western extent of pond. This will be retained as habitat, and only removed when monitoring indicates that suitable coverage of native macrophytes has established in this area.	
5.	2			1 very small patch on pond bank. Manual removal required during next programmed weed control session.	
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					

NB: Weed Density Classes. Class 2 = less than 1%. Class 3 = 1-10%. Class 4 = 11-50%. Class 5 > 50% **Actions Complete:** Signed ______________ Date ________

PREDATOR INSPECTION					
	Gambusia	**Fox Evidence**	**Action Required**	**Action Required**	**Date Complete**
POND	**Yes/No**	**scats/prints/kills**	**Y/N**		
1.	Yes		N	Gambusia sparse	
2.	Yes		N	Gambusia abundant	
3.	Yes		N	Gambusia abundant	
4.	Yes	Prints	N	Gambusia abundant	
5.	Yes	Scat	N	Gambusia abundant	
6.	Yes		N	Gambusia abundant	
7.	Yes	Scat	N	Gambusia very sparse	
8.	Yes		N	Gambusia very sparse	
9.	Yes		N	Gambusia very sparse	
10.	Yes		N	Gambusia very sparse	
11.	Yes		N	Gambusia sparse	
12.	Yes		N	Gambusia very sparse	
13.	Yes		N	Gambusia sparse	
14.	Yes		N	Gambusia sparse	
15.	No	Prints	N		
16.	No		N		
17.	Yes	Scat & Prints	N	Gambusia very abundant	
18.	Yes		N	Gambusia very abundant	

Actions Complete: Signed ________________ Date ________

Appendix B – Works Program

	Timeline																				
	Month	October																			
	Week	Week 3							Week 4							Week 5					
Projects	Task	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
NCIG	Fox baiting (2 man crew)																				
	Alligator Weed spraying (2 man crew)																				
	Monitoring (2 man crew)																				
	Macrophyte buffer weeding (CVA Better Earth - 10 man crew)																				
	Slashing tracks & frog fence (CVA Regen 2 man crew)																				
	Weeding sweep through site (CVA Regen 4 man crew)																				

November																													
Week 1								Week 2							Week 3							Week 5							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Appendix C – Fox Control Data

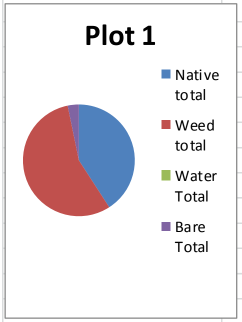
Site Name	Operator	Date	Station ID	Action	Observation	Bait Type	Toxin	Activity	Verification	Data Capture	Record
NCIG GGBF CH	P.Davidson	16/10/2015	1	Reset	Disturbed - Bait Taken	FoxOff	1080	Fox	Tracks	Survey	Data Sheet
NCIG GGBF CH	P.Davidson	16/10/2015	2	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	16/10/2015	3	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	16/10/2015	4	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	16/10/2015	5	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	16/10/2015	6	Reset	Disturbed - Bait Taken	FoxOff	1080	Fox	Tracks	Survey	Data Sheet
NCIG GGBF CH	P.Davidson	16/10/2015	7	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	16/10/2015	8	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	21/10/2015	1	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	21/10/2015	2	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	21/10/2015	3	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	21/10/2015	4	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	21/10/2015	5	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	21/10/2015	6	Reset	Disturbed - Bait Taken	FoxOff	1080	Fox	Tracks	Survey	Data Sheet
NCIG GGBF CH	P.Davidson	21/10/2015	7	Reset	Disturbed - Bait Taken	FoxOff	1080	Fox	Tracks	Survey	Data Sheet
NCIG GGBF CH	P.Davidson	21/10/2015	8	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	28/10/2015	1	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	28/10/2015	2	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	28/10/2015	3	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	28/10/2015	4	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	28/10/2015	5	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet
NCIG GGBF CH	P.Davidson	28/10/2015	6	Reset	Disturbed - Bait Taken	FoxOff	1080	Fox	Tracks	Survey	Data Sheet
NCIG GGBF CH	P.Davidson	28/10/2015	7	Reset	Disturbed - Bait Taken	FoxOff	1080	Fox	Tracks	Survey	Data Sheet
NCIG GGBF CH	P.Davidson	28/10/2015	8	Monitor only	Undisturbed	FoxOff	1080			Survey	Data Sheet

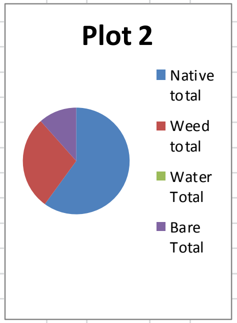
Appendix D – Vegetation Transect Data

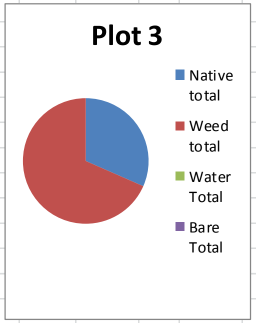
Monitoring - October 2015																																				
Monitoring Date	26/10/2015																																			
	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6		Plot 7		Plot 8		Plot 9		Plot 10		Plot 11		Plot 12		Plot 13		Plot 14		Plot 15		Plot 16		Plot 17		Plot 18	
	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%
Native Species																																				
Bulboschoenus sp.	4	4.3	12	12.6		0.0	33	28.0	1	1.0	1	0.7	1	1.0		0.0		0.0	4	4.6	14	16.7		0.0	3	1.9		0.0		0.0		0.0		0.0		0.0
Carex apressa		0.0		0.0		0.0		0.0		0.0		0.0		0.0	5	4.5		0.0		0.0		0.0		0.0	3	1.9		0.0	8	7.0		0.0		0.0		0.0
Cotula coronopifolia		0.0		0.0		0.0	10	8.5		0.0		0.0		0.0		0.0		0.0		0.0	1	1.2		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Paspalum distichum		0.0		0.0		0.0	2	1.7		0.0	4	3.0		0.0		0.0		0.0	7	8.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Eleocharis sp.		0.0	3	3.2		0.0	1	0.8		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	19	12.5		0.0		0.0		0.0		0.0
Lythrum hyssopifolia	4	4.3		0.0	3	3.9		0.0	6	5.7	12	8.9		0.0	2	1.8	1	2.0	6	6.9		0.0		0.0	9	5.8	1	0.7	5	4.3	5	6.8		0.0		0.0
Damasonium minus		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	3	3.3	1	0.6		0.0		0.0		0.0		0.0		0.0
Alisma plantago-aquatica		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Triglochin sp.		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	3	1.9		0.0		0.0		0.0		0.0		0.0
Juncus usitatus		0.0	14	14.7	3	3.9		0.0		0.0	4	3.0	3	2.9		0.0		0.0	20	23.0	11	13.1	9	10.0	8	5.1	26	17.1	2	1.7	1	1.4		0.0		0.0
Persicaria decipiens	5	5.4	2	2.1		0.0		0.0		0.0	6	4.4		0.0		0.0		0.0		0.0		0.0	6	6.7		0.0	8	5.3		0.0	5	6.8		0.0		0.0
Batrachium trichophyllum	9	9.7	16	16.8	2	2.6		0.0		0.0	2	1.5	1	1.0		0.0		0.0		0.0		0.0	3	3.3	3	1.9	3	2.0		0.0	12	16.4		0.0		0.0
Ludwigia peploides		0.0	1	1.1		0.0		0.0		0.0	1	0.7		0.0		0.0		0.0		0.0		0.0	1	1.1	3	1.9		0.0		0.0		0.0		0.0		0.0
Marsilea mutica		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	2	1.3	5	3.3		0.0		0.0		0.0		0.0
Ottelia ovalifolia		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	1	0.6		0.0		0.0		0.0		0.0		0.0
Lacnogrostis filiformis	16	17.2	9	9.5	13	17.1		0.0		0.0	15	11.1	8	7.7		0.0	1	2.0	9	10.3	14	16.7	4	4.4	12	7.7	4	2.6		0.0		0.0		0.0		0.0
Typha sp.		0.0		0.0	3	3.9		0.0	2	1.9	2	1.5		0.0		0.0		0.0	3	3.4	8	9.5		0.0	1	0.6	4	2.6		0.0		0.0		0.0		0.0
Azola		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	1	0.6	3	2.0		0.0		0.0		0.0		0.0
Dichondra/Centella		0.0		0.0		0.0		0.0	3	2.9	3	2.2	1	1.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	1	0.9	2	2.7		0.0		0.0
Weed Species																																				
Couch	17	18.3	8	8.4	24	31.6	28	23.7	43	41.0	26	19.3	23	22.1	26	23.4	9	18.0	14	16.1	30	35.7	21	23.3	16	10.3	36	23.7	49	42.6	24	32.9	26	60.5	20	39.2
Paspalum	7	7.5	1	1.1	1	1.3		0.0	3	2.9	7	5.2	7	6.7	4	3.6		0.0	7	8.0	1	1.2	14	15.6	16	10.3	23	15.1	3	2.6	10	13.7		0.0	2	3.9
Wild Aster		0.0	3	3.2		0.0	12	10.2	11	10.5	1	0.7		0.0		0.0	8	16.0		0.0	2	2.4		0.0		0.0		0.0		0.0		0.0	3	7.0	1	2.0
Kikuyu	27	29.0	14	14.7	27	35.5		0.0	15	14.3	20	14.8	37	35.6	13	11.7	16	32.0	8	9.2		0.0	16	17.8	30	19.2	3	2.0	7	6.1	11	15.1	6	14.0	11	21.6
Fireweed		0.0		0.0		0.0	1	0.8	1	1.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
White Clover		0.0		0.0		0.0		0.0		0.0	1	0.7		0.0	1	0.9		0.0		0.0		0.0		0.0	1	0.6		0.0		0.0		0.0		0.0		0.0
Plantain		0.0		0.0		0.0		0.0		0.0		0.0	2	1.9	15	13.5		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Perennial Rye	1	1.1		0.0		0.0		0.0		0.0		0.0		0.0	6	5.4		0.0	1	1.1		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Scarlet Pimpernel		0.0		0.0		0.0		0.0		0.0		0.0		0.0	9	8.1		0.0		0.0	1	1.2		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Dock		0.0	1	1.1		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	1	1.1	3	1.9		0.0	1	0.9	1	1.4		0.0		0.0
Evening Primrose		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Purpletop		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	6	3.8	1	0.7		0.0		0.0		0.0		0.0
Mullum Couch		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	1	1.1		0.0		0.0		0.0		0.0		0.0		0.0
Other																																				
Bare Ground	3	3.2	11	11.6		0.0	31	26.3	20	19.0	30	22.2	21	20.2	30	27.0	15	30.0	8	9.2	2	2.4	9	10.0	24	15.4	7	4.6	39	33.9	2	2.7	8	18.6	17	33.3
Water		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	2	2.2	10	6.4	9	5.9		0.0		0.0		0.0		0.0

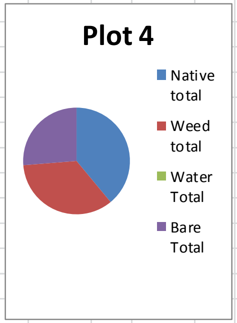
	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6		Plot 7		Plot 8		Plot 9	
Vegetation total	90.0	96.8	84.0	88.4	76.0	100.0	87.0	73.7	85.0	81.0	105.0	77.8	83.0	79.8	81.0	73.0	35.0	70.0
Native total	38.0	40.9	57.0	60.0	24.0	31.6	46.0	39.0	12.0	11.4	50.0	37.0	14.0	13.5	7.0	6.3	2.0	4.0
Weed total	52.0	55.9	27.0	28.4	52.0	68.4	41.0	34.7	73.0	69.5	55.0	40.7	69.0	66.3	74.0	66.7	33.0	66.0
Water Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Total	3.0	3.2	11.0	11.6	0.0	0.0	31.0	26.3	20.0	19.0	30.0	22.2	21.0	20.2	30.0	27.0	15.0	30.0

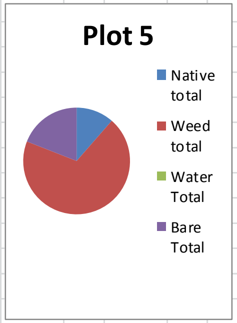
	Plot 10		Plot 11		Plot 12		Plot 13		Plot 14		Plot 15		Plot 16		Plot 17		Plot 18	
Vegetation total	79.0	90.8	82.0	97.6	79.0	87.8	122.0	78.2	136.0	89.5	76.0	66.1	71.0	97.3	35.0	81.4	34.0	66.7
Native total	49.0	56.3	48.0	57.1	26.0	28.9	50.0	32.1	73.0	48.0	16.0	13.9	25.0	34.2	0.0	0.0	0.0	0.0
Weed total	30.0	34.5	34.0	40.5	53.0	58.9	72.0	46.2	63.0	41.4	60.0	52.2	46.0	63.0	35.0	81.4	34.0	66.7
Water Total	0.0	0.0	0.0	0.0	2.0	2.2	10.0	6.4	9.0	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Total	8.0	9.2	2.0	2.4	9.0	10.0	24.0	15.4	7.0	4.6	39.0	33.9	2.0	2.7	8.0	18.6	17.0	33.3

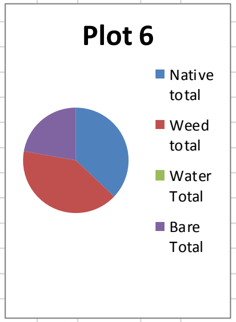


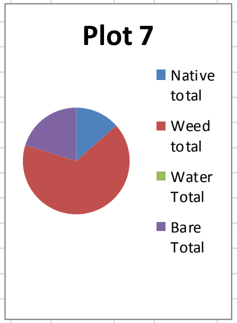


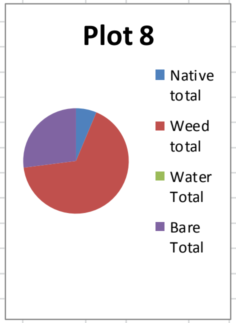


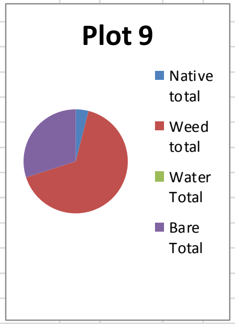


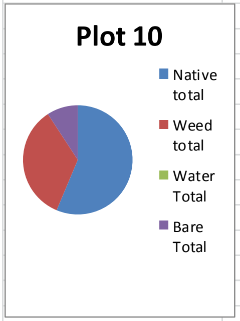


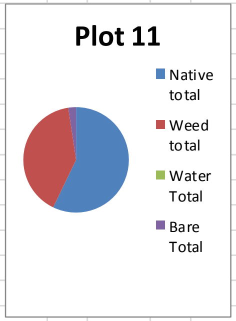


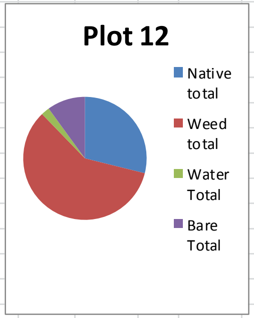


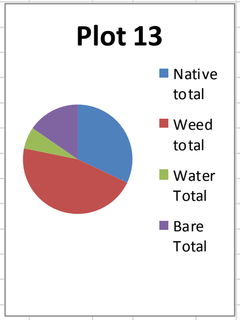


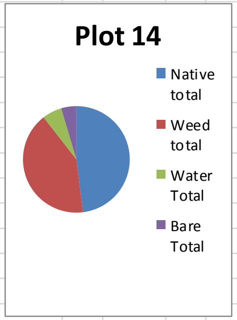


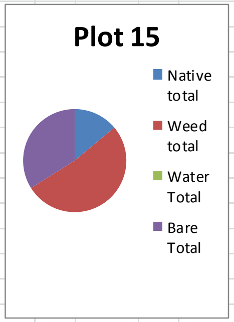


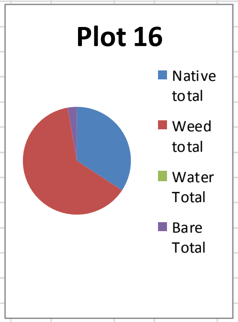


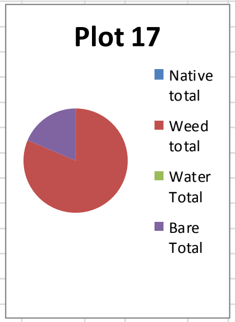


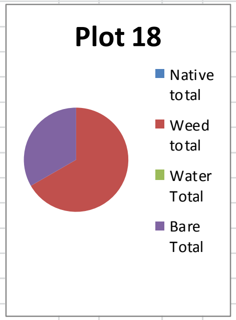












Appendix E – Photo Points

Pond 1

Pond 2

Pond 3

Pond 4

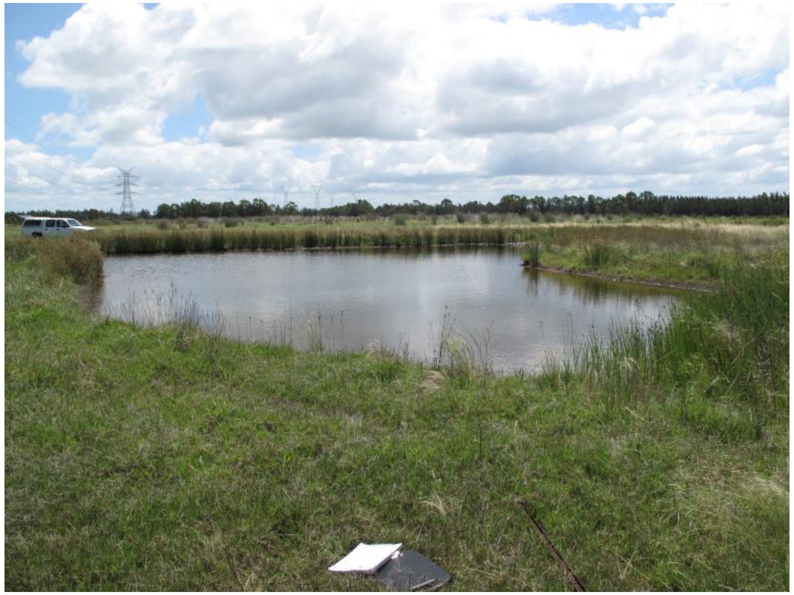
Pond 5

Pond 6

Pond 7

Pond 8

Pond 9



Pond 10

Pond 11

Pond 12

Pond 13

Pond 14

Pond 15

Pond 16

Pond 17

Pond 18

Appendix B – NCIG Shorebird Compensatory Habitat Monitoring (Avifauna Research and Services)

December | 2015

NCIG Shorebird Compensatory Habitat Monitoring

Pre-construction Period October - December 2015

Prepared by Avifauna Research & Services

AVIFAUNA RESEARCH & SERVICES PTY LTD
PO BOX 2006, ROCKDALE NSW 2216

INTRODUCTION

NCIG are committed to the enhancement and restoration of a section of Area E for migratory shorebirds to offset losses resulting from the development of NCIG Coal Export Terminal. The concept of the Area E restoration includes the removal of mangroves and management of tidal flows to expand both foraging and roosting habitat.

BACKGROUND

The Hunter Estuary is the most important site in NSW for shorebirds, providing critical feeding and roosting habitat for both migratory and resident shorebird species. The Ramsar listed wetlands support 45 species of migratory birds protected under international agreements. The Hunter Estuary has suffered extensive alteration as a result of urban, mining and industrial development, which has contributed to a decline in shorebird populations over the last 40 years.

Area E has been recognised as an important wetland for waterbird and shorebird abundance and diversity. The area selected for restoration includes a large area of former tidal flats and saltmarsh isolated from tidal influence during the 1960s. The mudflat substrate and saltmarsh were left intact at this time, though much of the marine life previously maintained by tidal waters has changed. No data exists of shorebird populations prior to the isolation of the area from tidal flows. However, data since the 1970s shows that the area was still used by relatively large numbers of migratory shorebirds as well as a high diversity of other species of waterbirds.

The substrate of large parts of Area E and Ash Island as a whole changed when the area was re-opened to tidal flows due to the fact that the area was below that of the tidal range in which saltmarsh could be sustained and within the tidal range utilised by the Grey mangrove. In the absence of any attempt to restrict the spread of mangroves the area quickly became mangrove dominated at the expense of migratory shorebirds previously using the area.

METHODS

Monitoring of shorebird populations were carried out during July and August 'off peak' on a monthly basis and during September to December 'peak' period. Nocturnal surveys were commenced in September 2015 during high and low tides. This required a total of seven surveys.

Surveys were conducted along pre-determined transects at the project site as well as at reference sites in the Hunter River Estuary (**Table 1**). Survey date, time, tide height, weather, abundance and behaviour of birds were recorded, along with any observed disturbances.

Monitoring at other major diurnal roost sites during high tide provided an estimate of the whole of estuary populations of shorebirds against which the project site and reference sites can be compared. The inclusion of all waterbirds during counts requires little additional effort but is useful to determine whether interaction of other species has an effect on specific habitat usage, as does the monitoring of disturbance from any other source.

Monitoring at Hexham Swamp sites are not covered under this contract but were monitored periodically to determine whether birds from Area E frequented the site and therefore explained significant changes in populations in Area E populations. Although Tomago Wetlands are an extremely important area for shorebirds, in particular nocturnal roosting, this site is not covered under this contract and is therefore not monitored.

Milham's Pond did not constitute a transect in itself although the southern tip was included in counts at Phoenix Flats.

Table 1. Survey sites

Location	Sub-site
Area E: Project site	Fish Fry Flats Fish Fry Creek Wader Creek
Area E: Reference sites	Wader Pond Swan Pond
Hunter River Estuary	Milham's Pond Phoenix Flats Hexham Swamp Kooragang Dykes Stockton Sandspit & Channel

RESULTS

A total of 22 species of shorebirds were observed during the October to first week in December 2015 survey period, including 7 resident and 15 migratory species (Table 2). The most abundant species recorded across Area E reference sites was the resident Black-winged Stilt, with a peak count of 1,407 at high tide and 1,489 at low tide (Appendix A). The most common migratory species sighted at Area E included Bar-tailed and Black-tailed Godwit, Common Greenshank and Marsh Sandpiper; while the Hunter Estuary subsites supported higher numbers of most migratory shorebirds including Sharp-tailed Sandpiper, Whimbrel, Eastern Curlew, Curlew Sandpiper, Pacific Golden Plover, Bar-tailed and Black-tailed Godwits, Common Greenshank and Marsh Sandpiper.

Shorebirds were typically observed feeding and roosting in response to tidal fluctuation, although there was little variation in total abundance of shorebirds present between high and low tides at Area E. No disturbances were noted during this survey period.

As expected prior to the restoration works, no shorebird species were recorded at the project site (Fish Fry Flats, Fish Fry and Wader Creeks) prior to the removal of mangroves. Small numbers of waterbirds were present, including Teals, Cormorants and Egrets.

Nocturnal surveys were commenced on 25 September and will be carried out fortnightly throughout the peak season. Nocturnal surveys found quite different usage of wetland sites by shorebirds compared with diurnal sites.

Monitoring of shorebirds at the project site and reference sites will continue on a monthly basis during the “off-peak” migratory bird season (April-August 2015), increasing to fortnightly from September 2015 – March 2016 with the return of key migratory species.

Table 2. All shorebird species observed July-Sept 2015

Species	EPBC listing	TSC listing
Pied Oystercatcher		Endangered
Sooty Oystercatcher		Vulnerable
Black-winged Stilt		
Red-necked Avocet		
Pacific Golden Plover	Migratory	
Red-capped Plover		
Black-fronted Dotterel		
Red-kneed Dotterel		
Black-tailed Godwit	Migratory	Vulnerable
Bar-tailed Godwit	Migratory	
Whimbrel	Migratory	
Eastern Curlew	Migratory	
Terek Sandpiper	Migratory	Vulnerable
Grey-tailed Tattler	Migratory	
Common Greenshank	Migratory	
Marsh Sandpiper	Migratory	
Ruddy Turnstone	Migratory	
Great Knot	Migratory	
Red Knot	Migratory	
Red-necked Stint	Migratory	
Sharp-tailed Sandpiper	Migratory	
Curlew Sandpiper	Migratory	Endangered

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Meters

Shorebird Survey Sites

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W E
S

Map produced by Avifauna Research & Services
Date: 26 November 2015
Coordinate System: Zone 56 MGA/GDA/94
GIS MAP REF:
Hunter River Estuary Area E survey sites

APPENDIX A – SHOREBIRD COUNT DATA AT ALL SITES

Site	Sub-site	Common Name	Count	Behaviour	Habitat	Date	Tide	Period
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Great Cormorant	1	Feeding	Shallow water	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	1	Feeding	Shallow water	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Pied Cormorant	1	Roosting	Emergent vegetation	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	13	Roosting	Rocks	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Egret	1	Roosting	Emergent vegetation	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian Pelican	1	Feeding	Shallow water	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	30	Feeding	Shallow water	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	22	Feeding	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Royal Spoonbill	1	Feeding	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	30	Feeding	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Whistling Kite	1	Flying		10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	1	Roosting	Tree/mangrove	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	12	Roosting	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian Pelican	2	Roosting	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	1	Feeding	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	White-faced Heron	1	Roosting	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	9	Roosting	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Pied Cormorant	2	Roosting	Saltmarsh	09/03/2015	High	Diurnal
AREA E - Hunter	Fish Fry Flat - Area E	Australian White Ibis	5	Feeding	Shallow water	09/03/2015	High	Diurnal

Estuary								
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Teal	12	Roosting	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	5	Roosting	Exposed mud/sand	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Royal Spoonbill	1	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Teal	16	Roosting	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	5	Feeding	Shallow water	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	1	Feeding	Shallow water	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	15	Roosting	Shallow water	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	1	Roosting	Tree/mangrove	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	3	Roosting	Exposed mud/sand	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	1	Roosting	Shallow water	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Royal Spoonbill	1	Roosting	Exposed mud/sand	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	8	Roosting	Shallow water	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	1	Feeding	Shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	1	roosting	dead mangroves	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	4	Roosting	Tree/mangrove	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Pied Cormorant	1	Roosting	Tree/mangrove	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	White-faced Heron	2	Roosting	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Royal Spoonbill	1	Roosting	Exposed mud/sand	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Yellow tailed Black Cockatoo	1	Roosting	Tree/mangrove	05/05/2015	High	Diurnal

AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	1	Roosting	Dead trees	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Royal Spoonbill	3	Roosting	Dead trees	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Pied Cormorant	1	Roosting	Dead trees	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	1	Roosting	Dead trees	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Pied Cormorant	3	Roosting	Tree/mangrove	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Egret	1	Roosting	Tree/mangrove	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	2	Roosting	Tree/mangrove	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Pied Cormorant	1	Roosting	Tree/mangrove	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	1	Roosting	Tree/mangrove	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Kingfisher	1	Roosting	Tree/mangrove	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	4	Roosting	Tree/mangrove	20/08/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Pied Cormorant	2	Roosting	Tree/mangrove	20/08/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	2	Roosting	Tree/mangrove	20/08/2015	Falling	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Egret	1	Roosting	Tree/mangrove	20/08/2015	Falling	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Teal	8	Roosting	Open water	20/08/2015	Falling	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	1	Roosting	Tree/mangrove	02/09/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Pied Cormorant	2	Roosting	Tree/mangrove	02/09/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	2	Roosting	Tree/mangrove	02/09/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	1	Roosting	Tree/mangrove	02/09/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Egret	2	Roosting	Tree/mangrove	02/09/2015	High	Diurnal

AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	1	Feeding	Shallow water	11/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	3	Roosting	Tree/mangrove	18/09/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Striated Heron	1	Feeding	Shallow water	25/09/2015	High	Nocturnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	2	Roosting	Tree/mangrove	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	10	Roosting	Tree/mangrove	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Pied Cormorant	1	Roosting	Tree/mangrove	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	4	Feeding	Shallow water	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	2	Feeding	Open water	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	3	Roosting	Tree/mangrove	09/10/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Pied Cormorant	1	Roosting	Tree/mangrove	09/10/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Darter	1	Roosting	Artificial structure	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	9	Roosting	Tree/mangrove	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	9	Roosting	Shallow water	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	1	Feeding	Shallow water	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	6	Roosting	Tree/mangrove	15/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	5	Feeding	Shallow water	21/10/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	4	Feeding	Shallow water	21/10/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Royal Spoonbill	1	Feeding	Shallow water	21/10/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	3	Feeding	Shallow water	21/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	17	Feeding	Shallow water	21/10/2015	Low	Diurnal

AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	2	Roosting	Shallow water	27/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Great Egret	1	Roosting	Shallow water	27/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	3	Roosting	Open water	27/10/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Pied Cormorant	1	Roosting	Open water	27/10/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	4	Roosting	Shallow water	27/10/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E		0			29/10/2015	Low	Nocturnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	6	Roosting	Shallow water	05/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	1	Roosting	Shallow water	05/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	1	Roosting	Shallow water	05/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Egret	2	Feeding	Shallow water	05/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	7	Roosting	Shallow water	05/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	3	Feeding	Shallow water	05/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	8	Roosting	Shallow water	05/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Royal Spoonbill	3	Feeding	Shallow water	05/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E		0			05/11/2015	Low	Nocturnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Pied Cormorant	1	Roosting	Tree/mangrove	11/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	1	Feeding	Shallow water	11/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	White-faced Heron	1	Feeding	Shallow water	11/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	13	Roosting	Tree/mangrove	11/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	1	Roosting	Tree/mangrove	11/11/2015	Low	Diurnal

AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	1	Feeding	Shallow water	11/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	7	Roosting	Tree/mangrove	11/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E		0			11/11/2015	High	Nocturnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	6	Feeding	Shallow water	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	1	Roosting	Tree/mangrove	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	3	Feeding	Shallow water	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Egret	1	Feeding	Shallow water	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	6	Roosting	Tree/mangrove	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Grey Teal	8	Roosting	Tree/mangrove	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	5	Roosting	Tree/mangrove	18/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Pied Cormorant	1	Roosting	Tree/mangrove	18/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	1	Roosting	Tree/mangrove	18/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Egret	2	Feeding	Shallow water	18/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	13	Feeding	Shallow water	18/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	1	Roosting	Tree/mangrove	26/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Great Egret	1	Roosting	Tree/mangrove	26/11/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Eastern Great Egret	1	Feeding	Shallow water	26/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	2	Feeding	Shallow water	26/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Grey Teal	3	Feeding	Shallow water	26/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Black Cormorant	8	Roosting	Tree/mangrove	03/12/2015	Low	Diurnal

AREA E - Hunter Estuary	Fish Fry Flat - Area E	Little Pied Cormorant	1	Roosting	Tree/mangrove	03/12/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	1	Feeding	Shallow water	03/12/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	55	Feeding	Shallow water	03/12/2015	Low	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Australian White Ibis	2	Roosting	Tree/mangrove	03/12/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Chestnut Teal	22	Feeding	Shallow water	03/12/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Flat - Area E	Grey Teal	12	Feeding	Shallow water	03/12/2015	High	Diurnal
AREA E - Hunter Estuary	Little Fish Fry Flat - Area E	Australian White Ibis	2	Feeding	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Little Fish Fry Flat - Area E	Australian White Ibis	2	Roosting	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Little Fish Fry Flat - Area E	Australian White Ibis	1	Feeding	Shallow water	11/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Little Fish Fry Flat - Area E	Chestnut Teal	2	Feeding	Open water	11/09/2015	Low	Diurnal

Site	Sub-site	Common Name	Count	Behaviour	Habitat	Date	Tide	Period
AREA E - Hunter Estuary	Fish Fry Creek - Area E	Australian White Ibis	2	Roosting	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Creek - Area E	Eastern Great Egret	1	Roosting	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Creek - Area E	Australian White Ibis	2	Feeding	Saltmarsh	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Creek - Area E	Eastern Great Egret	1	Roosting	Saltmarsh	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Fish Fry Creek - Area E	Chestnut Teal	14	Roosting	Tree/mangrove	26/11/2015	High	Diurnal

Site	Sub-site	Common Name	Count	Behaviour	Habitat	Date	Tide	Period
AREA E - Hunter Estuary	Wader Creek	White-faced Heron	1	Feeding	Shallow water	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Wader Creek	Australian White Ibis	1	Roosting	Saltmarsh	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Creek	White-faced Heron	1	Roosting	Saltmarsh	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Creek	Pied Cormorant	1	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Creek	Little Egret	1	Roosting	Grass	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Creek	White-faced Heron	1	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Creek	Chestnut Teal	6	Roosting	Shallow water	23/03/2015	High	Diurnal

AREA E - Hunter Estuary	Wader Creek	Osprey	1	nesting	Artificial Structure	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Wader Creek	Chestnut Teal	4	Roosting	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Creek	Little Egret	1	Feeding	Shallow water	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Creek	Little Egret	1	Feeding	Shallow water	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Creek	Chestnut Teal	5	Swimming	Open water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Creek	White-faced Heron	1	Feeding	Saltmarsh	11/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Wader Creek	Little Egret	1	Feeding	Open water	11/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Creek	Masked Lapwing	2	Feeding	Saltmarsh	15/10/2015	Low	Diurnal

Site	Sub-site	Common Name	Count	Behaviour	Habitat	Date	Tide	Period
AREA E - Hunter Estuary	Wader Pond - Area E	Common Greenshank	3	Feeding	Shallow water	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Sharp-tailed Sandpiper	6	Feeding	Saltmarsh	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	12	Feeding	Exposed mud/sand	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Australian White Ibis	32	Feeding	Saltmarsh	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	White-faced Heron	4	Feeding	Shallow water	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	80	Feeding	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	12	Feeding	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Australian White Ibis	5	Feeding	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	White-faced Heron	1	Feeding	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	60	Feeding	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	4	Roosting	Saltmarsh	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	7	Roosting	Saltmarsh	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	90	Feeding	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	100	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	14	Roosting	Saltmarsh	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Australian White Ibis	1	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	White-faced Heron	7	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	82	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	16	Roosting	Saltmarsh	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Australian White Ibis	1	Feeding	Saltmarsh	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	White-faced Heron	6	Feeding	Saltmarsh	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Marsh Sandpiper	3	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	140	Feeding	Shallow water	23/03/2015	High	Diurnal

AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	8	Roosting	Saltmarsh	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	White-faced Heron	3	Feeding	Saltmarsh	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	70	Feeding	Shallow water	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	8	Roosting	Saltmarsh	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Australian White Ibis	1	Roosting	Saltmarsh	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	White-faced Heron	3	Roosting	Saltmarsh	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Sharp-tailed Sandpiper	40	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	93	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	6	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	White-faced Heron	4	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Chestnut Teal	15	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black Swan	4	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	140	Feeding	Shallow water	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Australian White Ibis	1	Feeding	Saltmarsh	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Red-necked Avocet	150	Roosting	Shallow water	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Sharp-tailed Sandpiper	4	Feeding	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	190	Feeding	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	2	Roosting	Saltmarsh	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Australian White Ibis	1	Feeding	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Chestnut Teal	140	Feeding	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Red-necked Avocet	320	Feeding	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black Swan	7	Feeding	Shallow water	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	2	Feeding	Shallow water	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Red-necked Avocet	1100	Feeding	Shallow water	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	White-faced Heron	1	Feeding	Shallow water	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Red-necked Avocet	380	Feeding	Shallow water	05/05/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black Swan	7	Feeding	Shallow water	05/05/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	1	Feeding	Exposed mud/sand	05/05/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	6	Feeding	Shallow water	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	12	Roosting	Saltmarsh	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Eastern Great Egret	1	Feeding	Shallow water	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	White-faced Heron	1	Feeding	Shallow water	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Red-necked Avocet	1	Feeding	Shallow water	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	4	Feeding	Shallow water	18/06/2015	Low	Diurnal

AREA E - Hunter Estuary	Wader Pond - Area E	Black-fronted Dotterel	1	Feeding	Exposed mud/sand	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	14	Feeding	Saltmarsh	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Red-necked Avocet	17	Feeding	Shallow water	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Teal	3	Feeding	Shallow water	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	4	Feeding	Shallow water	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	3	Feeding	Saltmarsh	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black Swan	5	Roosting	Shallow water	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	White-bellied Sea-Eagle	1	Roosting	Artificial structure	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	20	Feeding	Shallow water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	2	Feeding	Saltmarsh	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black Swan	6	Feeding	Shallow water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Teal	45	Feeding	Shallow water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	4	Feeding	Shallow water	20/08/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	White-faced Heron	1	Feeding	Shallow water	20/08/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	2	Roosting	Saltmarsh	20/08/2015	Falling	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	White-faced Heron	1	Feeding	Shallow water	20/08/2015	Falling	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	2	Feeding	Saltmarsh	11/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Australian White Ibis	1	Feeding	Saltmarsh	11/09/2015	Falling	Diurnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	2	Feeding	Saltmarsh	18/09/2015	High	Diurnal
Hunter Estuary	Wader Pond - Area E	Eastern Great Egret	1	Feeding	Shallow water	18/09/2015	High	Diurnal
Hunter Estuary	Wader Pond - Area E	White-faced Heron	1	Feeding	Shallow water	18/09/2015	High	Diurnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	2	Feeding	Saltmarsh	25/09/2015	Low	Diurnal
Hunter Estuary	Wader Pond - Area E	Eastern Great Egret	1	Feeding	Shallow water	25/09/2015	Low	Diurnal
Hunter Estuary	Wader Pond - Area E	Chestnut Teal	2	Feeding	Shallow water	25/09/2015	Low	Diurnal
Hunter Estuary	Wader Pond - Area E	Red-necked Avocet	60	Feeding	Shallow water	25/09/2015	High	Nocturnal
Hunter Estuary	Wader Pond - Area E		0			30/09/2015	Falling	Diurnal
Hunter Estuary	Wader Pond - Area E	Red-necked Avocet	200	Feeding	Shallow water	30/09/2015	Rising	Nocturnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	2	Feeding	Saltmarsh	08/10/2015	Low	Diurnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	2	Roosting	Saltmarsh	09/10/2015	High	Diurnal
Hunter Estuary	Wader Pond - Area E	White-faced Heron	1	Feeding	Shallow water	09/10/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	1	Feeding	Saltmarsh	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	White-faced Heron	1	Feeding	Shallow water	15/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Eastern Great Egret	2	Feeding	Shallow water	15/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Black-winged Stilt	2	Feeding	Shallow water	16/10/2015	High	Diurnal

AREA E - Hunter Estuary	Wader Pond - Area E	Red-necked Avocet	30	Feeding	Shallow water	16/10/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	3	Feeding	Shallow water	16/10/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Pacific Golden Plover	7	Feeding	Shallow water	21/10/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	8	Feeding	Shallow water	21/10/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Pacific Golden Plover	7	Feeding	Shallow water	21/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	8	Feeding	Shallow water	21/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Pacific Golden Plover	6	Feeding	Shallow water	27/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Pacific Golden Plover	5	Feeding	Shallow water	27/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E		0			27/10/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Sharp-tailed Sandpiper	8	Feeding	Shallow water	29/10/2015	Low	Nocturnal
AREA E - Hunter Estuary	Wader Pond - Area E	Masked Lapwing	2	Feeding	Shallow water	29/10/2015	Low	Nocturnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	6	Feeding	Shallow water	05/11/2015	Low	Diurnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	5	Feeding	Shallow water	05/11/2015	High	Diurnal
Hunter Estuary	Wader Pond - Area E	Silver Gull	2	Feeding	Shallow water	05/11/2015	High	Diurnal
AREA E - Hunter Estuary	Wader Pond - Area E	Red-necked Avocet	78	Feeding	Shallow water	05/11/2015	Low	Nocturnal
AREA E - Hunter Estuary	Wader Pond - Area E	Chestnut Teal	3	Feeding	Shallow water	05/11/2015	Low	Nocturnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	2	Feeding	Saltmarsh	11/11/2015	High	Diurnal
Hunter Estuary	Wader Pond - Area E	Little Egret	1	Feeding	Shallow water	11/11/2015	High	Diurnal
Hunter Estuary	Wader Pond - Area E	Sharp-tailed Sandpiper	15	Feeding	Shallow water	11/11/2015	Low	Diurnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	3	Feeding	Saltmarsh	11/11/2015	Low	Diurnal
Hunter Estuary	Wader Pond - Area E	Chestnut Teal	2	Feeding	Saltmarsh	11/11/2015	Low	Diurnal
Hunter Estuary	Wader Pond - Area E	Red-necked Avocet	60	Feeding	Shallow water	11/11/2015	High	Nocturnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	4	Feeding	Saltmarsh	11/11/2015	High	Nocturnal
Hunter Estuary	Wader Pond - Area E	Chestnut Teal	10	Feeding	Shallow water	11/11/2015	High	Nocturnal
Hunter Estuary	Wader Pond - Area E	Australian White Ibis	2	Feeding	Shallow water	26/11/2015	High	Diurnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	15	Feeding	Saltmarsh	26/11/2015	High	Diurnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	19	Feeding	Shallow water	26/11/2015	Low	Diurnal
Hunter Estuary	Wader Pond - Area E	Sharp-tailed Sandpiper	11	Feeding	Shallow water	18/11/2015	Low	Diurnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	10	Feeding	Saltmarsh	18/11/2015	Low	Diurnal
Hunter Estuary	Wader Pond - Area E	Sharp-tailed Sandpiper	7	Feeding	Shallow water	18/11/2015	High	Diurnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	2	Feeding	Shallow water	18/11/2015	High	Diurnal
Hunter Estuary	Wader Pond - Area E	Great Egret	1	Feeding	Shallow water	03/12/2015	Low	Diurnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	2	Feeding	Shallow water	03/12/2015	Low	Diurnal
Hunter Estuary	Wader Pond - Area E	Masked Lapwing	6	Feeding	Saltmarsh	03/12/2015	High	Diurnal

Site	Sub-site	Common Name	Count	Behaviour	Habitat	Date	Tide	Period
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	758	Roosting	Shallow water	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	4	Roosting	Saltmarsh	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Silver Gull	3	Roosting	Shallow water	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	1	Feeding	Shallow water	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian White Ibis	6	Roosting	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Silver Gull	8	Roosting	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	520	Feeding	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Common Greenshank	39	Feeding	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Marsh Sandpiper	2	Feeding	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	46	Roosting	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	3	Roosting	Saltmarsh	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Bar-tailed Godwit	6	Feeding	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	1000	Roosting	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	4	Roosting	Saltmarsh	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Silver Gull	7	Feeding	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	8	Feeding	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Teal	64	Feeding	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	1	Roosting	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-tailed Godwit	42	Feeding	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	1000	Feeding	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	4	Roosting	Saltmarsh	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Silver Gull	15	Roosting	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	12	Feeding	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Common Greenshank	1	Roosting	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-tailed Godwit	49	Roosting	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Bar-tailed Godwit	12	Roosting	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	3	Feeding	Saltmarsh	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Bar-tailed Godwit	20	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Common Greenshank	57	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Stint	1	Feeding	Exposed mud/sand	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	1300	Roosting	Shallow water	09/03/2015	High	Diurnal

AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	4	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Silver Gull	12	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian White Ibis	2	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	1	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Teal	1500	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	3	Roosting	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	4	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	1	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Bar-tailed Godwit	11	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Common Greenshank	27	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	1400	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	8	Roosting	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Silver Gull	12	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian White Ibis	1	Feeding	Saltmarsh	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	3	Roosting	Saltmarsh	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	135	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Marsh Sandpiper	16	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-tailed Godwit	9	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	1	Roosting	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Bar-tailed Godwit	2	Roosting	Shallow water	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	400	Roosting	Shallow water	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Roosting	Saltmarsh	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian White Ibis	1	Feeding	Shallow water	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	5	Roosting	Saltmarsh	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	1	Roosting	Shallow water	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	8	Roosting	Shallow water	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	1	Roosting	Saltmarsh	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Common Greenshank	1	Feeding	Shallow water	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	800	Feeding	Shallow water	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	6	Roosting	Saltmarsh	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	3	Feeding	Saltmarsh	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	1	Roosting	Shallow water	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Sharp-tailed Sandpiper	40	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	62	feeding	shallow water	02/04/2015	outgoing tide	Diurnal

AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	4	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	2	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	1720	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Marsh Sandpiper	4	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	14	Feeding	Shallow water	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	4	Roosting	Saltmarsh	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	420	Roosting	Shallow water	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	1112	Roosting	Shallow water	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	1	Roosting	Shallow water	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	9	Feeding	Shallow water	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	18	Feeding	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	1308	Feeding	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	450	Roosting	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	12	Feeding	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Hoary-headed Grebe	15	Feeding	Shallow water	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	27	Feeding	Shallow water	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Mallard	2	Feeding	Shallow water	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	469	Feeding	Shallow water	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	150	Feeding	Shallow water	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	2	Roosting	Saltmarsh	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	1	Roosting	Saltmarsh	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Teal	100	Roosting	Shallow water	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	565	Feeding	Shallow water	05/05/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australasian Grebe	4	Feeding	Shallow water	05/05/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	32	Feeding	Shallow water	05/05/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	130	Feeding	Shallow water	05/05/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Feeding	Exposed mud/sand	05/05/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Feeding	Saltmarsh	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	33	Feeding	Shallow water	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	314	Feeding	Shallow water	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	6	Roosting	Artificial structure	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Pink-eared Duck	38	Roosting	Artificial structure	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Teal	240	Roosting	Exposed mud/sand	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australasian Grebe	2	Feeding	Shallow water	18/06/2015	High	Diurnal

AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	27	Feeding	Shallow water	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	12	Roosting	Saltmarsh	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	1410	Feeding	Shallow water	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Teal	180	Feeding	Shallow water	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	30	Feeding	Shallow water	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Pink-eared Duck	22	Feeding	Open water	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	1	Roosting	Saltmarsh	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Eastern Great Egret	1	Feeding	Shallow water	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	357	Roosting	Shallow water	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	4	Roosting	Shallow water	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-shouldered Kite	1	overhead		22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-fronted Dotterel	1	Feeding	Exposed mud/sand	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Feeding	Shallow water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	1	Feeding	Shallow water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-fronted Dotterel	1	Feeding	Exposed mud/sand	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	79	Feeding	Open water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	380	Feeding	Shallow water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	11	Feeding	Shallow water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	16	Feeding	Shallow water	20/08/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	4	Roosting	Saltmarsh	20/08/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	62	Roosting	Shallow water	20/08/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	8	Feeding	Shallow water	20/08/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Straw-necked Ibis	1	Feeding	Saltmarsh	20/08/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	6	Feeding	Shallow water	20/08/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Roosting	Saltmarsh	20/08/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Eastern Great Egret	2	Roosting	Saltmarsh	20/08/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	56	Feeding	Shallow water	20/08/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	5	Feeding	Shallow water	20/08/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Straw-necked Ibis	2	Feeding	Saltmarsh	20/08/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	3	Feeding	Saltmarsh	02/09/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Eastern Great Egret	1	feeding	Saltmarsh	02/09/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	256	Feeding	Shallow water	02/09/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	5	Feeding	Shallow water	11/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	5	Feeding	Saltmarsh	11/09/2015	Falling	Diurnal

AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	1	Feeding	Shallow water	11/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	1250	Roosting	Shallow water	11/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	2	Feeding	Shallow water	11/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	1	Feeding	Saltmarsh	11/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian White Ibis	2	Feeding	Shallow water	11/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	1	Feeding	Shallow water	11/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	1250	Roosting	Shallow water	11/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	1	Feeding	Rocks	11/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	1	Feeding	Saltmarsh	18/09/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Eastern Great Egret	1	Feeding	Shallow water	18/09/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	735	Roosting	Shallow water	18/09/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	1	Feeding	Open water	18/09/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Common Greenshank	6	Feeding	Shallow water	25/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Feeding	Saltmarsh	25/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	1070	Feeding	Shallow water	25/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	6	Roosting	Saltmarsh	25/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Feeding	Saltmarsh	25/09/2015	High	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	600	Feeding	Shallow water	25/09/2015	High	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	1	Roosting	Shallow water	25/09/2015	High	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	2	Feeding	Shallow water	25/09/2015	High	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	10	Feeding	Open water	25/09/2015	High	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Pacific Black Duck	2	Feeding	Open water	25/09/2015	High	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Common Greenshank	20	Feeding	Shallow water	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	6	Feeding	Shallow water	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Feeding	Saltmarsh	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Little Pied Cormorant	2	Roosting	Artificial structure	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australasian Shoveler	2	Feeding	Open water	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	4	Roosting	Saltmarsh	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	2	Feeding	Open water	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	888	Feeding	Shallow water	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	2	Feeding	Shallow water	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	523	Feeding	Shallow water	30/09/2015	Rising	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	3	Feeding	Shallow water	30/09/2015	Rising	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	2	Feeding	Shallow water	30/09/2015	Rising	Nocturnal

AREA E - Hunter Estuary	Main Swan Pond	Australasian Shoveler	2	Feeding	Open water	30/09/2015	Rising	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Pink-eared Duck	1	Feeding	Open water	30/09/2015	Rising	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Pacific Black Duck	2	Feeding	Open water	30/09/2015	Rising	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	10	Feeding	Shallow water	30/09/2015	Rising	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	2	Feeding	Shallow water	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Feeding	Saltmarsh	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	1	Feeding	Shallow water	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	15	Feeding	Shallow water	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	850	Roosting	Shallow water	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Eastern Great Egret	14	Roosting	Shallow water	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	14	Roosting	Exposed mud/sand	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Whiskered Tern	11	Roosting	Exposed mud/sand	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Sharp-tailed Sandpiper	60	Roosting	Shallow water	09/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	56	Roosting	Shallow water	09/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Roosting	Saltmarsh	09/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	13	Feeding	Open water	09/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	800	Roosting	Shallow water	09/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	10	Feeding	Shallow water	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	8	Roosting	Shallow water	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Eastern Great Egret	4	Feeding	Shallow water	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	8	Feeding	Shallow water	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	5	Feeding	Saltmarsh	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	5	Feeding	Shallow water	15/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Pacific Black Duck	1	Feeding	Open water	15/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	1	Feeding	Open water	15/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Little Pied Cormorant	1	Roosting	Tree/mangrove	15/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	13	Roosting	Shallow water	15/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Eastern Great Egret	1	Feeding	Shallow water	15/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	10	Feeding	Saltmarsh	15/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Pacific Black Duck	15	Feeding	Shallow water	16/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	8	Roosting	Shallow water	16/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	600	Feeding	Shallow water	16/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	3	Feeding	Shallow water	21/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	4	Feeding	Shallow water	21/10/2015	High	Diurnal

AREA E - Hunter Estuary	Main Swan Pond	Eastern Great Egret	1	Feeding	Shallow water	21/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	2	Feeding	Shallow water	21/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	300	Feeding	Shallow water	27/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Feeding	Shallow water	27/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	320	Feeding	Shallow water	27/10/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	53	Feeding	Shallow water	05/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	1	Feeding	Shallow water	05/11/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	1	Feeding	Shallow water	05/11/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Silver Gull	1	Feeding	Shallow water	05/11/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	83	Feeding	Shallow water	05/11/2015	Low	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	1	Feeding	Shallow water	05/11/2015	Low	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	130	Feeding	Shallow water	05/11/2015	Low	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	11	Roosting	Shallow water	11/11/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Feeding	Saltmarsh	11/11/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Feeding	Saltmarsh	11/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Little Pied Cormorant	1	Roosting	Saltmarsh	11/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Red-necked Avocet	90	Feeding	Shallow water	11/11/2015	High	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	4	Feeding	Saltmarsh	11/11/2015	High	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	1	Feeding	Shallow water	11/11/2015	High	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	84	Feeding	Shallow water	11/11/2015	High	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Grey Teal	4	Feeding	Shallow water	11/11/2015	High	Nocturnal
AREA E - Hunter Estuary	Main Swan Pond	Silver Gull	1	Roosting	Shallow water	26/11/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	2	Roosting	Saltmarsh	26/11/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	21	Roosting	Shallow water	26/11/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Marsh Sandpiper	2	Roosting	Shallow water	26/11/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	7	Feeding	Saltmarsh	26/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	27	Roosting	Shallow water	26/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australasian Shoveler	8	Feeding	Shallow water	26/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	17	Feeding	Shallow water	26/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Grey Teal	60	Feeding	Shallow water	26/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	6	Feeding	Shallow water	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	7	Feeding	Saltmarsh	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Australian Pelican	16	Roosting	Saltmarsh	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Eastern Great Egret	3	Feeding	Shallow water	18/11/2015	Low	Diurnal

AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	1	Feeding	Shallow water	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black Swan	1	Feeding	Shallow water	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	5	Feeding	Saltmarsh	18/11/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Black-winged Stilt	7	Feeding	Shallow water	18/11/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	7	Feeding	Shallow water	03/12/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	White-faced Heron	1	Feeding	Shallow water	03/12/2015	Low	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Masked Lapwing	7	Feeding	Saltmarsh	03/12/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Chestnut Teal	42	Feeding	Shallow water	03/12/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Grey Teal	22	Feeding	Shallow water	03/12/2015	High	Diurnal
AREA E - Hunter Estuary	Main Swan Pond	Royal Spoonbill	1	Feeding	Shallow water	03/12/2015	High	Diurnal

Site	Sub-site	Common Name	Count	Behaviour	Habitat	Date	Tide	Period
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	25	Roosting	Shallow water	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Roosting	Saltmarsh	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Silver Gull	3	Roosting	Shallow water	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Australian White Ibis	5	Feeding	Saltmarsh	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	8	Roosting	Shallow water	10/02/2015	Rising	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	21	Roosting	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Roosting	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Australian White Ibis	1	Roosting	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	2	Feeding	Shallow water	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Swamp Harrier	1	Roosting	Saltmarsh	10/02/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	29	Feeding	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Silver Gull	2	Feeding	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Australian White Ibis	6	Feeding	Shallow water	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Roosting	Rocks	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	1	Roosting	Artificial structure	25/02/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	82	Feeding	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Feeding	Saltmarsh	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Australian White Ibis	6	Feeding	Saltmarsh	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Royal Spoonbill	1	Feeding	Shallow water	25/02/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	7	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Feeding	Saltmarsh	09/03/2015	High	Diurnal

AREA E - Hunter Estuary	Swan Pond South	Silver Gull	2	Feeding	Shallow water	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Eastern Great Egret	1	Feeding	Saltmarsh	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	4	Feeding	Saltmarsh	09/03/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	7	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Feeding	Shallow water	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-fronted Dotterel	1	Feeding	Exposed mud/sand	09/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	52	Feeding	Shallow water	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	4	Feeding	Saltmarsh	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Silver Gull	1	Roosting	Shallow water	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Australian White Ibis	4	Roosting	Saltmarsh	23/03/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	44	Feeding	Shallow water	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	4	Roosting	Saltmarsh	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Silver Gull	1	Roosting	Shallow water	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Australian White Ibis	4	Roosting	Saltmarsh	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Feeding	Saltmarsh	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Royal Spoonbill	1	Roosting	Shallow water	23/03/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	52	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	2	feeding	shallow water	02/04/2015	outgoing tide	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	57	Feeding	Shallow water	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	30	Roosting	Shallow water	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Teal	2	Roosting	Shallow water	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-fronted Dotterel	10	Feeding	Shallow water	09/04/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	52	Feeding	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Roosting	Saltmarsh	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Australian White Ibis	1	Feeding	Saltmarsh	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Roosting	Saltmarsh	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	64	Feeding	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	14	Feeding	Shallow water	09/04/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	35	Feeding	Shallow water	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black Swan	2	Feeding	Shallow water	05/05/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	57	Feeding	Shallow water	05/05/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-fronted Dotterel	3	Feeding	Exposed mud/sand	05/05/2015	Low	Diurnal

AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	5	Feeding	Shallow water	05/05/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Hoary-headed Grebe	12	Feeding	Shallow water	05/05/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Feeding	Shallow water	05/05/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Roosting	Saltmarsh	05/05/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	8	Feeding	Shallow water	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Eastern Great Egret	1	Feeding	Shallow water	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Feeding	Saltmarsh	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	4	Feeding	Shallow water	18/06/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	6	Feeding	Shallow water	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	2	Feeding	Shallow water	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	10	Feeding	Shallow water	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	4	Feeding	Shallow water	18/06/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	2	Feeding	Shallow water	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Eastern Great Egret	1	Feeding	Shallow water	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Little Egret	1	Feeding	Shallow water	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Feeding	Shallow water	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	17	Roosting	Shallow water	22/07/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	4	Feeding	Shallow water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Little Egret	1	Feeding	Shallow water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Feeding	Shallow water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	2	Feeding	Shallow water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	3	Feeding	Shallow water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black Swan	1	Feeding	Shallow water	22/07/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Feeding	Shallow water	20/08/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Roosting	Saltmarsh	20/08/2015	Falling	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	2	Feeding	Shallow water	20/08/2015	Falling	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	1	Feeding	Saltmarsh	02/09/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Feeding	Shallow water	25/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	2	Feeding	Shallow water	25/09/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Roosting	Saltmarsh	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Common Greenshank	1	Feeding	Shallow water	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	12	Feeding	Shallow water	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Eastern Great Egret	1	Feeding	Shallow water	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	2	Feeding	Open water	30/09/2015	Falling	Diurnal

AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	3	Feeding	Shallow water	30/09/2015	Falling	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	2	Feeding	Shallow water	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Feeding	Saltmarsh	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Black Swan	4	Feeding	Shallow water	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	60	Feeding	Shallow water	08/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Eastern Great Egret	24	Roosting	Shallow water	09/10/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Australian Pelican	16	Roosting	Exposed mud/sand	09/10/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Little Egret	1	Feeding	Shallow water	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Eastern Great Egret	1	Feeding	Shallow water	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Feeding	Saltmarsh	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Silver Gull	1	Feeding	Open water	15/10/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	1	Feeding	Saltmarsh	15/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	7	Feeding	Saltmarsh	15/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	2	Feeding	Shallow water	16/10/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	3	Feeding	Shallow water	21/10/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Feeding	Shallow water	21/10/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	1	Feeding	Shallow water	27/10/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Eastern Great Egret	1	Feeding	Shallow water	27/10/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Little Pied Cormorant	1	Feeding	Open water	27/10/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Feeding	Saltmarsh	27/10/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Royal Spoonbill	1	Feeding	Shallow water	27/10/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	4	Feeding	Shallow water	05/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	6	Feeding	Shallow water	05/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	320	Feeding	Shallow water	05/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Feeding	Shallow water	05/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	1	Feeding	Shallow water	05/11/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Royal Spoonbill	1	Feeding	Shallow water	05/11/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	3	Feeding	Saltmarsh	11/11/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	4	Feeding	Saltmarsh	11/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Little Egret	1	Feeding	Shallow water	11/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	2	Feeding	Shallow water	11/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	3	Feeding	Saltmarsh	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Australian White Ibis	1	Feeding	Shallow water	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Feeding	Shallow water	18/11/2015	Low	Diurnal

AREA E - Hunter Estuary	Swan Pond South	Striated Heron	1	Feeding	Shallow water	18/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	1	Feeding	Saltmarsh	18/11/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Australian White Ibis	1	Feeding	Saltmarsh	18/11/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Australian White Ibis	1	Feeding	Saltmarsh	26/11/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	4	Feeding	Saltmarsh	26/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	2	Feeding	Shallow water	26/11/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Australian White Ibis	2	Feeding	Saltmarsh	03/12/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	4	Feeding	Saltmarsh	03/12/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Feeding	Shallow water	03/12/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	19	Feeding	Shallow water	03/12/2015	Low	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Little Black Cormorant	1	Feeding	Shallow water	03/12/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	White-faced Heron	1	Feeding	Saltmarsh	03/12/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	4	Feeding	Saltmarsh	03/12/2015	High	Diurnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Feeding	Saltmarsh	25/09/2015	High	Nocturnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	40	Feeding	Shallow water	25/09/2015	High	Nocturnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	36	Feeding	Shallow water	30/09/2015	Rising	Nocturnal
AREA E - Hunter Estuary	Swan Pond South	Royal Spoonbill	2	Feeding	Shallow water	30/09/2015	Rising	Nocturnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Feeding	Saltmarsh	29/10/2015	Low	Nocturnal
AREA E - Hunter Estuary	Swan Pond South	Black-winged Stilt	2	Feeding	Shallow water	29/10/2015	Low	Nocturnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	2	Feeding	Saltmarsh	29/10/2015	Low	Nocturnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	9	Feeding	Shallow water	05/11/2015	Low	Nocturnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	4	Feeding	Shallow water	05/11/2015	Low	Nocturnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	17	Feeding	Shallow water	05/11/2015	Low	Nocturnal
AREA E - Hunter Estuary	Swan Pond South	Grey Teal	1	Feeding	Shallow water	05/11/2015	Low	Nocturnal
AREA E - Hunter Estuary	Swan Pond South	Red-necked Avocet	6	Feeding	Shallow water	11/11/2015	High	Nocturnal
AREA E - Hunter Estuary	Swan Pond South	Masked Lapwing	4	Feeding	Saltmarsh	11/11/2015	High	Nocturnal
AREA E - Hunter Estuary	Swan Pond South	Chestnut Teal	1	Feeding	Shallow water	11/11/2015	High	Nocturnal

Site	Sub-site	Common Name	Count	Behaviour	Habitat	Date	Tide	Period
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	30	Roosting	Saltmarsh	10/02/2015	Rising	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Swamp Harrier	1	Flying		10/02/2015	Rising	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	7	Roosting	Saltmarsh	20/02/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Australian White Ibis	16	Feeding	Saltmarsh	20/02/2015	High	Diurnal

Hunter Estuary	Ash Island/Phoenix Flat	White-faced Heron	1	Feeding	Saltmarsh	20/02/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Sharp-tailed Sandpiper	1	Roosting	Saltmarsh	25/02/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	24	Roosting	Saltmarsh	25/02/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	22	Roosting	Saltmarsh	05/03/2015	Falling	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Eastern Curlew	2	Feeding	Saltmarsh	09/03/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	40	Roosting	Saltmarsh	09/03/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Australian White Ibis	55	Feeding	Saltmarsh	09/03/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Eastern Curlew	6	Roosting	Saltmarsh	20/03/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	31	Roosting	Saltmarsh	20/03/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Eastern Curlew	4	Roosting	Saltmarsh	23/03/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	14	Roosting	Saltmarsh	23/03/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	White-faced Heron	1	Roosting	Saltmarsh	23/03/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Eastern Curlew	16	roosting	saltmarsh	02/04/2015	outgoing tide	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	29	roosting	saltmarsh	02/04/2015	outgoing tide	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	1	roosting	saltmarsh	02/04/2015	outgoing tide	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Australian White Ibis	20	roosting	saltmarsh	02/04/2015	outgoing tide	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Red-capped Plover	1	Roosting	Saltmarsh	09/04/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Black-fronted Dotterel	1	Roosting	Saltmarsh	09/04/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	2	Roosting	Saltmarsh	05/05/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Australian White Ibis	1	Feeding	Saltmarsh	18/06/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	White-faced Heron	1	Feeding	Saltmarsh	18/06/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	1	Roosting	Saltmarsh	22/07/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Black-fronted Dotterel	3	Feeding	Saltmarsh	02/09/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	White-faced Heron	1	Feeding	Saltmarsh	02/09/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	White-necked Heron	1	Feeding	Exposed mud/sand	02/09/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	1	Roosting	Saltmarsh	11/09/2015	Falling	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	1	Feeding	Saltmarsh	11/09/2015	Falling	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Black-fronted Dotterel	1	Feeding	Saltmarsh	11/09/2015	Falling	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	2	Feeding	Saltmarsh	11/09/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Eastern Curlew	2	Roosting	Saltmarsh	18/09/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	2	Feeding	Saltmarsh	18/09/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Black-fronted Dotterel	1	Feeding	Saltmarsh	18/09/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Eastern Curlew	3	Feeding	Exposed mud/sand	25/09/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	2	Feeding	Saltmarsh	25/09/2015	Low	Diurnal

Hunter Estuary	Ash Island/Phoenix Flat	Chestnut Teal	2	Roosting	Saltmarsh	25/09/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	19	Roosting	Saltmarsh	30/09/2015	Falling	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	4	Feeding	Saltmarsh	30/09/2015	Falling	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	9	Roosting	Saltmarsh	08/10/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	2	Feeding	Saltmarsh	08/10/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Black-fronted Dotterel	1	Feeding	Exposed mud/sand	08/10/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Eastern Curlew	2	Feeding	Exposed mud/sand	09/10/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	9	Roosting	Saltmarsh	09/10/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	2	Roosting	Saltmarsh	09/10/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Australian White Ibis	1	Feeding	Exposed mud/sand	09/10/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	White-faced Heron	2	Feeding	Shallow water	09/10/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	25	Roosting	Saltmarsh	15/10/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Australian White Ibis	1	Roosting	Saltmarsh	21/10/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat		0			27/10/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Sharp-tailed Sandpiper	4	Roosting	Shallow water	27/10/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	20	Roosting	Shallow water	27/10/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	2	Feeding	Saltmarsh	27/10/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat		0			29/10/2015	Low	Nocturnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	53	Roosting	Shallow water	05/11/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat		0			05/11/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat		0			05/11/2015	Low	Nocturnal
Hunter Estuary	Ash Island/Phoenix Flat		0			11/11/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat		0			11/11/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat		0			11/11/2015	High	Nocturnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	36	Roosting	Saltmarsh	26/11/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Sharp-tailed Sandpiper	25	Roosting	Saltmarsh	26/11/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Pacific Golden Plover	30	Roosting	Saltmarsh	26/11/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Sharp-tailed Sandpiper	46	Roosting	Saltmarsh	26/11/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	3	Feeding	Saltmarsh	18/11/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	2	Feeding	Saltmarsh	18/11/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	1	Feeding	Shallow water	03/12/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Sharp-tailed Sandpiper	3	Feeding	Shallow water	03/12/2015	Low	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Masked Lapwing	2	Feeding	Saltmarsh	03/12/2015	High	Diurnal
Hunter Estuary	Ash Island/Phoenix Flat	Australian Pelican	1	Roosting	Saltmarsh	03/12/2015	High	Diurnal

Site	Sub-site	Common Name	Count	Behaviour	Habitat	Date	Tide	Period
Hunter Estuary	Kooragang Dykes	Bar-tailed Godwit	120	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	65	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	4000	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	4	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	9	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pacific Golden Plover	21	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	5	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	3	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	4	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	63	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	4	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	18	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian White Ibis	4	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	37	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Royal Spoonbill	1	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Black-tailed Godwit	1	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	38	Roosting	Rocks	25/02/2015	Rising	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	10	Roosting	Rocks	25/02/2015	Rising	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	2	Roosting	Rocks	25/02/2015	Rising	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	3	Roosting	Rocks	25/02/2015	Rising	Diurnal
Hunter Estuary	Kooragang Dykes	Pacific Golden Plover	60	Roosting	Rocks	25/02/2015	Rising	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	4	Roosting	Rocks	25/02/2015	Rising	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	2	Roosting	Rocks	25/02/2015	Rising	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	100	Roosting	Rocks	25/02/2015	Rising	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	4	Roosting	Rocks	25/02/2015	Rising	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	3	Roosting	Rocks	25/02/2015	Rising	Diurnal
Hunter Estuary	Kooragang Dykes	Australian White Ibis	2	Roosting	Rocks	25/02/2015	Rising	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	11	Roosting	Rocks	25/02/2015	Rising	Diurnal
Hunter Estuary	Kooragang Dykes	Royal Spoonbill	1	Roosting	Rocks	25/02/2015	Rising	Diurnal
Hunter Estuary	Kooragang Dykes	Bar-tailed Godwit	460	Roosting	Rocks	05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	70	Roosting	Rocks	05/03/2015	High	Diurnal

Hunter Estuary	Kooragang Dykes	Common Greenshank	6	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Grey-tailed Tattler	10	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Stint	15	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	3500	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Curlew Sandpiper	50	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Black-winged Stilt	10	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pacific Golden Plover	238	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	6	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	5	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	14	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	62	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	5	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	4	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian White Ibis	1	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	White-faced Heron	1	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	70	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Royal Spoonbill	4	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Avocet	30	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Darter	1	Roosting	Rocks		05/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	86	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Stint	63	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	600	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	1	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	14	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	6	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	10	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Tern	56	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	20	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	5	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	6	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian White Ibis	1	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	White-faced Heron	2	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	54	Roosting	Rocks		09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Royal Spoonbill	3	Roosting	Rocks		09/03/2015	High	Diurnal

Hunter Estuary	Kooragang Dykes	Black-tailed Godwit	1	Roosting	Rocks	09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Avocet	4	Roosting	Rocks	09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Darter	1	Roosting	Rocks	09/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Bar-tailed Godwit	484	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	27	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Stint	108	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	5	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Curlew Sandpiper	66	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	1	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Black-winged Stilt	1	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pacific Golden Plover	279	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Double-banded Plover	5	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	12	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	4	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	1	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Tern	44	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	168	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	4	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	10	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	White-faced Heron	1	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Striated Heron	1	Feeding	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	77	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Royal Spoonbill	8	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Avocet	4	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Darter	3	Roosting	Rocks	20/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	29	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Stint	3	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	19	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Curlew Sandpiper	36	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pacific Golden Plover	299	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	2	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	9	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	4	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Tern	50	Roosting	Rocks	23/03/2015	High	Diurnal

Hunter Estuary	Kooragang Dykes	Silver Gull	171	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	4	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Pied Cormorant	1	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	6	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	White-faced Heron	1	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	49	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Royal Spoonbill	8	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Darter	1	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Avocet	10	Roosting	Rocks	23/03/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Bar-tailed Godwit	125	roosting	rocks	02/04/2015	high	Diurnal
Hunter Estuary	Kooragang Dykes	Pacific Golden Plover	138	roosting	rocks	02/04/2015	high	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	3	roosting	rocks	02/04/2015	high	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	3	roosting	rocks	02/04/2015	high	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	16	roosting	rocks	02/04/2015	high	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	90	roosting	rocks	02/04/2015	high	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	4	roosting	rocks	02/04/2015	high	Diurnal
Hunter Estuary	Kooragang Dykes	Australian White Ibis	2	roosting	rocks	02/04/2015	high	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	45	roosting	rocks	02/04/2015	high	Diurnal
Hunter Estuary	Kooragang Dykes	Royal Spoonbill	5	roosting	rocks	02/04/2015	high	Diurnal
Hunter Estuary	Kooragang Dykes	Bar-tailed Godwit	126	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Stint	50	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	1685	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	5	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Black-winged Stilt	169	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pacific Golden Plover	98	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	8	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	6	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	17	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	25	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Great Egret	1	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	White-faced Heron	4	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	57	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Royal Spoonbill	3	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Black-tailed Godwit	37	Roosting	Rocks	09/04/2015	High	Diurnal

Hunter Estuary	Kooragang Dykes	Darter	2	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	3	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Great Cormorant	1	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Egret	1	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	66	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Great Egret	1	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Pied Cormorant	2	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	White-faced Heron	4	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	7	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	3	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	15	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Bar-tailed Godwit	1	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	18	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Black-winged Stilt	17	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Gull-billed Tern	1	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	2	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	108	Roosting	Rocks	05/05/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Bar-tailed Godwit	97	Roosting	Rocks	18/06/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	14	Roosting	Rocks	18/06/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	4	Roosting	Rocks	18/06/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Black-winged Stilt	140	Roosting	Rocks	18/06/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	2	Roosting	Rocks	18/06/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	12	Roosting	Rocks	18/06/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	35	Roosting	Rocks	18/06/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Pied Cormorant	1	Roosting	Rocks	18/06/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	1	Roosting	Rocks	18/06/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Egret	1	Roosting	Rocks	18/06/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	115	Roosting	Rocks	18/06/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Avocet	2	Roosting	Rocks	18/06/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Darter	2	Roosting	Rocks	18/06/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	2	Roosting	Rocks	22/07/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	14	Roosting	Rocks	22/07/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	1	Roosting	Rocks	22/07/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	6	Roosting	Rocks	22/07/2015	High	Diurnal

Hunter Estuary	Kooragang Dykes	Crested Tern	1	Roosting	Rocks	22/07/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	8	Roosting	Rocks	22/07/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	4	Roosting	Rocks	22/07/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Pied Cormorant	1	Roosting	Rocks	22/07/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	White-faced Heron	1	Roosting	Rocks	22/07/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Darter	2	Roosting	Rocks	22/07/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	18	Roosting	Rocks	22/07/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Gull-billed Tern	1	Roosting	Rocks	22/07/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	74	Roosting	Rocks	20/08/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Common Greenshank	25	Roosting	Rocks	20/08/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	29	Roosting	Rocks	20/08/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	2	Roosting	Rocks	20/08/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	3	Roosting	Rocks	20/08/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Great Egret	1	Roosting	Rocks	20/08/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	White-faced Heron	6	Roosting	Rocks	20/08/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	23	Roosting	Rocks	20/08/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Common Greenshank	36	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Stint	2	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	145	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	40	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	2	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	7	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	1	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	47	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	9	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Pied Cormorant	1	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	7	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Great Egret	1	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Egret	1	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	White-faced Heron	3	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	36	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Darter	1	Roosting	Rocks	02/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Bar-tailed Godwit	1	Roosting	Rocks	11/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	40	Roosting	Rocks	11/09/2015	High	Diurnal

Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	25	Roosting	Rocks	11/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	2	Roosting	Rocks	11/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	2	Roosting	Rocks	11/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	1	Roosting	Rocks	11/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	106	Roosting	Rocks	11/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	2	Roosting	Rocks	11/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Egret	1	Roosting	Rocks	11/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	27	Roosting	Rocks	11/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	30	Roosting	Exposed mud/sand	18/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	250	Roosting	Tree/mangrove	18/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	28	Roosting	Rocks	18/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	3	Roosting	Rocks	18/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	50	Roosting	Rocks	18/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	4	Roosting	Rocks	18/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	12	Roosting	Rocks	18/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Great Egret	1	Roosting	Rocks	18/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	70	Roosting	Rocks	18/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Royal Spoonbill	2	Roosting	Rocks	18/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Hobby	1	Feeding	Open water	18/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Darter	1	Roosting	Rocks	18/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	37	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Stint	35	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Curlew Sandpiper	75	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	1515	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pacific Golden Plover	66	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Common Greenshank	56	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	2	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	7	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Darter	1	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	1	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Great Egret	1	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	38	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	60	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	7	Roosting	Rocks	30/09/2015	High	Diurnal

Hunter Estuary	Kooragang Dykes	Swamp Harrier	1			30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	White-bellied Sea-Eagle	1			30/09/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	103	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Common Greenshank	52	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	45	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	42	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	6	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Black-winged Stilt	2	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pacific Golden Plover	4	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	3	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	250	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	1	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Egret	1	Roosting	Tree/mangrove	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	50	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Gull-billed Tern	24	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Darter	2	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Common Sandpiper	1	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Darter	1	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Pied Cormorant	13	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	9	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	88	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	White-faced Heron	1	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	39	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Common Greenshank	80	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Stint	2	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	1855	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Curlew Sandpiper	1	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	24	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	2	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	2	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	40	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	3	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Bar-tailed Godwit	1	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	222	Roosting	Rocks	21/10/2015	High	Diurnal

Hunter Estuary	Kooragang Dykes	Common Greenshank	56	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Common Sandpiper	1	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Ruddy Turnstone	1	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	700	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	20	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	2	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pacific Golden Plover	34	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	1	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	3	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	6	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Tern	1	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	38	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Darter	1	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	11	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	61	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Bar-tailed Godwit	1	Roosting	Rocks	05/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Common Greenshank	44	Roosting	Rocks	05/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Common Sandpiper	1	Feeding	Rocks	05/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	18	Roosting	Rocks	05/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	4	Roosting	Rocks	05/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pacific Golden Plover	1	Roosting	Rocks	05/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	3	Feeding	Open water	05/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Tern	5	Feeding	Open water	05/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	3	Roosting	Rocks	05/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australasian Grebe	75	Roosting	Rocks	05/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	170	Roosting	Rocks	05/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Common Greenshank	100	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Grey-tailed Tattler	2	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Ruddy Turnstone	1	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Stint	9	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	814	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Curlew Sandpiper	36	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	25	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pacific Golden Plover	91	Roosting	Rocks	11/11/2015	High	Diurnal

Hunter Estuary	Kooragang Dykes	Masked Lapwing	6	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	1	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	2	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	76	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Darter	3	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	10	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Pied Cormorant	1	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	16	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	58	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Black Cormorant	9	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	9	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Common Greenshank	75	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	120	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	2	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	17	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	24	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	76	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pacific Golden Plover	91	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Curlew Sandpiper	24	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	330	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Caspian Tern	2	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	4	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Tern	1	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Bar-tailed Godwit	310	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Eastern Curlew	61	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Common Greenshank	92	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Ruddy Turnstone	1	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Red-necked Stint	5	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sharp-tailed Sandpiper	810	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	21	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	2	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	7	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Crested Tern	1	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	79	Roosting	Rocks	18/11/2015	High	Diurnal

Hunter Estuary	Kooragang Dykes	Little Black Cormorant	2	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	7	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	83	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Egret	2	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	White-faced Heron	1	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Little Pied Cormorant	3	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Cormorant	3	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Common Greenshank	16	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Silver Gull	105	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	White-faced Heron	1	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Masked Lapwing	4	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Pied Oystercatcher	17	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Sooty Oystercatcher	5	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Australian Pelican	54	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Black-winged Stilt	1	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Royal Spoonbill	2	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Kooragang Dykes	Gull-billed Tern	2	Roosting	Rocks	03/12/2015	High	Diurnal

Site	Sub-site	Common Name	Count	Behaviour	Habitat	Date	Tide	Period
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	527	Roosting	Saltmarsh	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	130	Roosting	Saltmarsh	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	4	Roosting	Saltmarsh	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Stint	8	Roosting	Saltmarsh	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Sharp-tailed Sandpiper	2500	Roosting	Saltmarsh	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	6	Roosting	Saltmarsh	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	5	Roosting	Shallow water	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	22	Roosting	Saltmarsh	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-capped Plover	2	Roosting	Saltmarsh	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	22	Roosting	Saltmarsh	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Tern	5	Roosting	Emergent vegetation	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	2	Roosting	Saltmarsh	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	150	Roosting	Shallow water	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-tailed Godwit	43	Roosting	Saltmarsh	05/02/2015	High	Diurnal

Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	390	Roosting	Saltmarsh	23/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	130	Roosting	Saltmarsh	23/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	10	Roosting	Saltmarsh	23/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	3	Roosting	Saltmarsh	23/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	220	Roosting	Saltmarsh	23/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	39	Roosting	Saltmarsh	23/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	4	Roosting	Saltmarsh	23/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Pied Cormorant	1	Roosting	Saltmarsh	23/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Australian White Ibis	1	Feeding	Saltmarsh	23/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	3	Feeding	Saltmarsh	23/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	3200	Roosting	Shallow water	23/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Marsh Sandpiper	1	Roosting	Saltmarsh	23/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-tailed Godwit	60	Roosting	Saltmarsh	23/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	340	Roosting	Exposed mud/sand	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	120	Roosting	Saltmarsh	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	2	Roosting	Exposed mud/sand	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	14	Roosting	Exposed mud/sand	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	3	Roosting	Exposed mud/sand	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	350	Roosting	Shallow water	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	105	Feeding	Saltmarsh	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	11	Roosting	Saltmarsh	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	1	Roosting	Shallow water	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Great Egret	1	Roosting	Shallow water	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	4	Roosting	Saltmarsh	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	3700	Roosting	Shallow water	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Gull-billed Tern	43	Roosting	Exposed mud/sand	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Terek Sandpiper	1	Roosting	Exposed mud/sand	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-tailed Godwit	20	Roosting	Exposed mud/sand	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Australian Pelican	1	Roosting	Shallow water	29/12/2014	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	200	Roosting	Saltmarsh	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	105	Roosting	Saltmarsh	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Sharp-tailed Sandpiper	1400	Roosting	Saltmarsh	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	74	Roosting	Exposed mud/sand	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Roosting	Saltmarsh	10/02/2015	High	Diurnal

Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	280	Roosting	Saltmarsh	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	4	Roosting	Saltmarsh	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	15	Roosting	Exposed mud/sand	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Tern	1	Roosting	Exposed mud/sand	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Silver Gull	1	Roosting	Exposed mud/sand	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Egret	1	Roosting	Saltmarsh	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Gull-billed Tern	2	Roosting	Exposed mud/sand	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-tailed Godwit	20	Roosting	Saltmarsh	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	1	Roosting	Saltmarsh	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	97	Roosting	Saltmarsh	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	1	Roosting	Saltmarsh	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	3	Roosting	Saltmarsh	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Australian White Ibis	3	Feeding	Saltmarsh	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Great Egret	1	Roosting	Saltmarsh	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	2	Feeding	Shallow water	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	90	Roosting	Shallow water	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	50	Roosting	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	12	Feeding	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Stint	48	Feeding	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Sharp-tailed Sandpiper	90	Roosting	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	50	Roosting	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Roosting	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	240	Roosting	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Red-capped Plover	5	Feeding	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	3	Roosting	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Crested Tern	2	Roosting	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Little Tern	4	Roosting	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Silver Gull	13	Roosting	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	1	Feeding	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	60	Roosting	Shallow water	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Australian Pelican	5	Roosting	Exposed mud/sand	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	51	Roosting	Saltmarsh	05/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Sharp-tailed Sandpiper	500	Roosting	Saltmarsh	05/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	100	Roosting	Saltmarsh	05/03/2015	High	Diurnal

Hunter Estuary	Stockton Sandspit	Masked Lapwing	2	Roosting	Saltmarsh	05/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	1	Feeding	Shallow water	05/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Australian White Ibis	7	Feeding	Saltmarsh	05/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Egret	1	Roosting	Saltmarsh	05/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	2	Feeding	Saltmarsh	05/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-tailed Godwit	1	Roosting	Saltmarsh	05/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	450	Roosting	Shallow water	09/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	50	Roosting	Shallow water	09/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	320	Roosting	Shallow water	09/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Egret	1	Feeding	Saltmarsh	09/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	2	Feeding	Saltmarsh	09/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	5	Roosting	Shallow water	09/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-tailed Godwit	50	Roosting	Shallow water	09/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	240	Roosting	Saltmarsh	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	8	Roosting	Saltmarsh	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Roosting	Saltmarsh	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	46	Roosting	Shallow water	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-capped Plover	3	Roosting	Saltmarsh	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	2	Roosting	Saltmarsh	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Silver Gull	1	Feeding	Saltmarsh	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Egret	1	Feeding	Shallow water	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	2	Feeding	Saltmarsh	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	13	Roosting	Shallow water	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	580	Roosting	Shallow water	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	42	Roosting	Saltmarsh	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Common Greenshank	1	Roosting	Shallow water	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	38	Roosting	Shallow water	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	10	Roosting	Exposed mud/sand	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Silver Gull	1	Roosting	Exposed mud/sand	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Australian White Ibis	3	Roosting	Saltmarsh	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Egret	1	Roosting	Exposed mud/sand	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	2	Roosting	Saltmarsh	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	40	Roosting	Shallow water	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-tailed Godwit	40	Roosting	Saltmarsh	23/03/2015	High	Diurnal

Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	85	roosting	saltmarsh	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	Whimbrel	7	roosting	saltmarsh	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	14	roosting	saltmarsh	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	Grey-tailed Tattler	39	roosting	rocks	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	Terek Sandpiper	4	roosting	rocks	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	roosting	saltmarsh	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	56	roosting	saltmarsh	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	Black-tailed Godwit	5	roosting	saltmarsh	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	23	roosting	saltmarsh	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	6	roosting	saltmarsh	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	Australian White Ibis	1	roosting	saltmarsh	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	Little Egret	1	roosting	saltmarsh	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	2	roosting	saltmarsh	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	Australian Pelican	11	roosting	saltmarsh	02/04/2015	high	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	12	Roosting	Saltmarsh	09/04/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	118	Roosting	Shallow water	09/04/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	25	Roosting	Saltmarsh	09/04/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	4	Roosting	Shallow water	09/04/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Australian White Ibis	4	Feeding	Saltmarsh	09/04/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	2	Feeding	Shallow water	09/04/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	650	Roosting	Shallow water	09/04/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Gull-billed Tern	5	Roosting	Shallow water	09/04/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	1	Roosting	Shallow water	05/05/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Royal Spoonbill	4	Roosting	Shallow water	05/05/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	1	Roosting	Shallow water	05/05/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	380	Roosting	Shallow water	05/05/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Great Egret	1	Feeding	Shallow water	05/05/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	2	Feeding	Shallow water	05/05/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	120	Roosting	Shallow water	05/05/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	73	Roosting	Exposed mud/sand	18/06/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	10	Roosting	Exposed mud/sand	18/06/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	1	Feeding	Exposed mud/sand	18/06/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	4	Feeding	Exposed mud/sand	18/06/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	56	Roosting	Exposed mud/sand	18/06/2015	High	Diurnal

Hunter Estuary	Stockton Sandspit	Red-capped Plover	2	Feeding	Exposed mud/sand	18/06/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	1	Roosting	Exposed mud/sand	18/06/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	3	Roosting	Exposed mud/sand	18/06/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Great Egret	1	Feeding	Shallow water	18/06/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Egret	1	Feeding	Shallow water	18/06/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	1	Feeding	Saltmarsh	18/06/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Gull-billed Tern	4	Roosting	Exposed mud/sand	18/06/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	2200	Roosting	Shallow water	18/06/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	77	Roosting	Exposed mud/sand	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	23	Roosting	Exposed mud/sand	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Grey-tailed Tattler	5	Feeding	Exposed mud/sand	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	2	Feeding	Exposed mud/sand	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Feeding	Shallow water	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	19	Roosting	Shallow water	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	1	Feeding	Exposed mud/sand	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	2	Roosting	Saltmarsh	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	14	Roosting	Shallow water	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	2	Feeding	Shallow water	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Gull-billed Tern	5	Roosting	Shallow water	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	3800	Roosting	Shallow water	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-tailed Godwit	1	Roosting	Exposed mud/sand	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	75	Roosting	Shallow water	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	62	Roosting	Saltmarsh	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Grey-tailed Tattler	6	Roosting	Shallow water	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Feeding	Shallow water	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	66	Roosting	Shallow water	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	6	Roosting	Saltmarsh	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-capped Plover	3	Roosting	Saltmarsh	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	9	Roosting	Shallow water	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	5	Roosting	Saltmarsh	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Gull-billed Tern	44	Roosting	Shallow water	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	4000	Roosting	Shallow water	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	60	Roosting	Shallow water	02/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	112	Roosting	Saltmarsh	02/09/2015	High	Diurnal

Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	5	Roosting	Exposed mud/sand	02/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	36	Roosting	Shallow water	02/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-capped Plover	1	Roosting	Saltmarsh	02/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Australian White Ibis	3	Feeding	Exposed mud/sand	02/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Egret	1	Roosting	Saltmarsh	02/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	1	Feeding	Exposed mud/sand	02/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	4200	Roosting	Shallow water	02/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	10	Roosting	Shallow water	11/09/2015	Falling	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	127	Roosting	Shallow water	11/09/2015	Falling	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	1	Roosting	Exposed mud/sand	11/09/2015	Falling	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	8	Roosting	Saltmarsh	11/09/2015	Falling	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	2	Roosting	Saltmarsh	11/09/2015	Falling	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	4	Roosting	Exposed mud/sand	11/09/2015	Falling	Diurnal
Hunter Estuary	Stockton Sandspit	Little Egret	1	Roosting	Saltmarsh	11/09/2015	Falling	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	2	Feeding	Saltmarsh	11/09/2015	Falling	Diurnal
Hunter Estuary	Stockton Sandspit	Gull-billed Tern	3	Roosting	Exposed mud/sand	11/09/2015	Falling	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	5300	Roosting	Shallow water	11/09/2015	Falling	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	100	Roosting	Shallow water	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Whimbrel	6	Roosting	Shallow water	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	92	Roosting	Exposed mud/sand	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	126	Roosting	Exposed mud/sand	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Stint	1	Roosting	Exposed mud/sand	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Sharp-tailed Sandpiper	30	Roosting	Exposed mud/sand	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	66	Roosting	Exposed mud/sand	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Roosting	Exposed mud/sand	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Common Greenshank	5	Roosting	Shallow water	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-capped Plover	5	Feeding	Shallow water	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	1	Feeding	Saltmarsh	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	1	Roosting	Exposed mud/sand	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Gull-billed Tern	32	Roosting	Exposed mud/sand	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	250	Roosting	Shallow water	25/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	79	Roosting	Saltmarsh	25/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	230	Roosting	Exposed mud/sand	25/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Roosting	Saltmarsh	25/09/2015	High	Diurnal

Hunter Estuary	Stockton Sandspit	Caspian Tern	3	Roosting	Exposed mud/sand	25/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Gull-billed Tern	25	Roosting	Exposed mud/sand	25/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	4500	Roosting	Shallow water	25/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	311	Roosting	Saltmarsh	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	110	Roosting	Saltmarsh	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	70	Roosting	Exposed mud/sand	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Sharp-tailed Sandpiper	10	Roosting	Exposed mud/sand	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Nesting	Saltmarsh	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	23	Roosting	Shallow water	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	4	Roosting	Saltmarsh	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-tailed Godwit	7	Roosting	Saltmarsh	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	4200	Roosting	Shallow water	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Grey-tailed Tattler	19	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Terek Sandpiper	1	Roosting	Rocks	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	572	Roosting	Shallow water	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Whimbrel	1	Roosting	Exposed mud/sand	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Grey-tailed Tattler	27	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	860	Roosting	Exposed mud/sand	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	30	Roosting	Exposed mud/sand	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Nesting	Saltmarsh	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	85	Roosting	Shallow water	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	44	Roosting	Saltmarsh	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-capped Plover	2	Nesting	Saltmarsh	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Australian Pelican	6	Roosting	Shallow water	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	4000	Roosting	Shallow water	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Terek Sandpiper	2	Roosting	Rocks	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Egret	1	Feeding	Shallow water	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-tailed Godwit	30	Roosting	Shallow water	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	500	Roosting	Shallow water	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	70	Roosting	Saltmarsh	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	200	Roosting	Shallow water	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Sharp-tailed Sandpiper	1	Roosting	Shallow water	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	3	Roosting	Shallow water	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Nesting	Saltmarsh	15/10/2015	High	Diurnal

Hunter Estuary	Stockton Sandspit	Black-winged Stilt	50	Roosting	Shallow water	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	4000	Roosting	Shallow water	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-capped Plover	3	Feeding	Saltmarsh	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	2	Roosting	Saltmarsh	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	2	Roosting	Exposed mud/sand	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Grey-tailed Tattler	16	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	600	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-tailed Godwit	2	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	68	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	190	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	140	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Cormorant	1	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	56	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	4000	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-capped Plover	3	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	16	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Grey-tailed Tattler	13	Roosting	Rocks	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Crested Tern	1	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Tern	3	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	1	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Beach Stone-curlew	1	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Gull-billed Tern	20	Roosting	Shallow water	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	450	Roosting	Shallow water	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	140	Roosting	Shallow water	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	180	Roosting	Shallow water	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Sharp-tailed Sandpiper	2	Roosting	Shallow water	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	20	Roosting	Shallow water	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Feeding	Shallow water	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	4000	Roosting	Shallow water	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	14	Feeding	Saltmarsh	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Tern	2	Feeding	Shallow water	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Little Pied Cormorant	3	Feeding	Open water	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Australian White Ibis	2	Feeding	Shallow water	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	White-faced Heron	1	Feeding	Open water	27/10/2015	High	Diurnal

Hunter Estuary	Stockton Sandspit	Terek Sandpiper	2	Roosting	Shallow water	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Grey-tailed Tattler	28	Roosting	Shallow water	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	600	Roosting	Shallow water	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	152	Roosting	Shallow water	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Grey-tailed Tattler	2	Roosting	Shallow water	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	66	Roosting	Shallow water	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Stint	1	Roosting	Shallow water	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	60	Roosting	Shallow water	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Roosting	Shallow water	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	51	Roosting	Shallow water	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	4000	Roosting	Shallow water	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-capped Plover	3	Feeding	Saltmarsh	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	14	Roosting	Shallow water	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Grey Plover	1	Roosting	Shallow water	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	800	Roosting	Exposed mud/sand	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Whimbrel	2	Roosting	Saltmarsh	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	140	Roosting	Saltmarsh	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Great Knot	3	Roosting	Exposed mud/sand	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	36	Roosting	Exposed mud/sand	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Sharp-tailed Sandpiper	6	Roosting	Exposed mud/sand	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Feeding	Exposed mud/sand	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	36	Roosting	Shallow water	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	4000	Roosting	Exposed mud/sand	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-capped Plover	1	Feeding	Exposed mud/sand	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	3	Roosting	Exposed mud/sand	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Terek Sandpiper	3	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Grey-tailed Tattler	16	Roosting	Rocks	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	4000	Roosting	Artificial structure	26/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	80	Roosting	Saltmarsh	26/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	650	Roosting	Saltmarsh	26/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-tailed Godwit	1	Roosting	Saltmarsh	26/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	8	Roosting	Saltmarsh	26/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	4	Roosting	Saltmarsh	26/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	33	Roosting	Saltmarsh	26/11/2015	High	Diurnal

Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	1	Roosting	Saltmarsh	26/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Sharp-tailed Sandpiper	2	Roosting	Saltmarsh	26/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	60	Roosting	Saltmarsh	26/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	470	Roosting	Exposed mud/sand	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Eastern Curlew	65	Roosting	Saltmarsh	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Great Knot	1	Roosting	Exposed mud/sand	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red Knot	2	Roosting	Exposed mud/sand	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Stint	3	Roosting	Exposed mud/sand	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Sharp-tailed Sandpiper	44	Roosting	Exposed mud/sand	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Curlew Sandpiper	200	Roosting	Exposed mud/sand	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Roosting	Exposed mud/sand	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	30	Roosting	Exposed mud/sand	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	4000	Roosting	Exposed mud/sand	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Terek Sandpiper	2	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Grey-tailed Tattler	14	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	2	Roosting	Saltmarsh	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Caspian Tern	5	Roosting	Exposed mud/sand	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Silver Gull	1	Roosting	Exposed mud/sand	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Gull-billed Tern	56	Roosting	Exposed mud/sand	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Red-necked Avocet	4000	Roosting	Shallow water	03/12/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Bar-tailed Godwit	312	Roosting	Shallow water	03/12/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Masked Lapwing	16	Roosting	Saltmarsh	03/12/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pied Oystercatcher	2	Roosting	Exposed mud/sand	03/12/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Black-winged Stilt	40	Roosting	Shallow water	03/12/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Gull-billed Tern	3	Roosting	Shallow water	03/12/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Common Greenshank	1	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Pacific Golden Plover	40	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Stockton Sandspit	Grey-tailed Tattler	10	Roosting	Rocks	03/12/2015	High	Diurnal

Site	Sub-site	Common Name	Count	Behaviour	Habitat	Date	Tide	Period
Hunter Estuary	Stockton Channel	Grey-tailed Tattler	9	Roosting	Artificial structure	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	7	Roosting	Artificial structure	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Crested Tern	1	Roosting	Artificial structure	05/02/2015	High	Diurnal

Hunter Estuary	Stockton Channel	Pied Cormorant	1	Roosting	Artificial structure	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Channel	White-faced Heron	1	Roosting	Artificial structure	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Australian Pelican	1	Roosting	Artificial structure	05/02/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Grey-tailed Tattler	12	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	14	Roosting	Rocks	10/02/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Grey-tailed Tattler	1	Roosting	Rocks	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	8	Roosting	Rocks	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Common Tern	24	Roosting	Artificial structure	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Crested Tern	4	Roosting	Artificial structure	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Silver Gull	1	Roosting	Artificial structure	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	10	Roosting	Artificial structure	20/02/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Grey-tailed Tattler	1	Roosting	Artificial structure	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Channel	Little Pied Cormorant	1	Roosting	Artificial structure	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Channel	Australian Pelican	1	Roosting	Artificial structure	25/02/2015	Rising	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	13	Roosting	Rocks	05/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	1	Roosting	Artificial structure	05/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	8	Roosting	Rocks	09/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Common Tern	6	Roosting	Artificial structure	09/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Crested Tern	2	Roosting	Artificial structure	09/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	1	Roosting	Artificial structure	09/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	White-faced Heron	1	Roosting	Rocks	09/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	2	Roosting	Artificial structure	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Common Tern	3	Roosting	Artificial structure	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Silver Gull	2	Roosting	Artificial structure	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	1	Roosting	Artificial structure	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	White-faced Heron	1	Roosting	Emergent vegetation	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Australian Pelican	2	Roosting	Artificial structure	20/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Grey-tailed Tattler	7	Roosting	Artificial structure	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	4	Roosting	Artificial structure	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Common Tern	1	Roosting	Artificial structure	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	White-faced Heron	1	Feeding	Shallow water	23/03/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Grey-tailed Tattler	6	Roosting	Rocks	09/04/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	5	Roosting	Artificial structure	09/04/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Australian Pelican	1	Roosting	Artificial structure	09/04/2015	High	Diurnal

Hunter Estuary	Stockton Channel		0			05/05/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pied Cormorant	1	Roosting	Artificial structure	18/06/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	1	Roosting	Artificial structure	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Channel	White-faced Heron	3	Roosting	Rocks	22/07/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	2	Roosting	Artificial structure	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Channel	White-faced Heron	1	Roosting	Artificial structure	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Australian Pelican	1	Roosting	Artificial structure	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Darter	1	Roosting	Artificial structure	20/08/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Pied Cormorant	3	Roosting	Artificial structure	02/09/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Darter	1	Roosting	Artificial structure	02/09/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	1	Roosting	Artificial structure	11/09/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Osprey	1	Roosting	Tree/mangrove	18/09/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	3	Roosting	Artificial structure	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	5	Roosting	Artificial structure	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Pied Cormorant	1	Roosting	Artificial structure	30/09/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	5	Roosting	Artificial structure	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	7	Roosting	Artificial structure	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Australian Pelican	2	Roosting	Artificial structure	09/10/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	1	Roosting	Artificial structure	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	17	Roosting	Rocks	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Crested Tern	1	Roosting	Artificial structure	15/10/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	19	Roosting	Artificial structure	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	9	Roosting	Artificial structure	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Australian Pelican	34	Roosting	Artificial structure	21/10/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	21	Roosting	Rocks	27/10/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Grey-tailed Tattler	2	Roosting	Rocks	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	37	Roosting	Rocks	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	14	Roosting	Artificial structure	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Australian Pelican	10	Roosting	Artificial structure	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Silver Gull	3	Roosting	Artificial structure	05/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	32	Roosting	Artificial structure	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Silver Gull	1	Roosting	Artificial structure	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	9	Roosting	Artificial structure	11/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Australian Pelican	1	Roosting	Artificial structure	11/11/2015	High	Diurnal

Hunter Estuary	Stockton Channel	Little Black Cormorant	4	Roosting	Artificial structure	26/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Australian Pelican	1	Roosting	Artificial structure	26/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	30	Roosting	Artificial structure	26/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Grey-tailed Tattler	1	Roosting	Rocks	26/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Grey-tailed Tattler	17	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	102	Roosting	Rocks	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Australian Pelican	5	Roosting	Artificial structure	18/11/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Little Black Cormorant	5	Roosting	Artificial structure	03/12/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Darter	1	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Australian Pelican	11	Roosting	Artificial structure	03/12/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Pacific Golden Plover	50	Roosting	Rocks	03/12/2015	High	Diurnal
Hunter Estuary	Stockton Channel	Grey-tailed Tattler	11	Roosting	Rocks	03/12/2015	High	Diurnal

Newcastle Coal INFRASTRUCTURE GROUP

Compensatory Habitat and Ecological Monitoring Program – Quarterly Report

DATE: *30 April 2016*

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APPROVAL: Nathan Juchau

INTRODUCTION

This report provides an update of activities relating to the NCIG Compensatory Habitat and Ecological Monitoring Program since the previous Quarterly Report from December 2015. The report aims to provide information on key components of the program and how these are being implemented. An update will be provided to members of the Consultative Board every 3 months, in the form of a Quarterly report and presentations (every 6 months) coinciding with Board Meetings.

1. Research Area Ponds and Associated Monitoring (Alex Callen)

As in previous years, a population estimate of the bell frog population within the trial site was undertaken in February. These estimates have been conducted for three consecutive years and are a suitable preliminary indicator of the viability of the reintroduced population within the site.

Table 1 summarises the number of individual tadpoles released into the site and the subsequent number of frogs identified in the population estimate for each year. The population has declined dramatically in the last twelve months, despite the natural breeding events that occurred within the site in January 2015. The downward trend, together with the latest estimate of less than 30 individuals would suggest that local extinction within the site is possible in the next twelve months, without intervention (the addition of more tadpoles into the system). While causes of population decline are presently unable to be quantified (data analysis on disease-induced mortality still to be performed), it is likely that disease together with predation, are the key threats to bell frog survival at the site, and that escape from the site may also contribute to the decline. An increase in the presence of rats and mice within the site, and across the island generally, may be partly responsible for this decline. No frogs detected in the 2015 population estimate were recorded in the 2016 estimate.

Table 1-1 Annual reintroduction numbers (tadpoles) and population estimates (frogs) at the NCIG trial site 2013 – 2016

Year	Numbers of tadpoles introduced (Dec- Mar)	Numbers of frogs * estimated (Feb of each year)
2013	8000	
2014	12000	750
2015	>7000 (natural breeding)	320
2016		21

***Refers to the numbers of frogs of a size (>30mm) able to be microchipped, and therefore included in the mark-recapture survey for the population estimate. Frogs measuring less than 30mm at the time of population estimates formed a very small cohort of the population in 2014 and 2016. A considerable proportion of frogs were excluded from the 2015 population estimate due to small size (as a result of the natural breeding event).**

Weekly evening frog surveys and weekly water quality monitoring and tadpole surveys will continue until evening temperatures consistently fall below 18 degrees and/or there is a consistent reduction in the numbers of frogs being observed (commencement of overwintering). It is noted that the Trial Site Research Project will conclude in June 2016.

2. Annual Kooragang Island Green and Golden Bell Frog Monitoring

Monitoring of the industrial area of Kooragang continued through the reporting period. This included two (2) monitoring events (revised down from three due to access limitations), and took place at multiple water bodies across the industrial part of Kooragang Island and some areas of Ash Island (southern end near the Kooragang Main Rail Line). The 2015/16 monitoring has been jointly-funded by NCIG, Port Waratah Coal Services and the Hunter Development Corporation, due to potential impacts from future capping of the former Kooragang Island Waste Emplacement Facility (KIWEF).

Monitoring observations confirmed that breeding occurred in numerous ponds across the industrial area of Kooragang Island as a result of rain events experienced in January 2016. A complete annual report from the University of Newcastle is expected in Quarter 2, 2016.

3. Captive Breeding and Release Program

The captive breeding and translocation programme for L. aurea continued into the 2015/2016 year. It was the second year in which offspring produced from the captive colony (entirely derived from stock from the Ash/Kooragang Island complex) were released into the 75 hectare NCIG Compensatory Habitat. A total of 10718 captive bred stock (Table 2) were released into the constructed habitat including the Stage 1 (fenced) habitat and unfenced open habitats (a full breakdown of dates, stages, and ponds will be provided separately). Screening of released stock (as required under the NCIG Translocation Proposal) indicated the captive bred stock was free of chytridiomycosis at the time of release. Genetic samples of released tadpoles have been collected, and are currently archived at the University of Newcastle. All tadpole releases were into Gambusia free ponds of Stage 5 of the compensatory habitats during the 2015/2016 translocations (the only Stage containing Gambusia free ponds through the

2015/2016 phase of the translocation programme). Initial tadpole releases at Stage 5 ponds were into baskets to verify water quality. Metamorphs were released at Stage 5 ponds, and at ponds in other Stages (including Stage 1, fenced).

Table 3-1 – Release of Green and Golden Bell Frog (L. aurea) tadpoles and metamorphs by month into NCIG compensatory habitat, Ash Island, for the summer of 2015/2016.

Year/Month	Tadpoles released	Metamorphs released
2015/October	400	
2015/November	150	
2015/December	3514	1100
2016/January	1050	2326
2016/February	745	309
2016/March	1079	45
Sub-totals	**6938**	**3780**
Total released	**10718**	

4. Green and Golden Bell Frog Compensatory Habitat

4.1. Green and Golden Bell Frog Population

4.1.1. Overview

Ecological processes in the NCIG Compensatory Habitat area in the first quarter of 2016 – mid summer and early autumn – were to a great extent driven by the climatic conditions of the previous year combined with the climatic events that occurred in this period. Prior to December 2015 the spring and early summer of the 2015-16 season had been relatively dry and no major warm season rainfall events occurred in the lower Hunter region. However, most of the constructed wetlands that are designated as "permanent wetlands" remained charged throughout the preceding winter and spring seasons as a result of the substantial rainfall that occurred in April 2015. It is also likely that groundwater recharge plays a significant role in maintaining water levels in these wetlands. Similarly, many of the constructed wetlands that are designated as "ephemeral" also remained charged throughout the winter and spring seasons (2015), although, most remained as independent wetlands and were not interconnected with the permanent wetlands.

Green and Golden Bell Frogs (Litoria aurea) bred in several of the constructed wetlands of the NCIG Compensatory Habitat late in the summer season of 2014-2015, and also in several of the constructed wetlands in the NCIG Trial Habitat site. These breeding events resulted in recruitment of juveniles into the bell frog population on the western end of Ash Island. Some tadpoles in the Trial Site ponds did not metamorphose in the autumn season of 2015 and overwintered (i.e. they remained in the aquatic stage of the life cycle), and did not commence to metamorphose until the warmer temperatures of the spring and summers season conditions of late 2015 and early 2016. In addition to the production of offspring from these "natural breeding events", captive breed tadpoles and some juveniles were release to several of the wetland stages in the NCIG Compensatory Habitat in the summer of 2014-15. Thus at the beginning of the spring and summer season of 2015-16 the expectation was that the population of bell frogs in the NCIG Compensator Habitat would be larger than in previous seasons.

Major summer rainfall occurred in the lower Hunter region in early and mid-January 2016, and resulted in a total that almost doubled the long-term monthly average. All of the wetlands of the NCIG Compensatory Habitat were fully charged and many of the “permanent” and “ephemeral” wetlands became interconnected. At the same time other permanent and ephemeral wetlands in the local area were also recharged, and there was significant overland or surface flow that connected many of the wetlands. Major summer rains combined with daily average temperatures above 20oC are considered to be ideal for breeding of the Bell Frog. This was the case in the population of Bell Frogs on Kooragang Island to the east of the NCIG Compensatory Habitat Area, where choruses of adult males and dispersal of adults to ephemeral wetlands that were flooded at this time were observed. This aim of this report is to provide a summary of the observations made during January, February and March 2016 in the NCIG Compensatory Habitat Area.

4.1.2. Materials and Methods

Field methods employed have been described elsewhere (NCIG CHEMP 2014) and will not be described in detail here.

Prior to the occurrence of the rainfall events in January 2016, field surveys had been conducted at all the NCIG Compensatory Wetlands to determine whether adult Bell Frogs were present (visual encounter surveys and auditory surveys), and to make observations of the habitats (e.g. nature and extent of the aquatic and riparian vegetation; presence or absence of other amphibians, and of the predatory fish Gambusia).

Following the first rainfall events surveys focused on presence and absence of adult Bell Frogs and the location of male calling choruses. These surveys continued through most of January and February since the rainfall in January consisted of several events.

Once the rainfall events had ceased survey methods continued to focus on the occurrence and location of male chorusing and then to surveys for tadpoles and metamorphs. In mid and late February a full aquatic survey of all the NCIG Compensatory Habitat wetlands were undertaken to determine the occurrence and identity of tadpoles, and the presence, abundance and age class structure of the Gambusia population. Surveys involved dip-netting at all wetlands with five metre sweeps conducted every five metres around the wetland perimeter. These were combined with visual encounter for adults and juveniles, and auditory surveys for adult males.

At the same time that surveys were being conducted to determine whether “natural breeding” had occurred, a large number of tadpoles of advanced-stage of development from the captive breeding program, were released into selected wetlands. To prevent any confusion that these individuals may be identified as the progeny of a natural breeding event these tadpoles were marked with fluorescent polymers. The objective of this study was to investigate the movement of early metamorphs and juveniles.

Surveys were replicated so that all wetlands were inspected at least three times over the period.

Water quality parameters (Salinity, Dissolved Oxygen, and Temperature) were recorded at each wetland when frog surveys were conducted, and opportunistic observations of other fauna were also made.

Pond Numbering: To maintain consistency the pond numbering system adopted in the summer quarter report of 2015 has been maintained in this report. This system used a stage numbering (Stage 1: wetlands 1.1 to 1-5, and so on). However, so that direct comparisons are possible with the numbering system applied in the NCIG detail plans (numbered as ponds 1 to 18) the two numbering system are used throughout, although this does lead to some level of confusion. A full list of the pond numbers are provided in Appendix A.

4.1.3. Results

Rainfall: Heavy rainfall occurred in the lower Hunter Valley from the 2nd to the 7th of January 2016, charging the constructed wetlands. Further rainfall occurred on the 14th and 15th and on the 22nd and 23rd January which further increased wetland depths and resulted in considerable surface flow.

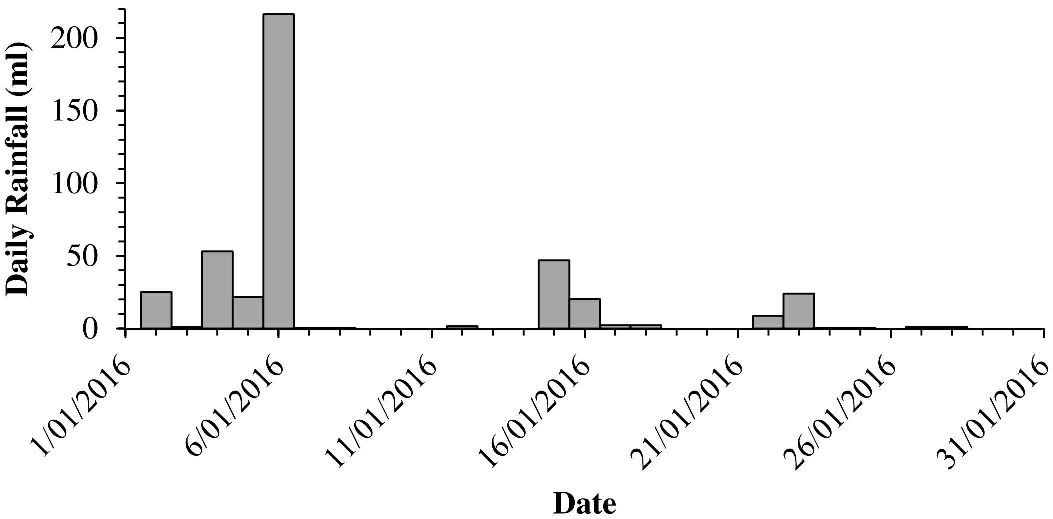


Figure 1: The total amount of rain (mm) recorded from the Newcastle University Weather Station (No. 61390) for January 2016.

Frog Surveys: Choruses of adult male bell frogs were detected at two wetlands of the NCIG Compensatory Wetlands. Wetland 17 (Stage 7: 7-1) and Wetland 16 (Stage 5: 5.1).

No Bell Frog tadpoles were detected in constructed NCIG Compensatory Habitat Wetlands. However, Bell Frog chorusing and subsequently tadpoles and metamorphs were detected in ephemeral wetlands adjacent to the NCIG stage 7 wetlands.

Several other species of frog were observed to occur at the NCIG Compensatory Habitat wetlands, however the distribution and abundance of these species was not uniform. These species included the Dwarf Green Tree Frog (Litoria fallax), Bleating Tree Frog (Litoria dentata), Emerald Spotted Tree Frog (Litoria peroni), and the Striped Marsh Frog (Limnodynastes peroni).

The invasive fish the Plague Minnow (also commonly called the Mosquito Fish)(Gambusia holbrooki) was found at over 80% of the NCIG Compensatory Habitat Wetlands. This fish was also found to occur in several of the natural wetlands and ephemeral swales (salt marshes and flooded meadows) in the local area. Abundance or density of the fish and the stages of development varied considerable among wetlands. In several of the permanent wetlands the development class structure of the population was composed of mature adults males and females, with a smaller number of juveniles and sub-adults, and in these cases the density of fish was high. In several of the ephemeral wetlands the population was dominated by sub-adults and juveniles with a fewer adults, and the density was low.

Repeated Gambusia surveys were conducted across all ponds within the 7 stages of the compensatory habitat in preparation for the first tadpole releases in October 2015. Only Stage 5 was completely devoid of Gambusia, although in some other stages, there were isolated ponds that avoided inundation in the April storms, and as such, were Gambusia free in the October monitoring round. All ponds in Stages 2 and 7 were colonised with Gambusia, as were most ponds in stages 1 and 3 (4 of 5 ponds and 3 of 4 ponds respectively). Eight of the 11 ponds in Stage 4 and 1 of 4 ponds in Stage 6 also contained Gambusia.

A comprehensive 2015/16 Compensatory Habitat Monitoring Report will be prepared by the university soon for communication to stakeholders, including the Department of Planning and the Environment.

4.2. Compensatory Habitat Management

Monitoring and management of compensatory habitat continued during the reporting period in accordance with the approved Green and Golden Bell Frog Compensatory Habitat Management Plan. Work during the reporting period has been conducted by Wetland Care Australia (WCA) and includes:

- Pond inspections, including visual inspections, photo points, water quality monitoring and monitoring for evidence of pests
- Vegetation transects
- Slashing around frog fence in Stage 1
- Repairs on frog fence in Stage 1
- Weed sweep targeting priority weeds

Observations were also made by WCA in January of an adult Bell Frog in Pond 9 (Stage 4) and a juvenile in Pond 1 (Stage 1) during the reporting period – see Figures 2 and 3. A copy of the monitoring and maintenance reports are provided in Appendix A.

Figure 2 – Adult Green and Golden Bell Frog observed at Pond 9, Stage 4.

Figure 3 – Juvenile Green and Golden Bell Frog observed at Pond 1, Stage 1.

Plans to pump a selection of ponds to assist in control of Gambusia were postponed during to saturated conditions caused by extensive rain. NCIG proposes to modify a selection of habitat ponds in Quarter 2, 2016 to include bunding and prevent interconnectedness between permanent and ephemeral water bodies that may normally lead to infestation of ponds by Gambusia. Once these modifications are approved and subsequently completed, NCIG will recommence with plans to pump a selection of ponds and potentially treat residual water with rotinone to ensure that Gambusia is eradicated.

5. Shorebird Compensatory Habitat

5.1. Land Security and Approvals

Final signing by the Minister for the Environment of the Deed of Agreement for the Migratory Shorebird Habitat area was completed on 11 March 2016. This was effectively the final approval document required prior to commencing Shorebird Habitat construction.

After approval of the Construction Environmental Management Plan and other associated construction plans by NPWS, NCIG were given approval to commence early works in April 2016. This was predominantly erection of a site compound and security fences, and improvement of access tracks. This was completed during the month of April in preparation for commencement of mangrove removal in May.

6. Shorebird Monitoring

6.1. Overview

Monitoring of Area E for shorebird usage continued throughout the latest quarter, from January to March (Appendix B). Monitoring was conducted fortnightly during this period, i.e. the 'peak' season. Monitoring of Area E commenced in April 2015.

6.2. Methods

Surveys were conducted along pre-determined transects at the project site as well as at reference sites in the Hunter River Estuary (Table 6-1). Survey date, time, tide height, weather, abundance and behaviour of birds were recorded, along with any observed disturbances.

Table 6-1. Survey sites

Location	Subsite
Area E: Project site	Fish Fry Flats Fish Fry Creek Wader Creek
Area E: Reference sites	Wader Pond Swan Pond
Hunter River Estuary	Milham's Pond Phoenix Flats Hexham Swamp Kooragang Dykes Stockton Sandspit & Channel

6.3. Results

A total of 22 species of shorebirds were observed during the January to March 2016 survey period, including 7 resident and 15 migratory species (Table 6-2). The most abundant species recorded across Area E reference sites was the resident Black-winged Stilt, although numbers dropped from a peak count of 1,407 at high tide and 1,489 at low tide to a maximum of 50 birds this quarter. The most common migratory species sighted adjacent to Area E included the included Bar-tailed and Black-tailed Godwit, Common Greenshank and Marsh Sandpiper; while the Hunter Estuary subsites supported higher numbers of most migratory shorebirds including Sharp-tailed Sandpiper, Whimbrel, Eastern Curlew, Curlew Sandpiper, Pacific Golden Plover, Bar-tailed and Black-tailed Godwit, Common Greenshank and Marsh Sandpiper.

Shorebirds were typically observed feeding and roosting in response to tidal fluctuation, although there was little variation in total abundance of shorebirds present between high and low tides at Area E. No disturbances were noted during this survey period.

As expected prior to the restoration works, no shorebird species were recorded at the project site (Fish Fry Flats, Fish Fry and Wader Creeks) prior to the removal of mangroves. Larger numbers of Chestnut Teals (315) than earlier counts were observed during this quarter while small numbers of other waterbirds were present, including Grey Teal, Cormorants and Egrets.

Nocturnal surveys commenced on 25 September and have continued throughout the peak season, Nocturnal surveys found quite different usagae of wetland sites by shorebirds compared with diurnal sites. Some of the wetlands were ised more extensively by more species at night than during the day, notably NW Pond and Wader Pond. The most frequently used wetland by the largest variety of species in Area E was the main lagoon of Swan Pond.

Monitoring of shorebirds will continue during the construction period, particularly when mangrove removal works occur directly adjacent to Swan and Wader Ponds.

Table 6-2. All shorebird species observed July 2015 to March 2016

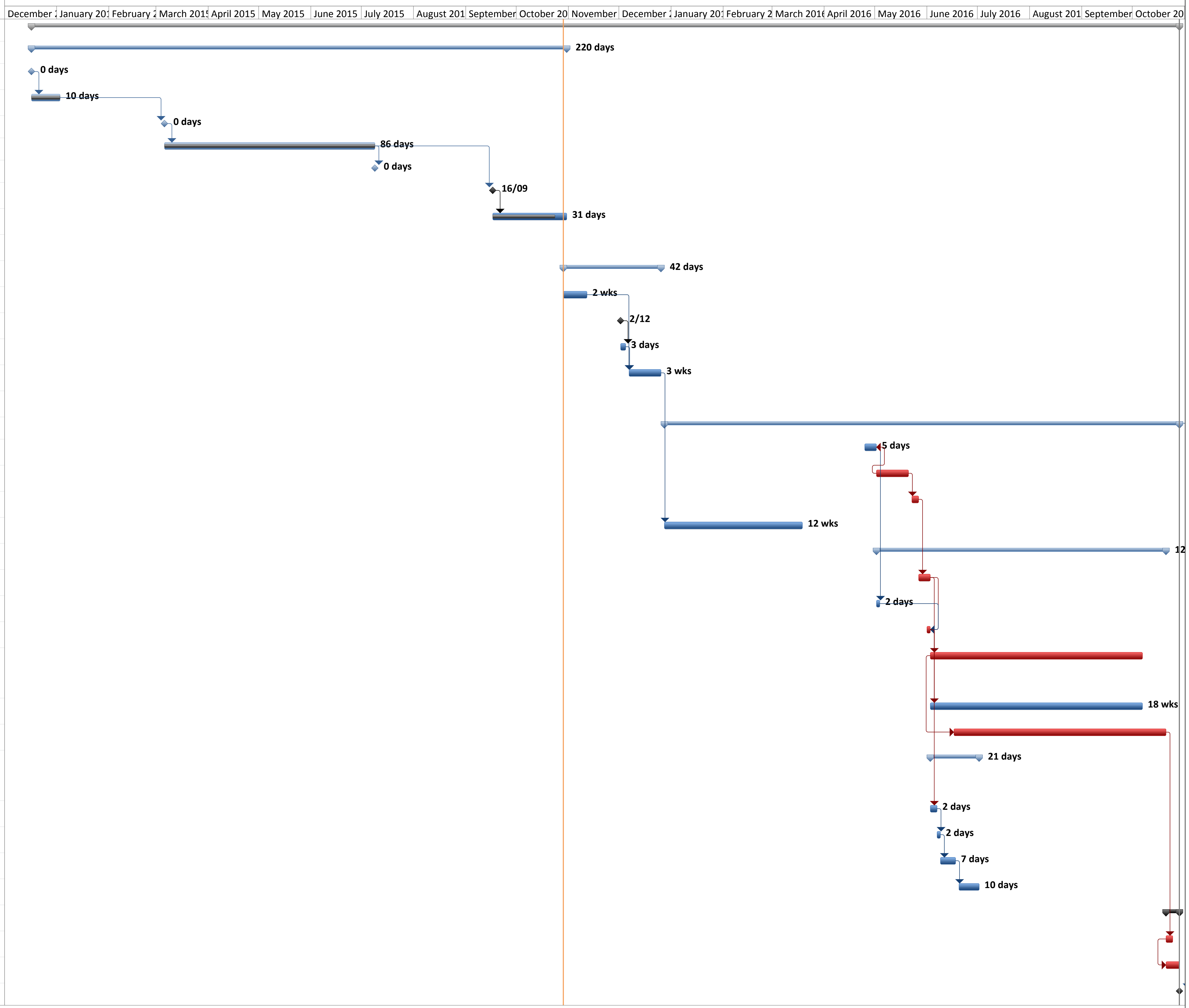
Species	July-Dec 15	Jan-Mar 16	EPBC listing	TSC listing
Pied Oystercatcher	*	*		Endangered
Sooty Oystercatcher	*	*		Vulnerable
Black-winged Stilt[1]	*	*		
Red-necked Avocet[1]	*	*		
Pacific Golden Plover[1]	*	*	Migratory	
Red-capped Plover	*	*		
Black-fronted Dotterel[1]	*	*		
Red-kneed Dotterel	*			
Masked Lapwing[1]	*	*		
Black-tailed Godwit[1]	*	*	Migratory	Vulnerable
Bar-tailed Godwit[1]	*	*	Migratory	
Whimbrel	*	*	Migratory	
Eastern Curlew[1]	*	*	Migratory	
Terek Sandpiper		*	Migratory	Vulnerable
Common Sandpiper	*	*	Migratory	
Grey-tailed Tattler	*	*	Migratory	
Common Greenshank[1]	*	*	Migratory	
Marsh Sandpiper[1]	*	*	Migratory	
Ruddy Turnstone	*		Migratory	
Great Knot	*	*	Migratory	
Red Knot	*	*	Migratory	
Red-necked Stint[1]	*	*	Migratory	
Sharp-tailed Sandpiper[1]	*	*	Migratory	
Curlew Sandpiper[1]	*	*	Migratory	Endangered

[1] Species occurring in Area E reference sites
*** Species observed at tidal and/or Area E wetlands**

7. NCIG Compensatory Habitat Schedule

A copy of the NCIG Compensatory Habitat Schedule of Works for Migratory Shorebirds is provided as part of this report. This has been updated to reflect construction timing in accordance with the REF conditions.

ID	Task Mode	Task Name	Duration	Start	Finish
0		**Shorebirds Compensatory Habitat**	**480 days**	**Wed 17/12/14**	**Fri 28/10/16**
1		**Project Approval**	220 days	Wed 17/12/14	Fri 30/10/15
2		Submit REF	0 days	Wed 17/12/14	Wed 17/12/14
3		OEH REF Preliminary Review	10 days	Wed 17/12/14	Fri 2/01/15
4		Resubmit REF addressing comments	0 days	Thu 5/03/15	Thu 5/03/15
5		Review of REF (inc. consultation)	86 days	Fri 6/03/15	Wed 8/07/15
6		REF Approval	0 days	Wed 8/07/15	Wed 8/07/15
7		Submit revised CHEMP	0 days	Wed 16/09/15	Wed 16/09/15
8		Approval of CHEMP	31 days	Thu 17/09/15	Fri 30/10/15
9					
10		**Land Tenure**	42 days	Thu 29/10/15	Fri 25/12/15
11		NCIG Finalise and sign Deed of Agreement	2 wks	Thu 29/10/15	Wed 11/11/15
12		Obtain s 151 license from NPWS	0 days	Wed 2/12/15	Wed 2/12/15
13		NCIG to sign s 151 license	3 days	Wed 2/12/15	Fri 4/12/15
14		Minister for the Environment to Execute Deed	3 wks	Mon 7/12/15	Fri 25/12/15
15					
16		**Construction**	**220 days**	**Mon 28/12/15**	**Fri 28/10/16**
17		Mobilise to site	5 days	Mon 25/04/16	Mon 2/05/16
18		Establish Exclusion Zones	15 days	Mon 2/05/16	Fri 20/05/16
19		Sediment Control	4 days	Mon 23/05/16	Thu 26/05/16
20		Procure smart Gate and Seed control Structure	12 wks	Mon 28/12/15	Fri 18/03/16
21		**Mangrove Removal**	**124 days**	**Mon 2/05/16**	**Thu 20/10/16**
22		Adjust Water levels	5 days	Fri 27/05/16	Thu 2/06/16
23		Adapt / Mod existing wader pond drainage	2 days	Mon 2/05/16	Tue 3/05/16
24		Mobilise and Establish Plant	2 days	Wed 1/06/16	Thu 2/06/16
25		Mechanical Mangrove Removal (2 crews @ 1250m2/d each)	18 wks	Fri 3/06/16	Thu 6/10/16
26		Manual Mangrove Removal	18 wks	Fri 3/06/16	Thu 6/10/16
27		Mulching	18 wks	Fri 17/06/16	Thu 20/10/16
28		**Construction of Smart Gate and Seed Control Structure**	**21 days**	**Fri 3/06/16**	**Fri 1/07/16**
29		Construct internal coffer dam	2 days	Fri 3/06/16	Mon 6/06/16
30		Construct external coffer dam	2 days	Tue 7/06/16	Wed 8/06/16
31		Install Smart Gates	7 days	Thu 9/06/16	Fri 17/06/16
32		Install mangrove seed screen	10 days	Mon 20/06/16	Fri 1/07/16
33		**Demobilise**	**6 days**	**Fri 21/10/16**	**Fri 28/10/16**
34		Demobilise plant	2 days	Fri 21/10/16	Mon 24/10/16
35		Remove all fencing and water controls	6 days	Fri 21/10/16	Fri 28/10/16
36		**Project Completion**	**0 days**	**Fri 28/10/16**	**Fri 28/10/16**



Project: Shorebirds Compensator
Date: Thu 29/10/15

Task		Summary		External Milestone		Inactive Summary		Manual Summary Rollup		Finish-only		Critical Split	
Split		Project Summary		Inactive Task		Manual Task		Manual Summary		Deadline		Progress	
Milestone		External Tasks		Inactive Milestone		Duration-only		Start-only		Critical			

Appendix A – Dip-net and water quality surveys of the NCIG Compensatory Habitat Wetlands in September and October 2015. (University of Newcastle).

These surveys were conducted to assess the suitability of wetlands for prospective release of captive breed tadpoles and metamorphs. Gambusia were observed in wetlands in all stages, except stage 5, and high densities were observed in wetlands in stages 1, 2, 3, and 4, with lower densities in stages 6 and 7. Water quality was considered suitable (i.e. within the known threshold ranges for Green and Golden Bell Frog eggs and tadpoles). Abbreviations: Temperature Co– T; Dissolved Oxygen – DO; Salinity% – Sal%; Ephemeral waterbody – Eph.

Date	Stage	Pond	T	DO	Sal%	pH	Depth	Eph	Bred 2015	Dipnet
26/09/2015	1	1 (1-1)	17.2	15.3	1.92	8.47	1.4			*Gambusia*
26/09/2015	1	2 (1-2)	16.4	11.26	1.06	7.47	0.2			*Gambusia*
26/09/2015	1	3 (1-3)	16	13.24	1.28	7.85	0.4			*Gambusia*
26/09/2015	1	1b (1-4)	17.6	12.22	1.8	8.27	1.0			*Gambusia*
26/09/2015	1	1a (1-5)	16.6	12.18	1.71	8.19	0.0			1 *Lim peroni* tad
3/10/2015	2	4a (2-1)	22.6	9.6	1.76	7.64	0.2			*Gambusia*
3/10/2015	2	4 (2-2)	22.7	8.08	1.63	5.59	1.4			*Gambusia*
3/10/2015	2	4b (2-3)	24.1	7.25	1.52	5.86	0.4			large fish, *Gambusia*
3/10/2015	2	4d (2-4)	23.7	7.59	1.37	6.07	0.2			0
3/10/2015	2	4c (2-5)	23.6	10.47	1.3	6.26	1.4			*Gambusia*
26/09/2015	3	5 (3-3)	17.9	11.98	1.74	9.13	1.4			1 *Crinia* signifera tad, *Gambusia*
26/09/2015	3	5a (3-1, 3-2)	16.6	15.66	1.76	9.38	0.4			*Gambusia*
26/09/2015	3	5b (3-4)	17.6	13.92	1.7	9.3	0.2			*Gambusia*
26/09/2015	3	5c (3-5)	19	9.84	0.66	7.65	0.2			0
3/10/2015	4	11 (4-11)	23.2	16.31	3.69	8.05	1.0			*Gambusia*
3/10/2015	4	10 (4-10)	23.1	8.44	1.77	7.75	0.4			*Gambusia*
3/10/2015	4	9 (4-9)	22.4	9.11	2.23	7.43	0.2			0
3/10/2015	4	8 (4-8)	23.7	8.65	0.44	7.22	1.0			*Gambusia*
3/10/2015	4	7b (4-7)	23.1	9	0.16	6.14	0			*Gambusia*
3/10/2015	4	7a (4-6)	22.1	7.32	0.16	5.8	0.2			*Gambusia*
3/10/2015	4	7 (4-7)	23.6	9.13	0.16	6.14	0.6			0
3/10/2015	4	6c (4-3)	23.5	16.48	0.34	7.28	1.2			0
3/10/2015	4	6 (4-3)	23.2	12.73	0.34	6.79	1.2			*Gambusia*
3/10/2015	4	6b (4-2)	23.9	11.27	0.32	6.81	0.2			*Gambusia*
3/10/2015	4	6a (4-1)	23.4	10.02	0.32	6.42	0.8			*Gambusia*
4/10/2015	5	15e (5-5)	22.8	11.19	0.24	6.43	0.0			0
4/10/2015	5	15f (5-7)	23.3	11.06	0.3	6.31	0.0			0
4/10/2015	5	15g (5-6)	20.3	9.61	0.3	7.79	0.0			1 *Lim peroni* tad
4/10/2015	5	15h (5-8)	23.3	10.12	0.3	6.33	0.6			big fish
4/10/2015	5	16a (5-3)	20.6	10.02	0.15	8.01	0.2			0
4/10/2015	5	16b (5-4)	21.8	8.07	0.15	7.65	0.2			1 *Lim peroni* tad
4/10/2015	5	16c (5-2)	24.3	8.23	0.13	7.66	0.3			0
4/10/2015	5	16d(5-1)	25	8.3	0.12	7.94	0.4			0

5/10/2015	6	13 (6-4)	24.3	8.51	0.32	5.39	1.2			0
5/10/2015	6	12 (6-6)	24.5	8.23	0.21	7.57	0.2			0
5/10/2015	6	13a (6-4)	22.7	11.92	0.31	7.42	0.2			0
5/10/2015	6	14 (6-1)	25.1	11.32	0.21	4.73	0.4			*Gambusia*
5/10/2015	6	14a (6-2)					0.2			
5/10/2015	7	17 (7-1)	23.6	11.89	1.99	9.61	0.4			*Gambusia*
5/10/2015	7	17a (7-2)	23.4	8.38	2.01	8.7	0			*Gambusia*
5/10/2015	7	18 (7-3)	24.3	10.19	2.04	8.39	0.2			4 *Gambusia*

Appendix B – NCIG GGBF Compensatory Habitat Project, Monitoring and Maintenance Reports, January 2016, February 2016 and March 2016 (Wetland Care Australia).

wetlandcare australia

NCIG GGBF Compensatory Habitat Project

Monitoring and Maintenance Report

January 2016

Version	Author	Date
2	T.Mouton	24/02/2016

WetlandCare Australia
44 Bishopsgate Street
Wickham NSW 2293

Introduction

The Newcastle Coal and Infrastructure Group (NCIG) developed a 78ha Compensatory Habitat and Ecological Monitoring Program (CHEMP), to offset areas lost as a result of the NCIG CET. The compensatory habitat comprises 18 constructed ponds. WetlandCare Australia has prepared a Green and Golden Bell Compensatory Habitat Management Plan (GGBF CHMP) based on requirements contained in the CHEMP, which sets out the methodology of site management and monitoring requirements for the ponds. The GGBF CHMP has been approved by the Office of Environment and Heritage, and forms part of the NCIG project approval. This monitoring report contains a monthly summary of site works and monitoring results undertaken as part of the GGBF CHMP.

Works Undertaken

The program of monitoring and maintenance continued throughout January 2016. The following works were undertaken this period:

Monitoring

- Pond inspections and monitoring, involving:
  - Visual inspection of pond condition and structure
  - Water quality monitoring
  - Monitoring for evidence of pest species (feral animals and noxious weeds)

  Results from these inspections and management recommendations are contained in Appendix A.

Maintenance

- No maintenance activities were undertaken in this period.

Appendix B contains the schedule of works undertaken during January, and works forecast for the following month in February.

Key Outcomes

Monitoring

<u>Water Quality</u>

- Salinity (Target range < 4 ppt tadpoles; < 6 ppt frogs)
  - All ponds were within the acceptable salinity range for tadpoles and frogs.
- pH (Target range 4-9)
  - All ponds were within the acceptable pH range for tadpoles and frogs.
  - Pond pH ranged 6.78 – 7.5.
- DO (Target range 4-17)
  - Ponds 1, 2, 3, 4, 10, 11, 12, 13, 14, 15, 16 and 17 were outside the acceptable range. The lowest was Pond 3 at 0.44 mg/L
- Depth
  - Water levels have significantly increased after recent periods of heavy rain
- Temperature (Target range 16-31^{0}C tadpoles; 4-35^{0}C frogs)
  - All ponds were within the temperature target range

Pest Species

- Gambusia were observed in 17/18 ponds.
- Pond 15 was Gambusia free.
- Small infestations of Alligator Weed were observed in ponds 1, 5. Treatment has been effective in controlling infestation in the macrophyte trench adjacent to Pond 1, however it was observed to be resprouting in some patches during this period.

Other Observations

- Water levels in all ponds are at maximum, right up to the edge of buffer zones.
- Diffuse Blue Green Algae was observed on the surface of pond 11.
- Frog activity was high in general after recent rain and warm/humid conditions:
    - *Littoria fallax* was observed in numbers at most ponds.
    - *Limnodynastes peronii* was observed in Stage 1-Pond 1.
    - Juvenile GGBF were observed in numbers in Stage 1-Pond 1 and Stage 5-Pond 15, within ephemeral wet areas surrounding the main water body
    - One adult GGBF was observed in Stage 4-Pond 9 within rock cobble refuge area. This was an interesting observation as this pond is devoid of any native macrophytes and is bare/exposed within the vegetation buffer zone.

Adult GGBF in Pond 9

Juvenile GGBF in Pond 1

Littoria fallax

Discussion & Recommendations

The influx of fresh water from recent storms has resulted in low salinity levels and neutral pH values for all ponds. The fresh water influx has also caused the majority of green algae to drop from the pond surfaces, and an increase in dissolved organic matter (observed as tannin staining). This has likely increased the decomposition of organic matter in the ponds, potentially leading to a reduction in DO (particularly Ponds 1,2,3,4). The increase in organic load after heavy rainfall is a natural fluctuation, however this will be closely monitored during the next period to see if levels stabilise.

Recent heavy rains have resulted in all ponds reaching capacity, and creating shallow wet areas outside the main water body in surrounding vegetation. These ephemeral areas have created ideal conditions for frog activity, which were heavily utilised by juvenile GGBF in Ponds 1 and 15.

Appendix A – Monitoring Results

Newcastle Coal Infrastructure Group		
	Date	13 & 22 January 2016
	Breeding Season (Oct-Dec)?	**Yes** / No
	Name of Inspector/s	Tim Mouton, Pasquale Masi
	Site	**NCIG Ponds** / KWRP Ponds / Research Ponds
	WEATHER	Hot/Sunny (13th) – Hot/Overcast (22nd)
	Temperature	30 – 31.2
	Total rainfall over preceding 3 days	1.5 mm (17th) – 8.8 mm (23rd)
	Total rainfall over preceding month	398.9 mm

WATER QUALITY INSPECTION

Parameter	**Target Range**	**1**	**2**	**3**	**4**	**5A**	**5B**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Target Condition	Permanent ponds wet	**Wet**			**Wet**	**Wet**	**Wet**	**Wet**		**Wet**			**Wet**		**Wet**			**Wet**		
Wet/Dry		Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet
Design Depth m		1.4	0.2	0.4	1.4	1.4		1.2	0.6	1.0	0.2	0.4	1.0	0.2	1.2	0.4	0.6	2.2	0.4	0.2
Measured Depth m		1.9	0.9	1.4	1.0	1.1	1.9	1.8	1.7	1.7	1.5	1.1	1.7	1.6	2.0	1.6	1.0	1.9	1.6	0.9
Temp ^{0}C	T: 16-31 F: 4-35	27.4	25.5	24.1	28.8	30.3	28.5	27.2	27	28.1	28.8	26.1	27.6	25.3	26	25.6	26	25.5	25.5	25.2
pH	4-9	7	7.12	6.78	6.89	7.34	6.85	7.1	7.2	7.27	7.41	7	6.82	6.89	7.26	7.4	7.1	6.78	7.16	7.5
Salinity uS/cm		1374	1055	1198	619	437	1555	364	171	462	630	580	2487	189	334	338	159	278	684	953
Salinity ppt	T < 4 F < 6	0.88	0.68	0.77	0.40	0.28	1.00	0.23	0.11	0.30	0.40	0.37	1.59	0.12	0.21	0.22	0.10	0.18	0.44	0.61
DO mg/L	4-17	2.4	0.7	0.44	1.76	4.61	4.01	4.28	5.33	4.81	5.55	3.64	4.5	2.89	3.72	3.5	3.8	3.56	2.52	4.08
Turbidity NTU	Not critical	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% Open Water	Min. 30% Max 70%	85	70	90	70	85	90	90	100	100	100	90	70	95	70	70	85	90	100	80
Meets all Targets	Y N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N

Notes: Influx of fresh water from recent storms has dropped the majority of algae from the pond surface in majority of ponds, which has increased the decomposition of organic matter in pond sediments and tannins in water column.

☞ **See Over**

WATER QUALITY ACTION				
POND	Action Required	Due Date	Completion Date	Signed
1,3,5a,5b,6,7,8,9, 10,12,15,16,17, 18	Ponds are above the maximum acceptable level of open water percentage. This can be addressed by additional macrophyte planting	Ongoing		
1,2,3,4,10,12,13, 14,15,16,17	Ponds are below the acceptable level for DO. Recent heavy rain has dropped the majority of algae from the pond surface. This has increased the decomposition of organic matter in pond sediments, potentially leading to reduction in DO (particularly Ponds 1,2,3,4). Increasing macrophyte growth could help address low DO levels.	Ongoing		
	Other Observations			
General	Influx of fresh water from recent storms has dropped algae from the pond surface in majority of ponds, which has increased the decomposition of organic matter in pond sediments and tannins in water column.			
General	Water levels currently at maximum in all ponds			
3,4	Dead Gambusia observed floating on pond surface			

NB: All vegetation work eg. removing macrophytes/in-fill planting should be recorded on the Vegetation Inspection Sheet

Date	Breeding Season (Oct-Dec) **Yes** / No			Name of inspector/s Tim Mouton, Pasquale Masi	
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds				
POND STUCTURE INSPECTION					
POND	**Is there evidence of leakage?**	**Is there evidence of erosion/sedimentation?**	**Action Required?**	**Define action**	**Date Complete**
1.	No	No	No		
2.	No	No	No		
3.	No	No	No		
4.	No	No	No		
5.	No	No	No		
6.	No	No	No		
7.	No	No	No		
8.	No	No	No		
9.	No	No	No		
10.	No	No	No		
11.	No	No	No		
12.	No	No	No		
13.	No	No	No		
14.	No	No	No		
15.	No	No	No		
16.	No	No	No		
17.	No	No	No		
18.	No	No	No		

All Actions Complete: Signed ________________ Date ________

Date	**Breeding Season (Oct-Dec) Yes** / No **Name of inspector/s** Tim Mouton, Pasquale Masi					
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds					
POND NATIVE VEGETATION INSPECTION						
POND	**Emergent Vegetation % Cover of water body**	**Emergent Vegetation Density**	**Emergent vegetation Condition**	**Buffer Width**	**Buffer Density (Weed + Native)**	**Buffer Density (Native) %**
Target	**40-70% Cover of water body**	**> 50%**	**Good**	**1.5 m**	**> 50% total veg cover**	**> 50% native cover**
1.	15% Macrophyte	60	Good			
2.	30% Macrophyte	80	Good			
3.	10% Macrophyte	10	Average			
4.	30% Macrophyte	80	Good			
5A.	15% Macrophyte	20	Average			
5B.	10% Macrophyte	30	Average			
6.	10% Macrophyte	50	Average			
7.	0% Macrophyte	0	Poor			
8.	0% Macrophyte	0	Very Poor			
9.	0% Macrophyte	0	Very Poor			
10.	10% Macrophyte	85	Very good			
11.	30% Macrophyte	15	Very good			
12.	5% Macrophyte	60	Poor			
13.	40% Macrophyte	80	Good			
14.	30% Macrophyte	5	Very good			
15.	15% Macrophyte	5	Average			
16.	10% Macrophyte	30	Average			
17.	0% Macrophyte	0	Very poor			
18.	10% Macrophyte	10	Average			
Notes						

POND NATIVE VEGETATION ACTION REQUIRED			
POND	**Action Required**	**Due Date**	**Completion Date**
7, 8, 9, 17, 18	Additional planting of macrophytes should be undertaken, within buffers and pond banks.	Ongoing	

COMMENTS:

All Actions Complete: Signed ________________ Date ________

WEEDS	Alligator Weed Density Class	Juncus acutus Density Class	Blackberry Density Class	Action Required	Date Action Complete
POND				**See Maintenance Guidelines in NCIG GGBF CH POM**	
1.	2			1 small patch coming under frog fence from access track, to be controlled during the next period.	
2.					
3.					
4.		2		1 small tussock present at western extent of pond. This will be retained as habitat, and only removed when monitoring indicates that suitable coverage of native macrophytes has established in this area.	
5.	2			1 very small patch on pond bank, extent has increased by approx. 5%, to be controlled during the next period.	
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					

NB: Weed Density Classes. Class 2 = less than 1%. Class 3 = 1-10%. Class 4 = 11-50%. Class 5 > 50% **Actions Complete:** Signed _______________ Date ________

PREDATOR INSPECTION					
	Gambusia	**Fox Evidence**	**Action Required**	**Action Required**	**Date Complete**
POND	**Yes/No**	**scats/prints/kills**	**Y/N**		
General Note				Gambusia control in ponds 2,3,10,12 programmed February 2016. Visibility was poor in all ponds due increased tannins in the water column.	
1.	Yes	No		Gambusia sparse	
2.	Yes	No		Gambusia dominant	
3.	Yes	No		Gambusia dominant	
4.	Yes	No		Gambusia dominant	
5.	Yes	No		Gambusia moderate	
6.	Yes	No		Gambusia dominant	
7.	Yes	No		Gambusia dominant	
8.	Yes	No		Gambusia dominant	
9.	Yes	No		Gambusia dominant	
10.	Yes	No		Gambusia dominant	
11.	Yes	No		Gambusia dominant	
12.	Yes	No		Gambusia dominant	
13.	Yes	No		Gambusia	
14.	Yes	No		Gambusia moderate	
15.	No	No			
16.	Yes	No		Gambusia sparse	
17.	Yes	No		Gambusia very dominant	
18.	Yes	Yes		Gambusia very dominant	

Actions Complete: Signed __________________ Date ________

Appendix B – Works Program

Timeline																												
Month	January																											
Week	Week 2							Week 3							Week 4							Week 5						
Task	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Alligator Weed spraying (4 man crew)																												
Monitoring (2 man crew)																												
Slashing tracks & frog fence (CVA Regen 2 man crew)																												
Weeding sweep through site (CVA Regen 4 man crew)																												

February																												
Week 1							Week 2							Week 3							Week 4							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

wetlandcare australia

NCIG GGBF Compensatory Habitat Project

Monitoring and Maintenance Report

February 2016

Version	Author	Date
1	T.Mouton	29/02/2016

WetlandCare Australia
44 Bishopsgate Street
Wickham NSW 2293

Introduction

The Newcastle Coal and Infrastructure Group (NCIG) developed a 78ha Compensatory Habitat and Ecological Monitoring Program (CHEMP), to offset areas lost as a result of the NCIG CET. The compensatory habitat comprises 18 constructed ponds. WetlandCare Australia has prepared a Green and Golden Bell Compensatory Habitat Management Plan (GGBF CHMP) based on requirements contained in the CHEMP, which sets out the methodology of site management and monitoring requirements for the ponds. The GGBF CHMP has been approved by the Office of Environment and Heritage, and forms part of the NCIG project approval. This monitoring report contains a monthly summary of site works and monitoring results undertaken as part of the GGBF CHMP.

Works Undertaken

The program of monitoring and maintenance continued throughout February 2016. The following works were undertaken this period:

Monitoring

- Pond inspections and monitoring, involving:
  - Visual inspection of pond condition and structure
  - Water quality monitoring
  - Monitoring for evidence of pest species (feral animals and noxious weeds)

  Results from these inspections and management recommendations are contained in Appendix A.

Maintenance

- Slashing around the frog fence in Stage 1, and weed sweep targeting priority weeds was undertaken in February.

Appendix B contains the schedule of works undertaken during January, and works forecast for the following month in March. Appendix C contains details of weed control areas.

Key Outcomes

Monitoring

<u>Water Quality</u>

- Salinity (Target range < 4 ppt tadpoles; < 6 ppt frogs)
  - All ponds were within the acceptable salinity range for tadpoles and frogs.
- pH (Target range 4-9)
  - All ponds were within the acceptable pH range for tadpoles and frogs.
  - Pond pH ranged 7.26 – 8.7.
- DO (Target range 4-17)
  - Ponds 1, 2, 3, 4, 10, 11, 12, 13, 14, 15, 16, 17 and 18 were outside the acceptable range. The lowest was Pond 3 at 0.51 mg/L
- Depth
  - Water levels have decreased slightly from previous monitoring, generally by 0.1-0.2m
- Temperature (Target range 16-31^{0}C tadpoles; 4-35^{0}C frogs)
  - All ponds were within the temperature target range

Pest Species

- Gambusia were observed in 17/18 ponds.
- Pond 15 was Gambusia free.
- Small infestations of Alligator Weed were observed in ponds 1, 5, which have subsequently been sprayed during this period.

Other Observations

- Water levels are still high in all ponds, however have dropped slightly since the last monitoring period
- Diffuse Blue Green Algae was observed on the surface of ponds 7 and 15.
- Azolla was observed covering approximately 30% of the open water surface of Pond 4.
- *Casuarina glauca* regrowth was observed within the buffer of Pond 18, this will require removal during the next weed sweep.
- Significant macrophyte growth was observed since previous monitoring in a number of ponds (2, 5A, 6, 13, 14, 15, 18), in particular *Typha sp.*
- Tadpoles (large) were observed in low numbers in Ponds 1 and 15.

Maintenance

- Slashing 1m from the outside of the frog fence in Stage 1 was undertaken. The inside of the fence was not slashed during this period, as high frog activity (juvenile GGBF) was observed directly behind the fence during monitoring. The inside of the fence will be slashed during the next period once monitoring has determined frogs have vacated the area.
- Weed control was undertaken throughout the site, within stages 1, 3, 5, 6, 7. Weeds targeted include Alligator Weed, Sharp Rush, and Groundsel Bush. Refer to the weed control map in Appendix C for areas covered (highlighted pink).

Discussion & Recommendations

Pond water levels remain high, however recent dry conditions over the last month has resulted levels dropping slightly from previous results. EC levels remain low after significant rainfall in January, and pH conditions within all ponds continues to remain stable from previous monitoring, averaging at 7.7.

Ponds 5A to 9 have consistently remained above DO target range of 4 since monitoring commenced, while the other ponds have fluctuated widely. This period 13 out of 18 ponds were below the DO target range of 4. Decaying organic matter was observed in a number of these ponds when sediments were disturbed, particularly in ponds 1, 2, 3, 4, 12, 16, 17, 18. This is most likely a result of perished Green Algae, which was initially abundant on the pond surface when monitoring first commenced, and has now sunk into pond substrates. Decaying organic matter has potentially resulted in a reduction in DO due to increased BOD, and will continue to be monitored closely. Increasing macrophyte growth could help address low DO levels in the long term.

Increases in macrophyte vegetation (predominantly *Typha sp.),* was observed in a number of ponds, in particular Ponds 2, 5A, 6, 13, 14, 15, 18. Growth in Ponds 5A, and 18 increased from previous monitoring, to meet target levels above 40%. *Casuarina glauca* regrowth was observed within the buffer of Pond 18, which will require removal during the next weed sweep, programmed in May.

Appendix A – Monitoring Results

Date	24 February 2016
Breeding Season (Oct-Dec)?	Yes / **No**
Name of Inspector/s	Tim Mouton, Paul Davidson
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds
WEATHER	Warm/Sunny
Temperature	28.9
Total rainfall over preceding 3 days	0.4 mm
Total rainfall over preceding month	26 mm

WATER QUALITY INSPECTION

Parameter	**Target Range**	**1**	**2**	**3**	**4**	**5A**	**5B**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Target Condition	Permanent ponds wet	**Wet**			**Wet**	**Wet**	**Wet**	**Wet**		**Wet**			**Wet**		**Wet**			**Wet**		
Wet/Dry		Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet
Design Depth m		1.4	0.2	0.4	1.4	1.4		1.2	0.6	1.0	0.2	0.4	1.0	0.2	1.2	0.4	0.6	2.2	0.4	0.2
Measured Depth m		1.9	0.7	1.3	0.8	0.9	1.9	1.8	1.5	1.4	1.3	1.0	1.6	1.5	2.0	1.4	0.9	1.9	1.3	0.8
Temp ^{0}C	T: 16-31 F: 4-35	28.4	26.2	26.7	25.3	28.5	29.2	26.8	26.1	28.5	28.4	26	26.5	25.1	26	25.8	26.3	26	25.7	24.2
pH	4-9	7.62	7.43	7.26	7.36	7.94	7.97	7.56	8.7	8.67	7.86	7.41	7.37	7.6	7.5	7.88	7.48	7.29	7.9	7.35
Salinity uS/cm		1348	1211	1561	986	664	1667	407	168	493	1026	1013	4817	248	361	390	222	348	1377	1615
Salinity ppt	T < 4 F < 6	0.86	0.78	1.0	0.63	0.42	1.07	0.26	0.11	0.32	0.66	0.65	3.08	0.16	0.23	0.25	0.14	0.22	0.88	1.03
DO mg/L	4-17	3.26	2.7	0.51	0.72	6.44	6.51	5.5	6.76	5.94	5.98	3.17	3.57	2.77	3.4	3.74	2.57	2.05	2.25	1.76
Turbidity NTU	Not critical	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% Open Water	Min. 30% Max 70%	85	60	90	40 (Azolla 30%)	55	90	70	100	100	100	80	70	85	60	60	75	85	100	60
Meets all Targets	Y / N	N	N	N	N	Y	N	Y	N	N	N	N	N	N	N	N	N	N	N	N
Notes:																				

☞ **See Over**

WATER QUALITY ACTION				
POND	**Action Required**	**Due Date**	**Completion Date**	**Signed**
1,3,5b,7,8,9,10, 12,15,16,17	Ponds are above the maximum acceptable level of open water percentage. This can be addressed by additional macrophyte planting	Ongoing		
1,2,3,4,10,11,12, 13,14,15,16,17, 18	Ponds are below the acceptable level for DO. Decaying organic matter in pond sediments was observed, most likely a result of perished Green Algae. This has potentially lead to reduction in DO due to increased BOD. Increasing macrophyte growth could help address low DO levels.	Ongoing		
	Other Observations			
General	Water levels are still high, but have generally dropped by 0.1-0.2m since last monitoring period due to dry conditions.			

NB: All vegetation work eg. removing macrophytes/in-fill planting should be recorded on the Vegetation Inspection Sheet

Date	Breeding Season (Oct-Dec) Yes / **No**	Name of inspector/s Tim Mouton, Paul Davidson			
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds				
POND STUCTURE INSPECTION					
POND	**Is there evidence of leakage?**	**Is there evidence of erosion/sedimentation?**	**Action Required?**	**Define action**	**Date Complete**
1.	No	No	No		
2.	No	No	No		
3.	No	No	No		
4.	No	No	No		
5.	No	No	No		
6.	No	No	No		
7.	No	No	No		
8.	No	No	No		
9.	No	No	No		
10.	No	No	No		
11.	No	No	No		
12.	No	No	No		
13.	No	No	No		
14.	No	No	No		
15.	No	No	No		
16.	No	No	No		
17.	No	No	No		
18.	No	No	No		

All Actions Complete: Signed ________________ Date ________

Date	Breeding Season (Oct-Dec) Yes / **No**		Name of inspector/s Tim Mouton, Paul Davidson			
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds					
POND NATIVE VEGETATION INSPECTION						
POND	**Emergent Vegetation % Cover of water body**	**Emergent Vegetation Density**	**Emergent vegetation Condition**	**Buffer Width**	**Buffer Density (Weed + Native)**	**Buffer Density (Native) %**
Target	**40-70% Cover of water body**	**> 50%**	**Good**	**1.5 m**	**> 50% total veg cover**	**> 50% native cover**
1.	15% Macrophyte	60	Good			
2.	40% Macrophyte	70	Good			
3.	10% Macrophyte	10	Average			
4.	30% Macrophyte	70	Good			
5A.	45% Macrophyte	40	Good			
5B.	10% Macrophyte	30	Average			
6.	30% Macrophyte	50	Good			
7.	0% Macrophyte	0	Poor			
8.	0% Macrophyte	0	Very Poor			
9.	0% Macrophyte	0	Very Poor			
10.	20% Macrophyte	85	Very good			
11.	30% Macrophyte	25	Very good			
12.	15% Macrophyte	60	Average			
13.	40% Macrophyte	70	Good			
14.	40% Macrophyte	70	Very good			
15.	25% Macrophyte	20	Good			
16.	10% Macrophyte	30	Good			
17.	0% Macrophyte	0	Very poor			
18.	40% Macrophyte	30	Good			
Notes	Slight to moderate increases in macrophyte densities were observed in Ponds 2, 5A, 6, 13, 14, 15, 18, predominantly *Typha sp.* Pond 4 was observed to contain an abundance of submerged vegetation resembling *Myriophyllum sp.* (ID to be confirmed), and approximately 30% coverage of open water by *Azolla sp.*					

POND NATIVE VEGETATION ACTION REQUIRED			
POND	**Action Required**	**Due Date**	**Completion Date**
7, 8, 9, 17	Additional planting of macrophytes should be undertaken, within buffers and pond banks.	Ongoing	

COMMENTS:

All Actions Complete: Signed _________________ Date ________

WEEDS	Alligator Weed Density Class	Juncus acutus Density Class	Blackberry Density Class	Action Required	Date Action Complete
POND				**See Maintenance Guidelines in NCIG GGBF CH POM**	
1.	2			1 small patch near the fence approx.. 15m east of the gate, missed during previous weed spraying. Follow up spraying required.	
2.					
3.					
4.		2		1 small tussock present at western extent of pond. This will be retained as habitat, and only removed when monitoring indicates that suitable coverage of native macrophytes has established in this area.	
5.	2			1 small patch on pond bank. This infestation has been sprayed this period.	
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					

NB: Weed Density Classes. Class 2 = less than 1%. Class 3 = 1-10%. Class 4 = 11-50%. Class 5 > 50% **Actions Complete:** Signed ______________ Date ________

PREDATOR INSPECTION					
	Gambusia	**Fox Evidence**	**Action Required**	**Action Required**	**Date Complete**
POND	**Yes/No**	**scats/prints/kills**	**Y/N**		
General Note				Gambusia control in ponds 2,3,10,12 programmed February 2016. Visibility was poor in all ponds due increased tannins in the water column.	
1.	Yes	No		Gambusia dominant	
2.	Yes	No		Gambusia very dominant	
3.	Yes	No		Gambusia very dominant	
4.	Yes	No		Gambusia moderate	
5.	Yes	No		Gambusia moderate	
6.	Yes	No		Gambusia dominant	
7.	Yes	No		Gambusia dominant	
8.	Yes	No		Gambusia dominant	
9.	Yes	No		Gambusia dominant	
10.	Yes	No		Gambusia dominant	
11.	Yes	No		Gambusia dominant	
12.	Yes	No		Gambusia very dominant	
13.	Yes	No		Gambusia dominant	
14.	Yes	No		Gambusia moderate	
15.	No	Yes (tracks, scat)			
16.	Yes	No		Gambusia moderate	
17.	Yes	No		Gambusia very dominant	
18.	Yes	Yes		Gambusia very dominant	

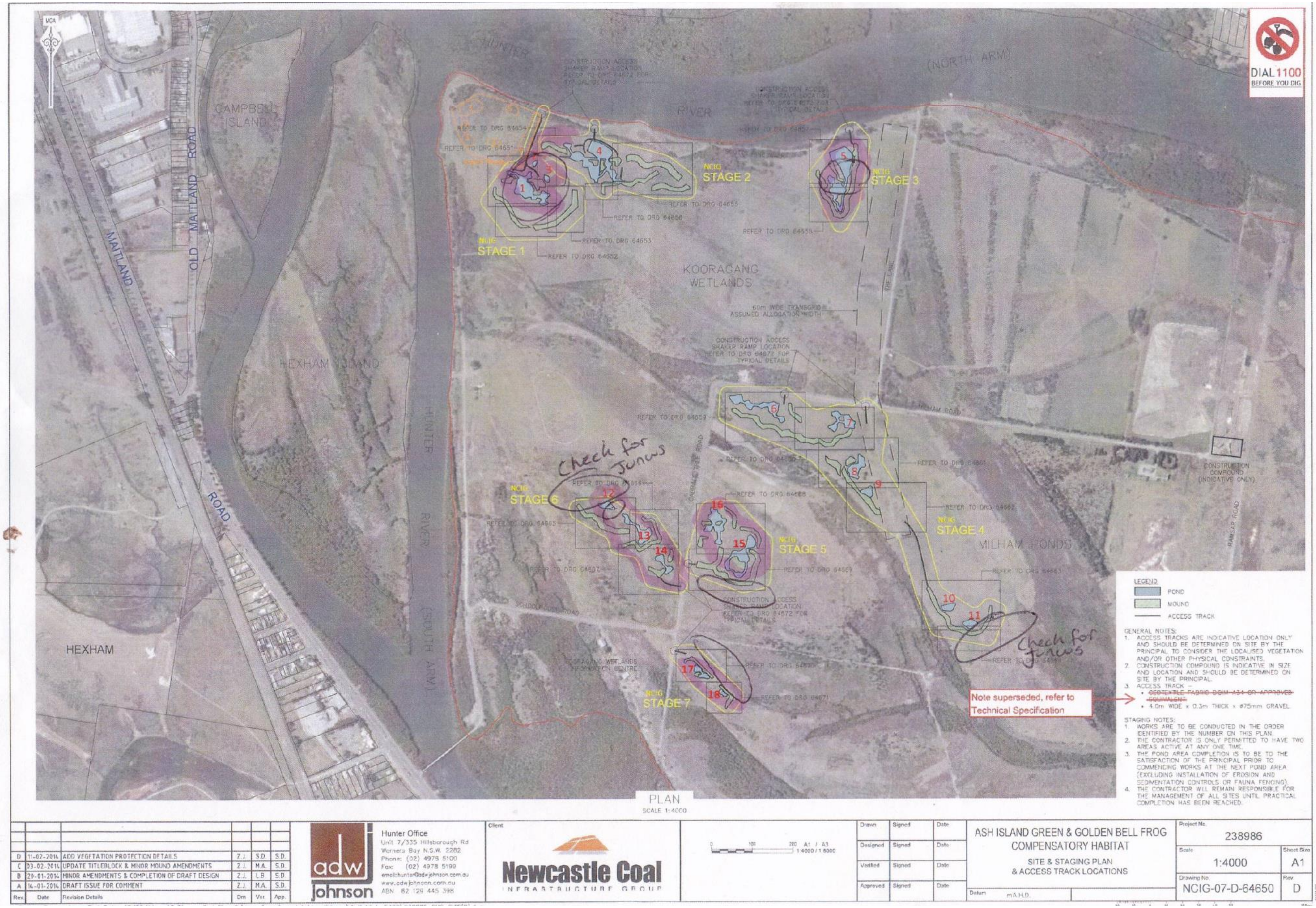
Actions Complete: Signed ___________________ Date _________

Appendix B – Works Program

	Timeline																													
	Month	February																												
	Week	Week 1							Week 2							Week 3							Week 4							
Projects	Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
NCIG	Alligator Weed spraying (4 man crew)																													
	Monitoring (2 man crew)																													
	Slashing tracks & frog fence (CVA Regen 2 man crew)																													
	Weeding sweep through site (CVA Regen 4 man crew)																													

March																														
Week 1						Week 2							Week 3							Week 4							Week 5			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

Appendix C – Weed Control Areas



NCIG GGBF Compensatory Habitat Project

Monitoring and Maintenance Report

March 2016

Version	Author	Date
1	T.Mouton	11/04/2016

WetlandCare Australia
44 Bishopsgate Street
Wickham NSW 2293

Introduction

The Newcastle Coal and Infrastructure Group (NCIG) developed a 78ha Compensatory Habitat and Ecological Monitoring Program (CHEMP), to offset areas lost as a result of the NCIG CET. The compensatory habitat comprises 18 constructed ponds. WetlandCare Australia has prepared a Green and Golden Bell Compensatory Habitat Management Plan (GGBF CHMP) based on requirements contained in the CHEMP, which sets out the methodology of site management and monitoring requirements for the ponds. The GGBF CHMP has been approved by the Office of Environment and Heritage, and forms part of the NCIG project approval. This monitoring report contains a monthly summary of site works and monitoring results undertaken as part of the GGBF CHMP.

Works Undertaken

The program of monitoring and maintenance continued throughout March 2016. The following works were undertaken this period:

Monitoring

- Pond inspections and monitoring, involving:
  - Visual inspection of pond condition and structure
  - Vegetation transect monitoring
  - Photo points taken
  - Water quality monitoring
  - Monitoring for evidence of pest species (feral animals and noxious weeds)

  Results from these inspections and management recommendations are contained in Appendix A, C and D.

Maintenance

- Slashing around the frog fence in Stage 1
- Repairs on frog fence surrounding Stage 1

Appendix B contains the schedule of works undertaken during March, and works forecast for the following month in April.

Key Outcomes

Monitoring

Water Quality

- Salinity (Target range < 4 ppt tadpoles; < 6 ppt frogs)
  - All ponds were within the acceptable salinity range for tadpoles and frogs.
- pH (Target range 4-9)
  - Ponds 7 and 10 were slightly above the pH target range. All other ponds were within target conditions for pH.
  - Pond pH ranged 7.28 – 9.3.
- DO (Target range 4-17)
  - Ponds 2, 3, 4 (northern pond) were outside the acceptable range. The lowest was Pond 4 at 0.85 mg/L
- Depth
  - Water levels have decreased from previous monitoring by 0.2m across all ponds

- Temperature (Target range 16-31^{0}C tadpoles; 4-35^{0}C frogs)
    - All ponds were within the temperature target range

<u>Vegetation Transects</u>

- Results of vegetation monitoring showed a general increase in percentage cover of native species within all pond buffers
- Ponds 11 and 13 were within acceptable range for all vegetation target conditions.

<u>Pest Species</u>

- Gambusia were observed in all ponds except 15.
- Small infestations of Alligator Weed and Blackberry were observed in ponds 1, 5, and 8 which will require respraying during the next weed control sweep.

<u>Other Observations</u>

- Water levels have continued to drop since the last monitoring period due to minimal rainfall.
- Diffuse Blue Green Algae was observed on the surface of ponds 4 and 9.
- The northern section of pond 4 is dominated by native aquatic vegetation (*Ceratophyllum demersum* – Hornwort).
- *Casuarina glauca* regrowth was observed within the buffer of Pond 18, this will require removal during the next weed sweep.
- Significant macrophyte growth was observed in the majority of ponds since previous monitoring, in particular *Typha sp.*

Maintenance

- Slashing 1m from the inside of the frog fence in Stage 1 was undertaken.
- Frog fence repairs were undertaken in Stage 1 to mend holes in mesh and straighten posts that were leaning over.

Fence repairs and slashing

Discussion & Recommendations

Recent dry conditions over the last month has resulted levels dropping further from previous results. All EC results are within acceptable levels. EC levels are slightly elevated since previous monitoring as there have been no significant freshwater flows into ponds. Similarly pH conditions within all ponds are slightly elevated since previous monitoring, averaging at 8.3.

Dissolved Oxygen results have improved across all ponds since previous monitoring, and are all within acceptable levels with the exception of Ponds 2 and 3. Ponds 2 and 3 have consistently received low DO readings below target levels since monitoring began in October 2015. Breakdown of excess organic matter from January storms is likely to have reduced, and cooler temperatures coming into winter will also allow greater oxygen transfer in ponds waters. Therefore we are likely to see an upwards trend in DO levels during the coming monitoring periods.

Overall there has been an improvement in water quality across all ponds, with 8 ponds meeting all target conditions, compared to 2 in the previous monitoring period.

Results of vegetation monitoring showed an increase in percentage cover of native species within the majority of pond buffers. This increase in percentage cover of native species generally corresponded to natives outcompeting weed species and/or a reduction in the amount of bare ground. Ponds 11 and 13 were within acceptable range for all vegetation target conditions.

Moderate increases in macrophyte densities were observed in the majority of ponds, in particular *Typha sp.* Ponds 2, 5a, and 18 are nearing the upper limit of emergent vegetation coverage, and may require management of *Typha sp.* should densities continue to increase. Photo points clearly show increases in Typha growth in many ponds. The northern section of Pond 4 was dominated by native aquatic vegetation (*Ceratophyllum demersum* – Hornwort), which is present throughout the water column and potentially affecting DO levels. Future management may be required.

It is unlikely some ponds will reach target vegetation conditions through natural recruitment alone, in particular 7, 8, 9, 17,18. These ponds would benefit from additional macrophyte planting to increase the cover of emergent vegetation, and buffer densities. Increasing macrophyte densities will also help address low DO levels in the long term.

Appendix A – Monitoring Results

Date	17,23 March 2016
Breeding Season (Oct-Dec)?	Yes / **No**
Name of Inspector/s	Tim Mouton, Trent Nielson
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds
WEATHER	Mild/Sunny
Temperature	26.5
Total rainfall over preceding 3 days	42 mm
Total rainfall over preceding month	60.8 mm

WATER QUALITY INSPECTION

Parameter	**Target Range**	**1**	**2**	**3**	**4**	**5A**	**5B**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Target Condition	Permanent ponds wet	**Wet**			**Wet**	**Wet**	**Wet**	**Wet**		**Wet**			**Wet**		**Wet**			**Wet**		
Wet/Dry		Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet
Design Depth m		1.4	0.2	0.4	1.4	1.4		1.2	0.6	1.0	0.2	0.4	1.0	0.2	1.2	0.4	0.6	2.2	0.4	0.2
Measured Depth m		1.5-1.6	0.5	1.1	0.6	0.6	1.7	1.5+	1.3	1.4	0.9-1	1	1.4	1.3	1.5+	1.2	0.6	1.6+	1.2	0.6
Temp ^{0}C	T: 16-31 F: 4-35	20.6	18.5	20.4	18.7	21.4	21.5	23.4	22.8	22.6	22.8	21.9	22.7	21.6	22.6	21.9	25	23.5	23.8	23.1
pH	4-9	7.93	7.7	7.55	7.28	8.03	7.75	8.58	9.05	8.28	8.48	9.3	8.4	8.77	8.7	9	8.84	8.46	8.68	8.22
Salinity uS/cm		1635	1408	1643	1133	780	1730	429	213	536	935	1115	5298	276	388	402	268	382	1511	1853
Salinity ppt	T < 4 F < 6	1.05	0.9	1.05	0.73	0.5	1.11	0.27	0.14	0.34	0.6	0.71	3.39	0.18	0.25	0.26	0.17	0.24	0.97	1.19
DO mg/L	4-17	4.82	2.5	2.83	4.01 (0.85)	5.78	4.15	8.3	9.4	7.26	8.2	8.5	5.3	7.48	7.87	7.06	9.4	7.3	8.3	6.45
Turbidity NTU	Not critical	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% Open Water	Min. 30% Max 70%	75	30	80	65	30	80	60	75	100	100	80	70	85	60	60	75	75	95	30
Meets all Targets	Y N	N	Y	N	Y	Y	N	Y	N	N	N	N	Y	N	Y	Y	N	N	N	Y

Notes:	The northern section of Pond 4 showed a low DO reading of 0.85 compared to 4.01 in the southern pond. The northern section is dominated by native aquatic vegetation (*Ceratophyllum demersum* – Hornwort). This is potentially impacting DO concentrations due to over consumption of oxygen by plant respiration.

☞ **See Over**

WATER QUALITY ACTION				
POND	**Action Required**	**Due Date**	**Completion Date**	**Signed**
1,3,5b,7,8,9,10, 12,15,16,17	Ponds are above the maximum acceptable level of open water percentage. This can be addressed by additional macrophyte planting	Ongoing		
2,3,(4)	Ponds are below the acceptable level for DO. The northern section of Pond 4 showed a low DO reading of 0.85 compared to 4.01 in the southern pond. The northern section is dominated by native aquatic vegetation (*Ceratophyllum demersum* – Hornwort). This is potentially impacting DO concentrations due to over consumption of oxygen by plant respiration. Increasing macrophyte growth could help address low DO levels.	Ongoing		
	Other Observations			
4, 9	Diffuse/small patches of Blue Green Algae were observed.			

NB: All vegetation work eg. removing macrophytes/in-fill planting should be recorded on the Vegetation Inspection Sheet

Date	Breeding Season (Oct-Dec) Yes / **No**		Name of inspector/s Tim Mouton, Trent Neilson		
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds				
POND STUCTURE INSPECTION					
POND	**Is there evidence of leakage?**	**Is there evidence of erosion/sedimentation?**	**Action Required?**	**Define action**	**Date Complete**
1.	No	No	No		
2.	No	No	No		
3.	No	No	No		
4.	No	No	No		
5.	No	No	No		
6.	No	No	No		
7.	No	No	No		
8.	No	No	No		
9.	No	No	No		
10.	No	No	No		
11.	No	No	No		
12.	No	No	No		
13.	No	No	No		
14.	No	No	No		
15.	No	No	No		
16.	No	No	No		
17.	No	No	No		
18.	No	No	No		

All Actions Complete: Signed __________________ Date ________

Date	Breeding Season (Oct-Dec) Yes / **No**		Name of inspector/s Tim Mouton, Trent Neilson				
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds						
POND NATIVE VEGETATION INSPECTION							
POND	**Emergent Vegetation % Cover of water body**	**Emergent Vegetation Density**	**Emergent vegetation Condition**	**Buffer Width**	**Buffer Density (Weed + Native) % Cover**	**Buffer Density (Native) % Cover**	**Meets All Targets**
Target	**40-70% Cover of water body**	**> 50%**	**Good**	**1.5 m**		**> 50% native cover**	**Y** / **N**
1.	25% Macrophyte	60	Very Good	1.5+	98.3	50	**N**
2.	70% Macrophyte	70	Very Good	1.5+	98.3	43.1	**N**
3.	20% Macrophyte	10	Average	0-1	100	34	**N**
4.	35% Macrophyte	70	Good	1.5+	95.6	66.2	**N**
5A.	70% Macrophyte	40	Good	1.5	89.5	28.1	**N**
5B.	15-20% Macrophyte	30	Average	1	89.5	28.1	**N**
6.	30-40% Macrophyte	50	Good	1.5	78	39.4	**N**
7.	20-25% Macrophyte	0	Average	1.5	83.3	16.7	**N**
8.	0% Macrophyte	0	Very Poor	1.5	57	7.6	**N**
9.	0% Macrophyte	0	Very Poor	1.5	64.7	2	**N**
10.	20% Macrophyte	85	Very Good	1.5+	78.1	68.8	**N**
11.	30-40% Macrophyte	50	Very Good	1.5+	83.1	68.8	**Y**
12.	15% Macrophyte	60	Average	1.5	60	29.2	**N**
13.	40-50% Macrophyte	70	Very Good	1.5+	90.5	52.4	**Y**
14.	40% Macrophyte	70	Very Good	1.5+	86	48.3	**N**
15.	25% Macrophyte	20	Good	1.5+	81.2	20.8	**N**
16.	20-25% Macrophyte	30	Good	1.5	100	34.3	**N**
17.	5% Macrophyte	0	Very Poor	1.5	73.3	4.4	**N**
18.	70% Macrophyte	50	Good	1	81.5	11.1	**N**
Notes	Moderate increases in macrophyte densities were observed in the majority of ponds, in particular *Typha sp.* Ponds 2, 5a, and 18 are nearing the upper limit of emergent vegetation coverage, and may require management of *Typha sp.* should densities continue to increase. The northern section of Pond 4 was observed to contain an abundance of native aquatic vegetation (*Ceratophyllum demersum* – Hornwort). *Casuarina glauca* regrowth was observed within the buffer of Pond 18.						

POND NATIVE VEGETATION ACTION REQUIRED			
POND	**Action Required**	**Due Date**	**Completion Date**
7, 8, 9, 17,18	Additional planting of macrophytes should be undertaken, within buffers and pond banks, within ponds showing poor growth and recruitment of macrophytes.	Ongoing	

COMMENTS:

All Actions Complete: Signed _________________ Date ________

WEEDS	Alligator Weed Density Class	Juncus acutus Density Class	Blackberry Density Class	Action Required	Date Action Complete
POND				**See Maintenance Guidelines in NCIG GGBF CH POM**	
1.	2			1 small patch near the fence approx. 15m east of the gate, missed during previous weed spraying. Follow up spraying required.	
2.					
3.					
4.					
5.	2			1 small patch on pond bank. This infestation has been sprayed and observed to be resprouting.	
6.					
7.					
8.			2	Small patch of Blackberry was observed adjacent to rock cobble on western bank.	
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					

NB: Weed Density Classes. Class 2 = less than 1%. Class 3 = 1-10%. Class 4 = 11-50%. Class 5 > 50% **Actions Complete:** Signed ______________ Date ________

PREDATOR INSPECTION					
	Gambusia	**Fox Evidence**	**Action Required**	**Action Required**	**Date Complete**
POND	**Yes/No**	**scats/prints/kills**	**Y/N**		
General Note				Visibility was poor in a number of ponds due increased tannins in the water column.	
1.	Yes	No		Gambusia moderate	
2.	Yes	No		Gambusia dominant	
3.	Yes	No		Gambusia very dominant	
4.	Yes	No		Could not estimate, visibility poor	
5.	Yes	No		Gambusia dominant	
6.	Yes	No		Gambusia very dominant	
7.	Yes	No		Gambusia very dominant	
8.	Yes	No		Gambusia dominant	
9.	Yes	No		Gambusia dominant	
10.	Yes	No		Could not estimate, visibility poor	
11.	Yes	No		Gambusia dominant	
12.	Yes	No		Could not estimate, visibility poor	
13.	Yes	No		Gambusia dominant	
14.	Yes	No		Gambusia dominant	
15.	No	Yes (tracks)			
16.	Yes	No		Could not estimate, visibility poor	
17.	Yes	No		Could not estimate, visibility poor	
18.	Yes	Yes		Could not estimate, visibility poor	

Actions Complete: Signed ________________ Date ________

Appendix B – Works Program

	Month	March					April			
	Week	Week 1	Week 2	Week 3	Week 4	Week 5	Week 1	Week 2	Week 3	Week 4
Projects	Task									
NCIG	Fox baiting									
	Alligator Weed spraying									
	Monitoring									
	Macrophyte buffer weeding									
	Slashing tracks & frog fence									
	Weeding sweep through site									

Appendix C – Vegetation Transect Data

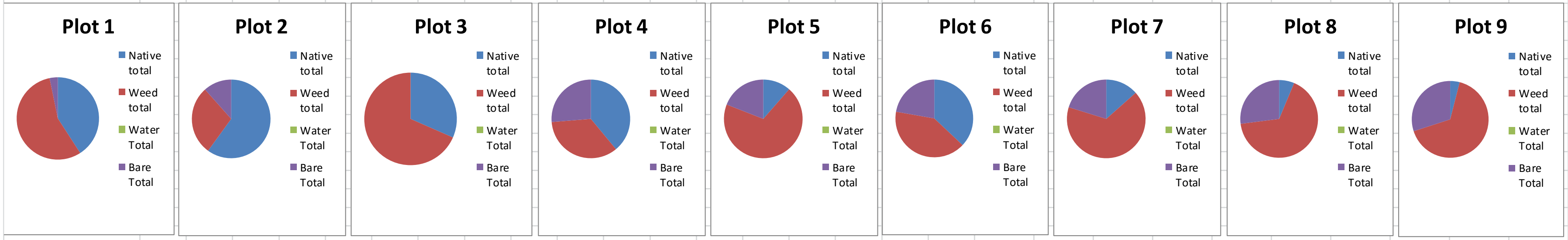
Monitoring - March 2016																		
Monitoring Date	17/03/2016																	
	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6		Plot 7		Plot 8		Plot 9	
	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%
Native Species																		
Bulboschoenus sp.	12	20.0	6	10.3	5	10.0	27	39.7	8	7.0	1	0.8		0.0		0.0		0.0
Carex apressa		0.0		0.0	1	2.0		0.0		0.0		0.0		0.0	4	5.1		0.0
Cotula coronopifolia		0.0		0.0		0.0	13	19.1		0.0		0.0		0.0		0.0		0.0
Paspalum distichum	5	8.3		0.0		0.0	2	2.9	11	9.6	9	6.8		0.0		0.0	1	2.0
Eleocharis sp.	5	8.3	7	12.1	1	2.0		0.0	2	1.8		0.0		0.0		0.0		0.0
Lythrum hyssopifolia		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Damasonium minus		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Alisma plantago-aquatica		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Triglochin sp.		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Juncus usitatus		0.0	1	1.7	3	6.0	2	2.9	1	0.9	8	6.1	4	7.4		0.0		0.0
Persicaria decipiens	7	11.7	7	12.1	2	4.0		0.0		0.0	17	12.9	1	1.9		0.0		0.0
Batrachium trichophyllum	1	1.7		0.0	2	4.0		0.0		0.0	2	1.5	1	1.9		0.0		0.0
Ludwigia peploides		0.0	2	3.4		0.0		0.0		0.0	1	0.8		0.0		0.0		0.0
Marsilea mutica		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Ottelia ovalifolia		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Lacnogrostis filiformis		0.0		0.0		0.0		0.0		0.0	1	0.8		0.0	2	2.5		0.0
Typha sp.		0.0	2	3.4	3	6.0	1	1.5	10	8.8	13	9.8	2	3.7		0.0		0.0
Azola		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Dichondra/Centella		0.0		0.0		0.0		0.0		0.0		0.0	1	1.9		0.0		0.0
Casuarina glauca		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Cyperus difformis		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Weed Species																		
Couch	14	23.3	2	3.4	4	8.0	16	23.5	46	40.4	37	28.0	25	46.3	24	30.4	9	17.6
Paspalum	5	8.3	9	15.5	1	2.0		0.0	7	6.1	5	3.8	10	18.5	7	8.9	5	9.8
Wild Aster		0.0	3	5.2	2	4.0	4	5.9	11	9.6	2	1.5	1	1.9	8	10.1	10	19.6
Kikuyu	10	16.7	16	27.6	26	52.0		0.0	6	5.3	7	5.3		0.0		0.0	8	15.7
Fireweed		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
White Clover		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Plantain		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Perennial Rye		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Scarlet Pimpernel		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Dock		0.0	2	3.4		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Evening Primrose		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Purpletop		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Mullum Couch		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Cyperus eragrostis		0.0		0.0		0.0		0.0		0.0	3	2.3	2	3.7		0.0		0.0
Barnyard Grass		0.0		0.0		0.0		0.0		0.0	4	3.0	3	5.6		0.0		0.0
Other																		
Bare Ground	1	1.7	1	1.7		0.0	3	4.4	12	10.5	22	16.7	4	7.4	34	43.0	18	35.3
Water		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0

	Plot 10		Plot 11		Plot 12		Plot 13		Plot 14		Plot 15		Plot 16		Plot 17		Plot 18	
	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%	Tally	%
Native Species																		
Bulboschoenus sp.	2	3.1	18	23.4		0.0	1	1.2		0.0		0.0		0.0	2	4.4		0.0
Carex apressa		0.0		0.0		0.0		0.0		0.0	7	4.7		0.0		0.0		0.0
Cotula coronopifolia		0.0	2	2.6		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Paspalum distichum	14	21.9	3	3.9	18	15.0	14	16.7	1	0.6		0.0		0.0		0.0		0.0
Eleocharis sp.		0.0		0.0		0.0	1	1.2	23	13.4		0.0		0.0		0.0		0.0
Lythrum hyssopifolia		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Damasonium minus		0.0		0.0	2	1.7		0.0		0.0		0.0		0.0		0.0		0.0
Alisma plantago-aquatica		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Triglochin sp.		0.0	4	5.2		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Juncus usitatus	26	40.6	2	2.6	3	2.5	5	6.0	34	19.8	14	9.4		0.0		0.0		0.0
Persicaria decipiens		0.0		0.0	8	6.7	6	7.1	6	3.5	8	5.4	15	21.4		0.0		0.0
Batrachium trichophyllum		0.0		0.0	2	1.7	2	2.4	6	3.5		0.0	5	7.1		0.0		0.0
Ludwigia peploides		0.0		0.0	1	0.8	5	6.0	1	0.6		0.0		0.0		0.0		0.0
Marsilea mutica		0.0		0.0		0.0	4	4.8	7	4.1		0.0		0.0		0.0		0.0
Ottelia ovalifolia		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Lacnogrostis filiformis		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Typha sp.	2	3.1	24	31.2	1	0.8	6	7.1	5	2.9	2	1.3	4	5.7		0.0	6	11.1
Azola		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Dichondra/Centella		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Casuarina glauca		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	1	1.9
Cyperus difformis		0.0		0.0		0.0		0.0	12	7.0		0.0		0.0		0.0	2	3.7
Weed Species																		
Couch	5	7.8	10	13.0	20	16.7	1	1.2	30	17.4	57	38.3	28	40.0	29	64.4	18	33.3
Paspalum	1	1.6		0.0	16	13.3	11	13.1	23	13.4	20	13.4	15	21.4	1	2.2	5	9.3
Wild Aster		0.0	1	1.3		0.0		0.0		0.0	10	6.7	1	1.4	1	2.2		0.0
Kikuyu		0.0		0.0	1	0.8	10	11.9		0.0	3	2.0	2	2.9		0.0	12	22.2
Fireweed		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
White Clover		0.0		0.0		0.0	1	1.2		0.0		0.0		0.0		0.0		0.0
Plantain		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Perennial Rye		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Scarlet Pimpernel		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Dock		0.0		0.0		0.0	1	1.2		0.0		0.0		0.0		0.0		0.0
Evening Primrose		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Purpletop		0.0		0.0		0.0	8	9.5		0.0		0.0		0.0		0.0		0.0
Mullum Couch		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Cyperus eragrostis		0.0		0.0	23	19.2	2	2.4	2	1.2	3	2.0		0.0		0.0		0.0
Barnyard Grass	8	12.5		0.0	24	20.0	3	3.6	15	8.7	4	2.7		0.0		0.0		0.0
Other																		
Bare Ground	6	9.4	13	16.9	1	0.8	3	3.6	7	4.1	21	14.1		0.0	12	26.7	10	18.5
Water		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0

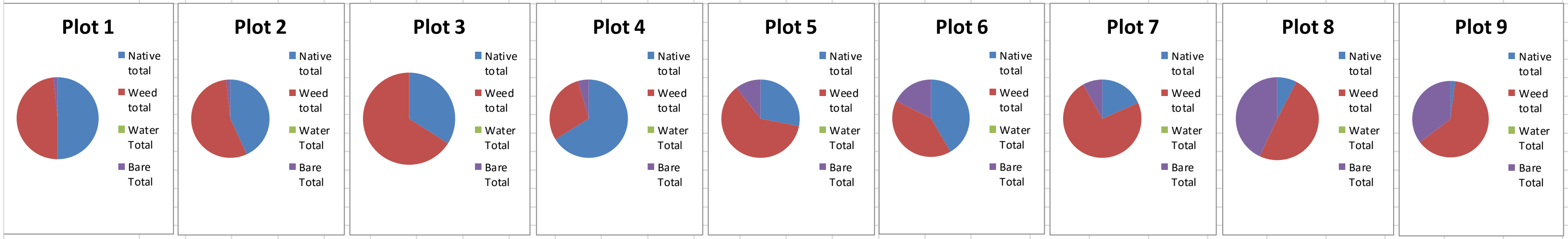
2015-2015 Comparison	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6		Plot 7		Plot 8		Plot 9	
% Cover	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Vegetation total	96.8	98.3	88.4	98.3	100.0	100.0	73.7	95.6	81.0	89.5	77.8	78.0	79.8	83.3	73.0	57.0	70.0	64.7
Native total	40.9	50.0	60.0	43.1	31.6	34.0	39.0	66.2	11.4	28.1	37.0	39.4	13.5	16.7	6.3	7.6	4.0	2.0
Weed total	55.9	48.3	28.4	55.2	68.4	66.0	34.7	29.4	69.5	61.4	40.7	38.6	66.3	66.7	66.7	49.4	66.0	62.7
Water Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Total	3.2	1.7	11.6	1.7	0.0	0.0	26.3	4.4	19.0	10.5	22.2	16.7	20.2	7.4	27.0	43.0	30.0	35.3

	Plot 10		Plot 11		Plot 12		Plot 13		Plot 14		Plot 15		Plot 16		Plot 17		Plot 18	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Vegetation total	90.8	78.1	97.6	83.1	87.8	60.0	78.2	90.5	89.5	86.0	66.1	81.2	97.3	100.0	81.4	73.3	66.7	81.5
Native total	56.3	68.8	57.1	68.8	28.9	29.2	32.1	52.4	48.0	48.3	13.9	20.8	34.2	34.3	0.0	4.4	0.0	11.1
Weed total	34.5	9.4	40.5	14.3	58.9	30.8	46.2	38.1	41.4	30.8	52.2	60.4	63.0	65.7	81.4	68.9	66.7	64.8
Water Total	0.0	0.0	0.0	0.0	2.2	0.0	6.4	0.0	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Total	9.2	9.4	2.4	16.9	10.0	0.8	15.4	3.6	4.6	4.1	33.9	14.1	2.7	0.0	18.6	26.7	33.3	18.5

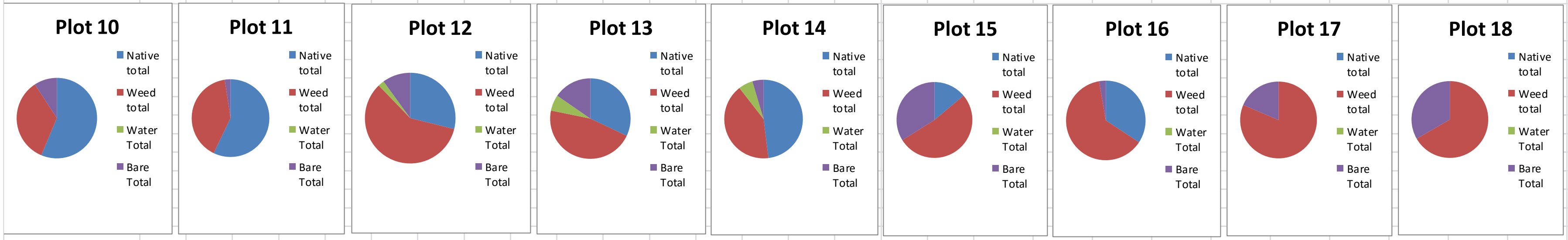
2015



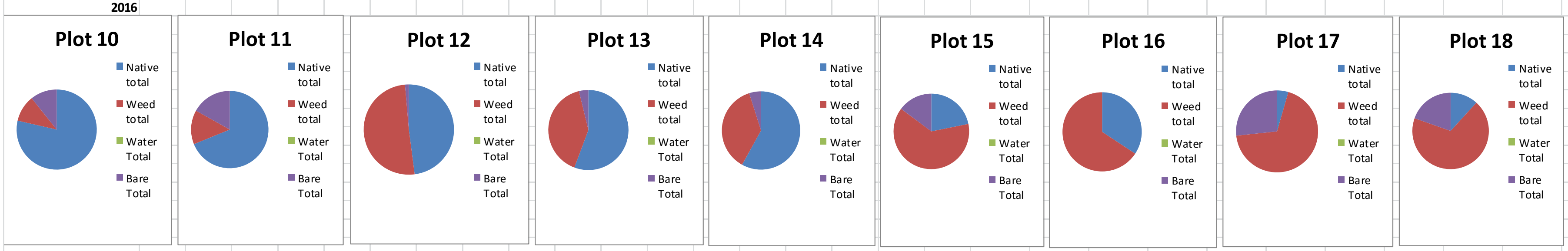
2016



2015



2016



Appendix C – Photo Points

Pond 1 PP1 – October 2015

Pond 1 PP1 – March 2016

Pond 2 PP1 – October 2015

Pond 2 PP1 – March 2016

Pond 3 PP1 – October 2015

Pond 3 PP1 – March 2016


Pond 4 PP1 – October 2015 Pond 4 PP1 – March 2016


Pond 5 PP1 – October 2015 Pond 5 PP1 – March 2016


Pond 6 PP1 – October 2015 Pond 6 PP1 – March 2016

Pond 6 PP2 – October 2015 Pond 6 PP2 – March 2016

Pond 7 PP1 – October 2015 Pond 7 PP1 – March 2016

Pond 7 PP2 – October 2015 Pond 7 PP2 – March 2016

Pond 7 PP3 – October 2015

Pond 7 PP3 – March 2016

Pond 8 PP1 – October 2015

Pond 8 PP1 – March 2016

Pond 9 PP1 – October 2015

Pond 9 PP1 – March 2016

Pond 10 PP1 – October 2015 Pond 10 PP1 – March 2016

Pond 11 PP1 – October 2015 Pond 11 PP1 – March 2016

Pond 12 PP1 – October 2015 Pond 12 PP1 – March 2016


Pond 13 PP1 – October 2015


Pond 13 PP1 – March 2016


Pond 14 PP1 – October 2015


Pond 14 PP1 – March 2016


Pond 15 PP1 – October 2015


Pond 15 PP1 – March 2016

Pond 16 PP1 – October 2015

Pond 16 PP1 – March 2016

Pond 17 PP1 – October 2015

Pond 17 PP1 – March 2016

Pond 18 PP1 – October 2015

Pond 18 PP1 – March 2016

Appendix C – NCIG Shorebird Compensatory Habitat Monitoring (Avifauna Research and Services)

March 2016

NCIG Shorebird Compensatory Habitat Monitoring

Pre-construction Period January – March 2016

Prepared by Avifauna Research & Services

AVIFAUNA RESEARCH & SERVICES PTY LTD
PO BOX 2006, ROCKDALE NSW 2216

INTRODUCTION

NCIG are committed to the enhancement and restoration of a section of Area E for migratory shorebirds to offset losses resulting from the development of NCIG Coal Export Terminal. The concept of the Area E restoration includes the removal of mangroves and management of tidal flows to expand both foraging and roosting habitat including saltmarsh, exposed mud and tidal pools.

BACKGROUND

The Hunter Estuary is the most important site in NSW for shorebirds, providing critical feeding and roosting habitat for both migratory and resident shorebird species. The Ramsar listed wetlands support 45 species of migratory birds protected under international agreements. The Hunter Estuary has suffered extensive alteration as a result of urban, mining and industrial development, which has contributed to a decline in shorebird populations over the last 40 years.

Area E has been recognised as an important wetland for waterbird and shorebird abundance and diversity. The area selected for restoration includes a large area of former tidal flats and saltmarsh isolated from tidal influence during the 1960s. The mudflat substrate and saltmarsh were left intact at this time, though much of the marine life previously maintained by tidal waters has changed. No data exists of shorebird populations prior to the isolation of the area from tidal flows. However, data since the 1970s shows that the area was still used by relatively large numbers of migratory shorebirds as well as a high diversity of other species of waterbirds.

The substrate of large parts of Area E and Ash Island as a whole changed when the area was re-opened to tidal flows due to the fact that the area was below that of the tidal range in which saltmarsh could be sustained and within the tidal range utilised by the Grey mangrove. In the absence of any attempt to restrict the spread of mangroves the area quickly became mangrove dominated at the expense of migratory shorebirds previously using the area.

METHODS

Monitoring of shorebird populations were carried out during July and August 'off peak' on a monthly basis and during September 2015 to March 2016 'peak' period. Nocturnal surveys were commenced in September 2015 during high and low tides and continued to the end of March 2016.

Surveys were conducted along pre-determined transects at the project site as well as at reference sites in the Hunter River Estuary (**Table 1**). Survey date, time, tide height, weather, abundance and behaviour of birds were recorded, along with any observed disturbances.

Monitoring at other major diurnal roost sites during high tide provided an estimate of the whole of estuary populations of shorebirds against which the project site and reference sites can be compared. The inclusion of all waterbirds during counts requires little additional effort but is useful to determine whether interaction of other species has an effect on specific habitat usage, as does the monitoring of disturbance from any other source.

Monitoring at Hexham Swamp sites are not covered under this contract but were monitored periodically to determine whether birds from Area E frequented the site and therefore explained significant changes in populations in Area E populations. Although Tomago Wetlands are an extremely important area for shorebirds, in particular nocturnal roosting, this site is not covered under this contract and is therefore not monitored.

Milham's Pond did not constitute a transect in itself although the southern tip was included in counts at Phoenix Flats.

Table 1. Survey sites

Location	**Sub-site**
Area E: Project site	Fish Fry Flats Fish Fry Creek Wader Creek
Area E: Reference sites	Wader Pond NW Pond Swan Pond main northern and southern sections
Hunter River Estuary	Milham's Pond Phoenix Flats Hexham Swamp Kooragang Dykes Stockton Sandspit & Channel

RESULTS

A total of 22 species of shorebirds were observed during the January to mid-March 2016 survey period, including 7 resident and 15 migratory species (Table 2).

The most abundant species recorded across Area E reference sites was the resident Black-winged Stilt, although numbers dropped from a peak count of 1,407 at high tide and 1,489 at low tide to a maximum of 50 birds this quarter (Appendix A). The most common migratory species sighted at Area E included Bar-tailed and Black-tailed Godwit, Common Greenshank and Marsh Sandpiper; while the Hunter Estuary subsites supported higher numbers of most migratory shorebirds including Sharp-tailed Sandpiper, Whimbrel, Eastern Curlew, Curlew Sandpiper, Pacific Golden Plover, Bar-tailed and Black-tailed Godwits, Common Greenshank and Marsh Sandpiper.

Shorebirds were typically observed feeding and roosting in response to tidal fluctuation, although there was little variation in total abundance of shorebirds present between high and low tides at Area E. No disturbances were noted during this survey period.

As expected prior to the restoration works, no shorebird species were recorded at the project site: Fish Fry Flats, Fish Fry and Wader Creeks (Figure 1) prior to the removal of mangroves. Larger numbers of Chestnut Teal (315) than earlier counts were observed during this quarter while small numbers of other waterbirds were present, including Grey Teal, cormorants and egrets.

Nocturnal surveys were commenced on 25 September and will be carried out fortnightly throughout the peak season. Nocturnal surveys found quite different usage of wetland sites by shorebirds compared with diurnal sites. Some of the wetlands were used more extensively by more species at night than during the day, notably NW Pond and Wader Pond.

The most frequently used wetland by the largest variety of species in Area E was the main lagoon of Swan Pond.

Monitoring of shorebirds at the project site and reference sites continued on a monthly basis during the “off-peak” migratory bird season (April-August 2015), increasing to fortnightly from September 2015 – March 2016 with the return of key migratory species.

Table 2. All shorebird species observed July 2015 to March 2016

Species	July-Dec 15	Jan-Mar 16	EPBC listing	TSC listing
Pied Oystercatcher	*	*		Endangered
Sooty Oystercatcher	*	*		Vulnerable
Black-winged Stilt[1]	*	*		
Red-necked Avocet[1]	*	*		
Pacific Golden Plover[1]	*	*	Migratory	
Red-capped Plover	*	*		
Black-fronted Dotterel[1]	*	*		
Red-kneed Dotterel	*			
Masked Lapwing[1]	*	*		
Black-tailed Godwit[1]	*	*	Migratory	Vulnerable
Bar-tailed Godwit[1]	*	*	Migratory	
Whimbrel	*	*	Migratory	
Eastern Curlew[1]	*	*	Migratory	
Terek Sandpiper	*	*	Migratory	Vulnerable
Common Sandpiper		*	Migratory	
Grey-tailed Tattler	*	*	Migratory	
Common Greenshank[1]	*	*	Migratory	
Marsh Sandpiper[1]	*	*	Migratory	
Ruddy Turnstone	*		Migratory	
Great Knot	*	*	Migratory	
Red Knot	*	*	Migratory	
Red-necked Stint[1]	*	*	Migratory	
Sharp-tailed Sandpiper[1]	*	*	Migratory	
Curlew Sandpiper[1]	*	*	Migratory	Endangered

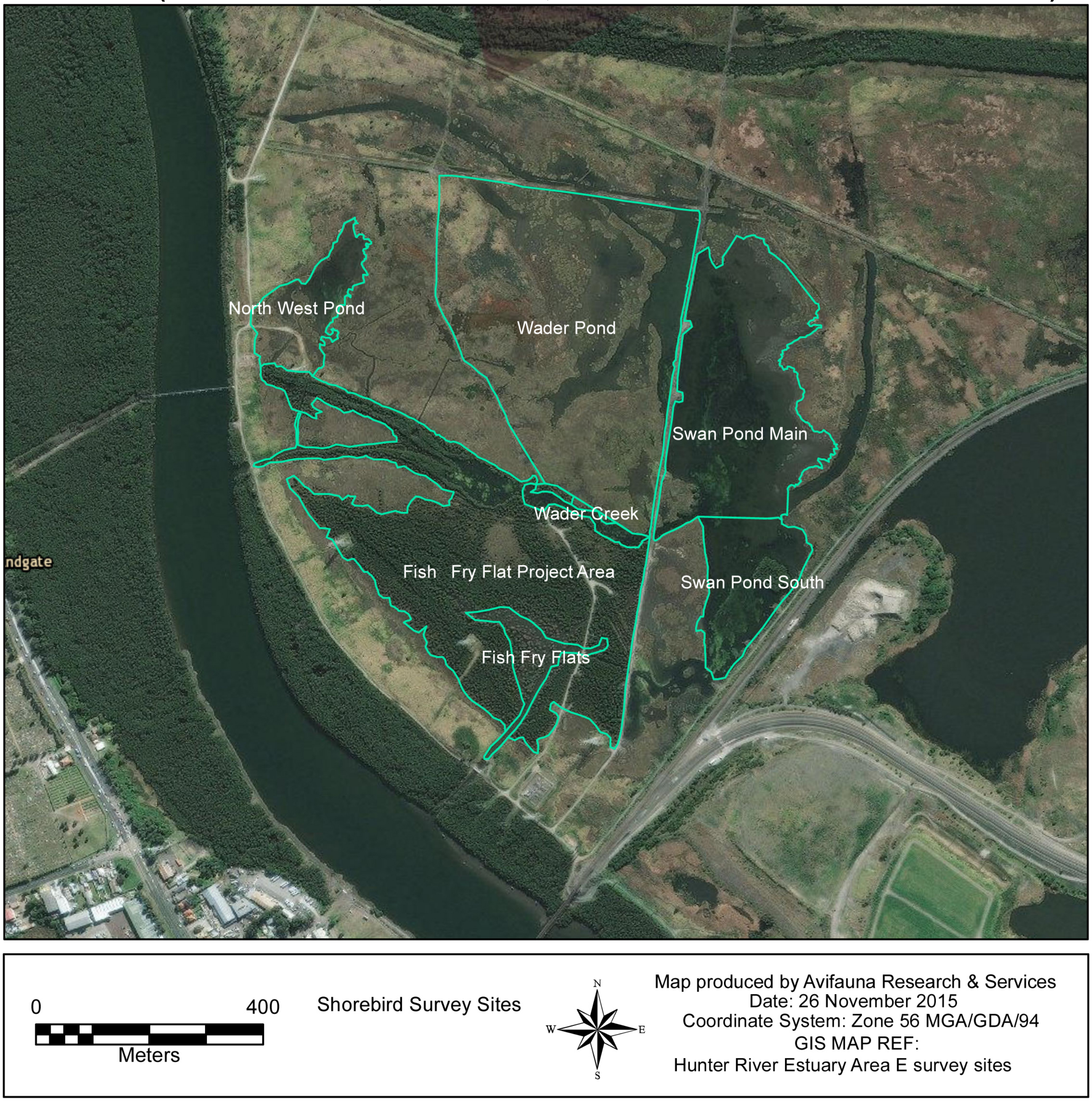
[1] Species occurring in Area E reference sites
*** Species observed at tidal and/or Area E wetlands**

SURVEY SITES

Survey sites selected for this study included the ‘project area’ of Fish Fry Flats and Wader Creek, and the reference sits which includes the main significant lagoons within the Area E (Figure 1).

The project area comprised almost entirely of mangrove forest or relatively deep open water consequently the variety of waterbird species were low compared with the reference sites which were comprised of open saltmarsh and shallow lagoons.

Figure 1: Project area (Fish Fry Flats and Wader Creek) and Area E reference sites (North West Pond; Wader Pond; Swan Pond Main and Swan Pond South).



Compensatory Habitat and Ecological Monitoring Program – Quarterly Report

DATE: *6 July 2016*

AUTHOR: Philip Reid (NCIG), Alex Callen, Michael Mahony, John Clulow (Uni of Newcastle), Kleinfelder Consulting, Tim Mouton (Wetland Care Australia)

APPROVAL: Nathan Juchau

INTRODUCTION

This report provides an update of activities relating to the NCIG Compensatory Habitat and Ecological Monitoring Program since the previous Quarterly Report from April 2016. The report aims to provide information on key components of the program and how these are being implemented. An update will be provided to members of the Consultative Board every 3 months, in the form of a Quarterly report and presentations (every 6 months) coinciding with Board Meetings.

1. Research Area Ponds and Associated Monitoring (Alex Callen)

There is no further update on the Trial Site since the April report, as stated previously, the local Trial Site population had dropped noticeably during the last summer season, with the population estimated at approximately 21 Adults in February 2016. Subsequently, a small number of metamorphs (121) were released in the Trial Site during March that were remaining from experimental work in the laboratory.

Alex Callen concluded the fieldwork component of her PhD research project in June, which is the end of her formal engagement with NCIG. Alex will spend the coming months writing her thesis, which will be based on results and observations gained from the Trial Site over the past 3.5 years.

2. Annual Kooragang Island Green and Golden Bell Frog Monitoring (Michael Mahony)

As discussed in the previous quarterly report, monitoring of the industrial area of Kooragang was conducted during the 2015/16 summer season. This included two (2) monitoring events (revised down from three due to access limitations), and took place at multiple water bodies across the industrial part of Kooragang Island and some areas of Ash Island (southern end near the Kooragang Main Rail Line). The 2015/16 monitoring has been jointly-funded by NCIG, Port Waratah Coal Services and the Hunter Development Corporation, due to potential impacts from future capping of the former Kooragang Island Waste Emplacement Facility (KIWEF).

Results from the monitoring indicate a 'raw count' population size (individuals that are known to be alive) of 1,021 frogs. This number will be refined using capture-mark-recapture data over the monitoring period and ecological modelling. This and discussion points will be made in a final report from the university which will be finalised this month.

Figure 1: Kooragang Island Green and Golden Bell Frog Monitoring Survey Locaitions

3. Captive Breeding and Release Program

As discussed in the previous monthly report, a total of 10,718 captive-bred animals were introduced into the NCIG Compensatory Habitat during the 2015/16 season. Months in which these were released, and the tadpole/metamorph breakdown is shown in Table 4-1 below. The total number does not include the 121 animals that were introduced into the Trial Site ponds in March. Figure 1 provides a geographical representation of where animals were released across the landscape.

Table 3-1 – Release of Green and Golden Bell Frog (L. aurea) tadpoles and metamorphs by month into NCIG compensatory habitat, Ash Island, for the summer of 2015/2016.

Year/Month	Tadpoles released	Metamorphs released
2015/October	400	
2015/November	150	
2015/December	3514	1100
2016/January	1050	2326
2016/February	745	309
2016/March	1079	45
Sub-totals	**6938**	**3780**
Total released	**10718**	

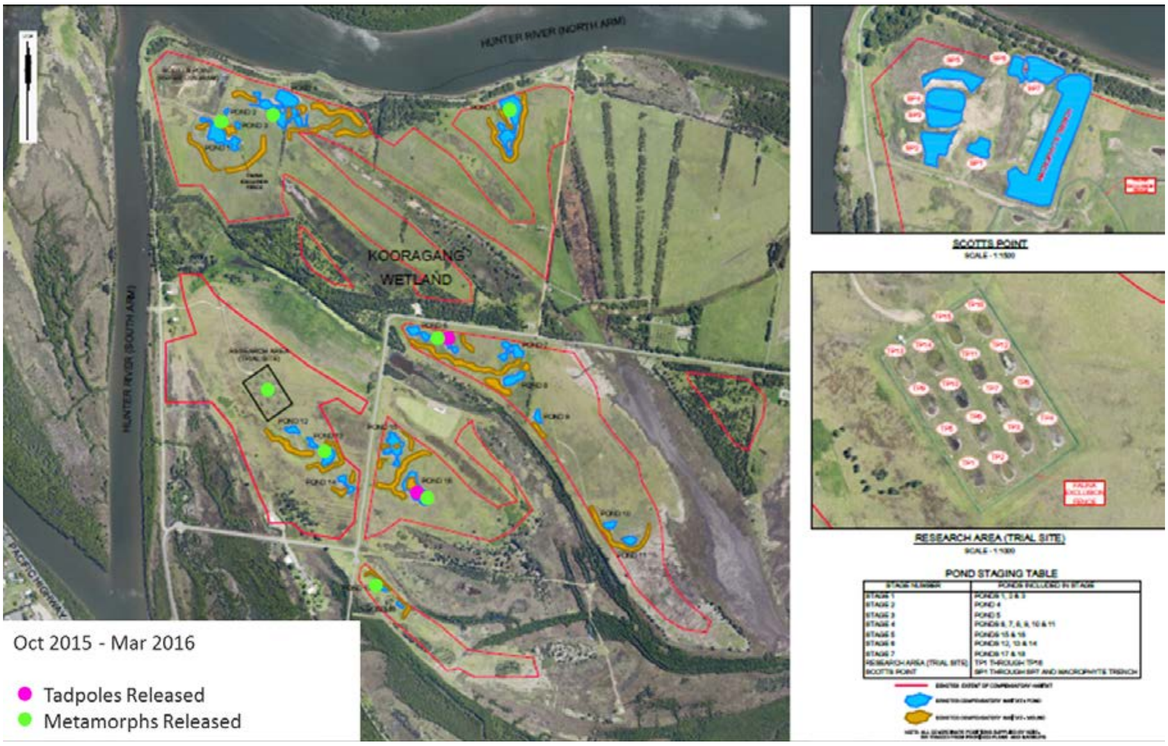


Figure 2: Captive-bred Green and Golden Bell Frog Release Sites

Captive breeding and release of animals into the NCIG Compensatory Habitat is schedule for the 2016/17 season.

4. Green and Golden Bell Frog Compensatory Habitat

4.1. Green and Golden Bell Frog Compensatory Habitat Monitoring

4.1.1. Overview

Major summer rainfall occurred in the lower Hunter region in early and mid-January 2016, and resulted in a total that almost doubled the long-term monthly average. All of the wetlands of the NCIG Compensatory Habitat were fully charged and many of the “permanent” and “ephemeral” wetlands became interconnected. At the same time other permanent and ephemeral wetlands in the local area were also recharged, and there was significant overland or surface flow that connected many of the wetlands. Major summer rains combined with daily average temperatures above 20oC are considered to be ideal for breeding of the Bell Frog. This was the case in the population of Bell Frogs on Kooragang Island to the east of the NCIG Compensatory Habitat Area, where choruses of adult males and dispersal of adults to ephemeral wetlands that were flooded at this time were observed. This aim of this report is to provide a summary of the observations made during January, February and March 2016 in the NCIG Compensatory Habitat Area.

4.1.2. Materials and Methods

Details of the monitoring methodology were provided in the previous Quarterly Report.

4.1.3. Results

Frog Surveys: Choruses of adult male bell frogs were detected at twelve of the NCIG Compensatory Wetlands (Table 4-1). In the period between the 8th and 22nd of January a total of 23 adult males and 9 females were observed. Observations of adults were restricted to wetlands in stages 4, 5 and 7 (Tables 4-1 and 4-2). The survey effort was equivalent in all wetlands and was based on a standardised habitat search. Large wetlands take proportionally longer to survey than smaller wetlands. Surveys in wetlands in stages 1, 2, 3 and 6 did not result in the detection of any adults, and no choruses were heard in wetlands in these stages over the period of surveys. Aural surveys are conducted at the time of visual encounter surveys using direct listening and response to call playback. These techniques are known to be effective in detecting calling males. Because the male call carries up to 50 metres on a still night, it is often possible to hear males calling in wetlands away from the location of survey, and we consider that in such circumstance that all calling activity would be detected in the precinct that encompasses the NCIG Compensatory Habitat Wetland. Once calling was heard an active search of the habitat was conducted and call playback employed. Thus we are confident that the sites where calling occurred represent the only sites where male bells frogs were actively calling.

Examination of the wetland locations where calling was detected reveals that activity was focused in the southern and central region of the NCIG Compensatory Habitat.

Demography of the adults collected show that the population consists largely of first year males and females (< 12 months since metamorphosis)(see Figures 3 and 4). The number of males observed was larger than the number of females, but this most likely reflects the fact that males are more easily detected than females rather than a real difference in the sex ratio. It is also likely that females under the age of 12 months are dispersed in the habitat and not found around wetlands. The age-class structure is a significant feature since only second year females (12 to 24+ months) are reproductive, and the observations are that there are few adults in this category in the system.

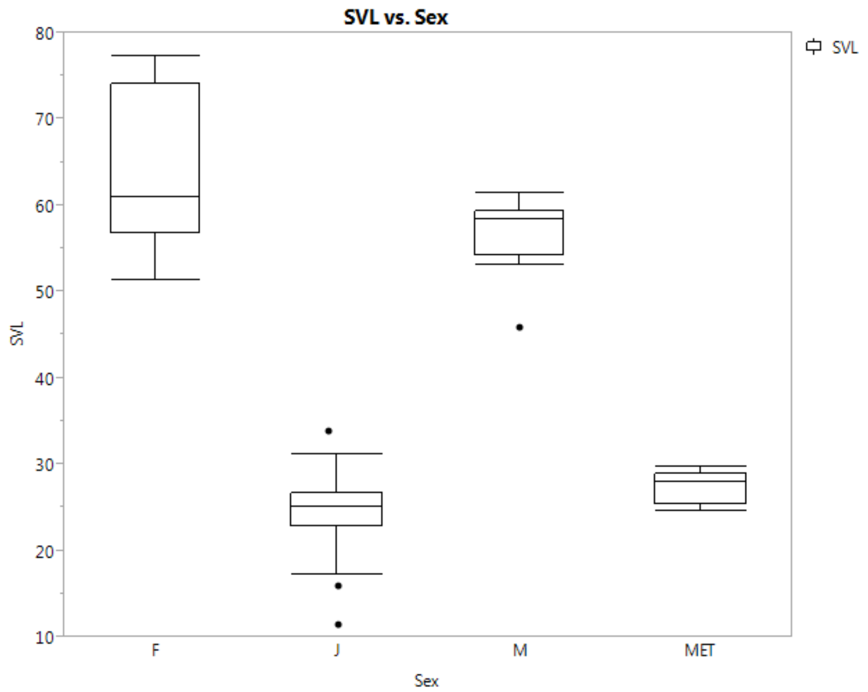


Figure 3. Graph of body length (SVL) for age and gender classes, of bell frogs collected in the precinct of the NCIG Compensatory Habitat Wetlands.

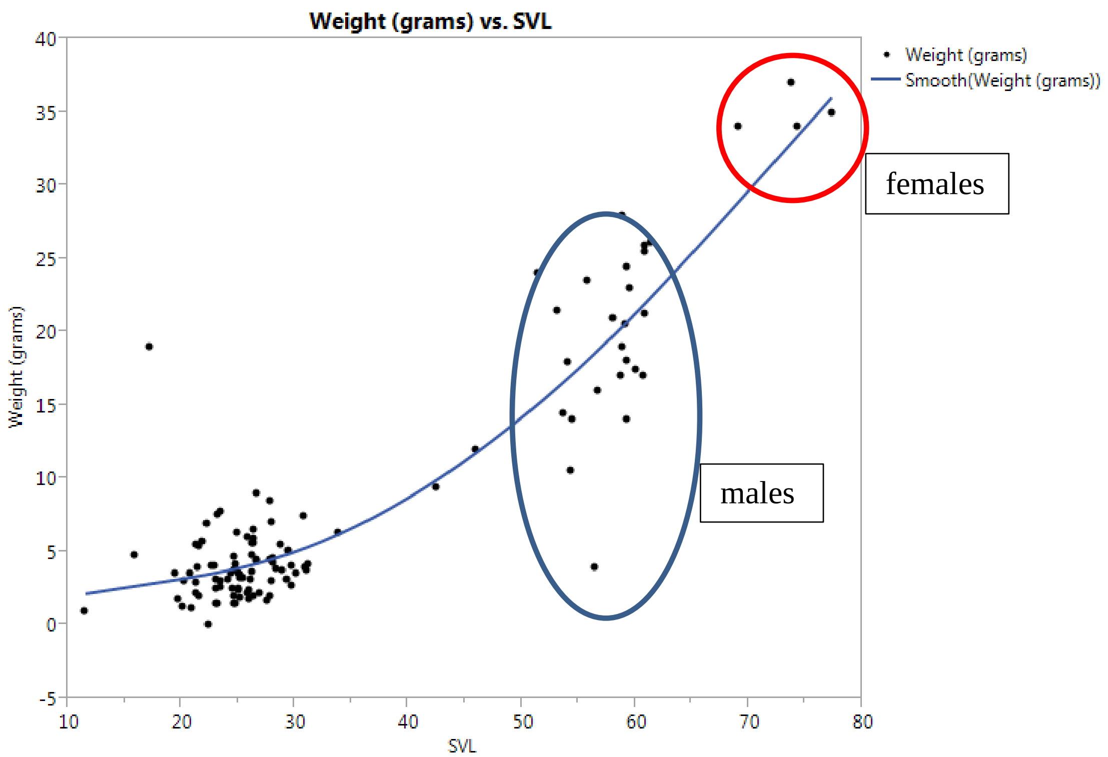


Figure 4. Graph of body length (SVL) against body weight for all bell frogs collect in the precinct of the NCIG Compensatory Habitat Wetlands. The juveniles are at the lower left , adult males in the middle and females at the top right.

Tadpoles and Metamorph Surveys: No bell frog tadpoles were detected in surveys conducted across all the NCIG Compensatory Habitat Wetlands prior to the rainfall in early January.

Tadpole surveys were conducted in all wetlands in February 2016 in the time period 4 to 8 weeks after the rainfall in January. Bell frog tadpoles and metamorphs were detected in two wetlands, K7A and K27, which are adjacent to the NCIG Compensatory Wetlands stages 4 and 7 respectively. No tadpoles or metamorphs were detected in the NCIG Compensatory Habitat Wetlands. Geographical presentation of the frog, metamorph and tadpole monitoring results is shown in Figure 5.

Tables 4-1 and 4-2. Occurrence of calling male Green and Golden Bell Frogs in the NCIG Compensatory Habitat Wetlands, wetland location of calling and dates and numbers of calling males and females observed in January and February 2016.

Wetland Stage (Pond Number)	January 2016	February 2016
4-1	Calling	Calling
4-2	Calling	Calling
4-3	Calling	Calling
4-5	Calling	
4-7	Calling	
4-9	Calling	
4-10	Calling	Calling
4-11	Calling	Calling
5-1	Calling	Calling
7-1	Calling	Calling
7-2		Calling
7-3	Calling	

Date	Number of Males	Number of Females
8/1/16	3	
11/1/16	5	
13/1/16	7	3
15/1/16	3	2
16/1/16	2	2
22/1/16	2	2

Bell Frog chorusing and subsequently tadpoles and metamorphs were detected in ephemeral wetlands adjacent to the NCIG stage 4 wetlands, and stage 7 wetlands (Table 4-3). In both cases adult males were observed calling in the constructed wetlands, with breeding confirmed in the adjacent ephemeral wetlands.

Table 4-3. Observations of Green and Golden Bell Frog breeding on the western end of Kooragang Island in January 2016

Wetland Stage (Pond Number)	January 2016	February 2016	Observations
K7A Adjacent to but outside the NCIG Stage 4	**Calling & Breeding**	**Tadpoles observed (late February)**	**Breeding occurred in the small ephemeral swales adjacent to the larger wetland that has a saline (tidal) influence to the east.**
K27 (K58A, K58B) Adjacent to but outside the NCIG Stage 7	**Calling & Breeding**	**Tadpoles and metamorphs observed (late February)**	**Breeding occurred in the small ephemeral swale adjacent to the constructed wetlands. The swale has a distinct saline influence as evidenced by its plant community.**

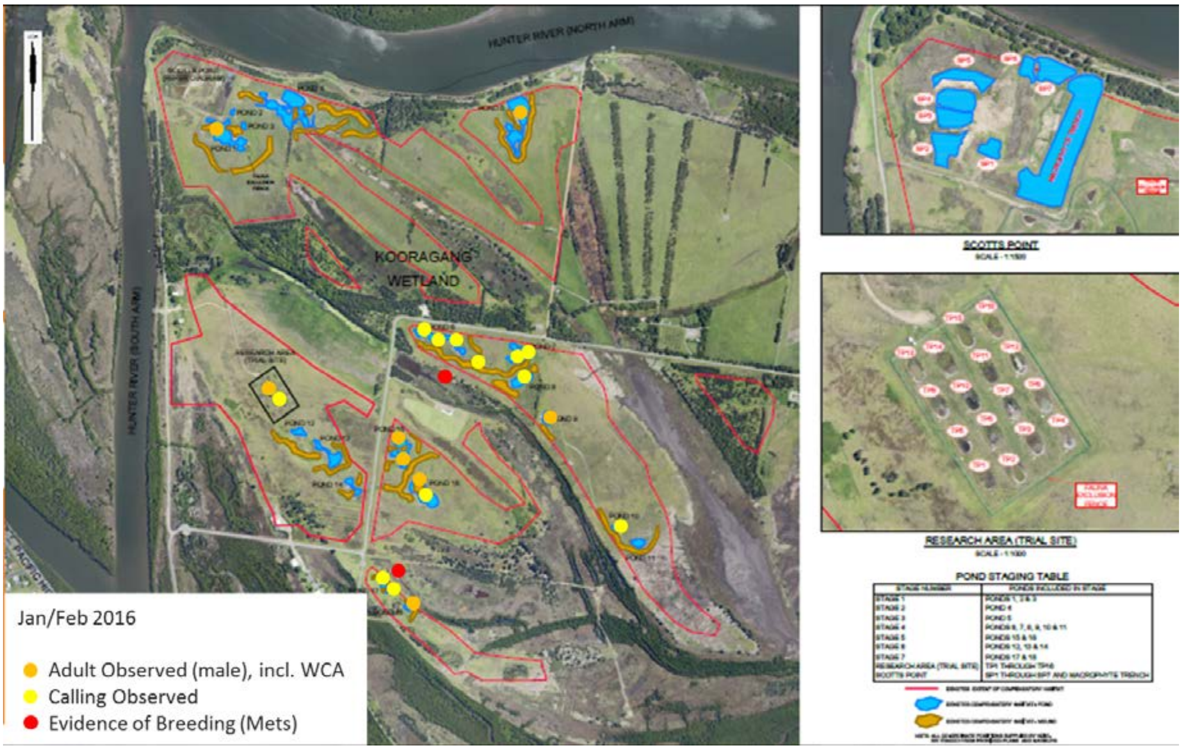


Figure 5: Green and Golden Bell Frog, Metamorph and Tadpole Survey Results (including Wetland Care Australia observations)

Gambusia surveys: The invasive fish the Plague Minnow (also commonly called the Mosquito Fish)(Gambusia holbrooki) was found at over 80% of the NCIG Compensatory Habitat Wetlands. This fish was also found to occur in several of the natural wetlands and ephemeral swales (salt marshes and flooded meadows) in the local area. Abundance or density of the fish and the stages of development varied considerable among wetlands. In several of the permanent wetlands the development class structure of the population was composed of mature adults males and females, with a smaller number of juveniles and sub-adults, and in these cases the density of fish was high. In several of the ephemeral wetlands the population was dominated by sub-adults and juveniles with a fewer adults, and the density was low.

Repeated Gambusia surveys were conducted across all ponds within the 7 stages of the compensatory habitat in preparation for the first tadpole releases in October 2015. Only Stage 5 was completely devoid of Gambusia, although in some other stages, there were isolated ponds that avoided inundation in the April storms, and as such, were Gambusia free in the October monitoring round. All ponds in Stages 2 and 7 were colonised with Gambusia, as were most ponds in stages 1 and 3 (4 of 5 ponds and 3 of 4 ponds respectively). Eight of the 11 ponds in Stage 4 and 1 of 4 ponds in Stage 6 also contained Gambusia.

4.1.4. Discussion

Choruses of Bell frogs were observed in three wetlands in two of the wetland stages during surveys in January and February of 2016. The choruses were observed in wetlands in Stages 4, 5 and 7. In total calling was observed in 8 of the 11 wetlands in stage 4, one in stage 5 and three in stage 7. A total of 22 males were observed calling and 9 females were observed in these wetlands at the same time. These are minimum numbers of adults, since they were individuals that were caught and marked, and not all individuals are encountered in surveys. Adult bell frogs were not observed in any of the wetlands in stages 1, 2, 3 and 6 despite equivalent survey effort to that where the frogs were observed. We are confident that this pattern of wetland occupancy reflects the reality of the situation across the two month period when bell frogs were most active following the charging of the wetlands.

An observation that comes from the two breeding events that were recorded, is that they were in ephemeral wetlands that have a short hydroperiod (i.e. less than 8 weeks, e.g. wetlands K27 and K7A), and have a vegetation community that is indicative of a salt influence. Both are identified from historical aerial photographs as being from salt swales. Another important observation is that the adult bell frogs make use of the more permanent wetlands created by the compensatory habitat, migrate into the swales to breed, and once that has occurred they migrate back to the more permanent wetlands. This is a clear example of the use of a mosaic habitat structure in the life cycle of the bell frog, and is a feature that has previously been identified.

Although no breeding was observed in the NCIG Compensatory Habitat Wetlands it is likely that no breeding would have occurred on the western end of the island and in the precinct of the NCIG Compensatory Wetlands without the occurrence of permanent freshwater bodies that the compensatory wetlands provide, and the release over a period of two years of bell frog tadpoles / metamorphs to the area/precinct. There is direct evidence that the more permanent freshwater wetlands are providing important foraging and sheltering habitat for the bell frog, and that the mosaic of the wetlands provides for connectivity in the landscape. What is less easy to understand is why the adult frogs make a choice of highly ephemeral wetlands (i.e. < 8 weeks hydroperiod) for breeding. Biological explanations for such life history strategies focus on the advantages that ephemeral situations have with respect to few predators and competitors, and high levels of nutrients. On Kooragang Island two other features that are potentially linked to bell frog survival can be added; the occurrence of some level of salinity which may infer an advantage over the amphibian disease pathogen chytrid, and a high average water temperature which promotes rapid tadpole growth and development. Balanced against these advantages is the need for rapid development to prevent desiccation and failure to metamorphose if the hydroperiod is too short.

The occurrence of male choruses also signifies that there are adult males in the ecosystem, and provides information about survival of individuals to the adult stage. The age class structure of the adults collected (see Tables 4-1 and 4-2 and Figures 3 and 4) shows that most of the adults were in the first year of their life. There are three possible means by which the males observed in the chorus can be accounted for. Firstly, and most likely, these males are the offspring of breeding observed in the Compensatory Habitat and natural habitats in 2015, or tadpoles released to the Compensatory Habitat in 2015 and possibly a small number from 2014. Secondly they may be offspring and/or escapees from the Trial Site that emigrated prior to being caught for microchipping. Thirdly they may be individuals that have migrated from further east on Ash/Kooragang Island. If either of the first two explanations is correct the captive breeding program has been successful in reintroducing a population of bell frogs to the western portion of Ash Island.

The number of adult females observed was less than males although the numbers of females did increase towards the end of the activity period. It is likely that the adult sex ratio is equal (50:50) and that there is no differential mortality between the sexes. Therefore the lower number of females is likely to reflect unequal detection. This can be explained by the observation that females are not occupying habitat at the wetlands (edge or emergent vegetation), and it may be that pre-reproductive females avoid these habitats so that they are not mobbed by male frogs. If there is not a differential mortality then the number of adult females should be equivalent to the number of males and therefore there should be about the same number as there are males. However, it is the number of second year females that are important in terms of reproduction (body length > 72 mm), and only five females in this age class were detected.

Further information regarding monitoring of the Green and Golden Bell Frog Compensatory Habitat can be found in Appendix A.

4.2. Compensatory Habitat Management

Monitoring and management of compensatory habitat continued during the reporting period in accordance with the approved Green and Golden Bell Frog Compensatory Habitat Management Plan. Work during the reporting period has been conducted by Wetland Care Australia (WCA) and includes:

- Pond inspections, including visual inspections, photo points, water quality monitoring and monitoring for evidence of pests

- Slashing around frog fence in Stage 1
- Weed sweep targeting priority weeds

A copy of the May monitoring and maintenance report is provided in Appendix B.

A modification was made to the NCIG Green and Golden Bell Frog Compensatory Habitat Management Plan to address proposed shaping of bunds around aquatic habitat and use of agents (eg. Rotenone or lime) to manage Gambusia. The purpose of the bunding is to exlude constructed aquatic habitat from surrounding surface water during flood events, which carries Gambusia. For this to be effective, ponds would need to be pumped out (already allowed for in the management plan) and dosed with an agent, for example a piscicide, targeting Gambusia. This is required as the majority of NCIG aquatic habitat has become infested with Gambusia during flood events in April 2015 and January 2016.

This modification to the management plan was subsequently determined to be permissible by NPWS in June, providing relevant regulatory approvals were obtained for use of Rontene. Creation of bunds commenced in June with the Trial Site and Stage 7 complete (see Plate 1) and Stages 1, 4 and 5 scheduled to be done in early July. The opportunity will also be used to creat minor scrapings in mounds and elevated areas for marginal ephemeral aquatic habitat, observed to be favourable breeding habitat across the island during the 2015/16 season.

Plate 1: Creation of Bunds around Stage 7 Ponds to control Gambusia

5. Shorebird Compensatory Habitat

5.1. Migratory Shorebird Habitat Construction

It was reported in the previous quarterly report that early works for the Migratory Shorebird Habitat Construction Project commenced in April. Construction works commenced in full in May, including removal of mangroves. Mangrove removal work has continued throughout the period, with approximately 70% of mangroves removed to date. Figure 6 provides a geographical presentation of mangrove removal, including Phase 1 (tree felling) and Phase 2 (trimming of stumps and pneumatophores). The following photos provide a visual representation of the mangrove removal process to date.

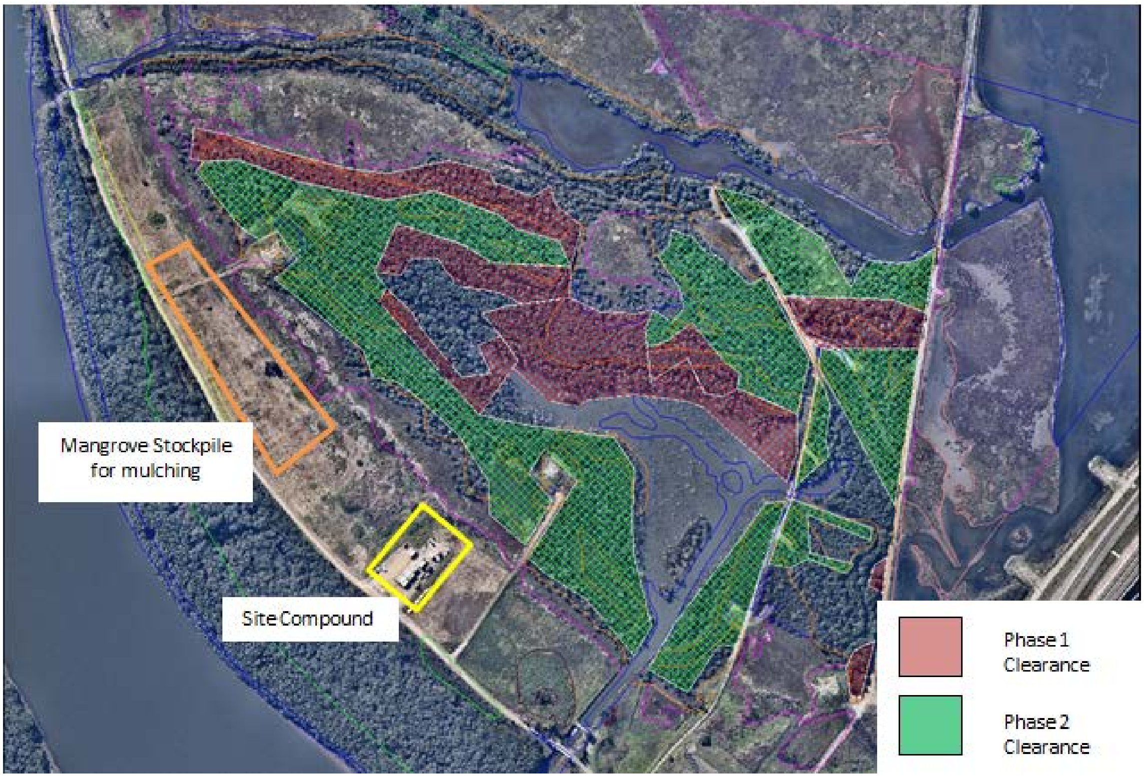


Figure 6: Mangrove Removal Works Area (current as at 23/6/16)

Plate 2: Competency training for manual removal crews

Plate 3: Long reach excavator removing mangroves with hydraulic sheer

Plate 4: Hydraulic sheer attachment removing mangroves

Plate 5: Positrack removing mangroves with hydraulic sheer

Plate 6: Ride-on mower used to complete Phase 2 clearing

Plate 7: Completed Phase 2 clearing area

Plate 8: Mulcher used for mulching felled mangroves

Plate 9: Forestry saws with different sawing implements

Plate 10: Forestry saw being used for Phase 2 clearing

Plate 11: Chainsaw being used for Phase 1 clearing

Plate 12: “Bog mats” used by trucks for accessing felled trees

Plate 13: Utilisation of drop boards at Fish Fry Creek to manipulate tide level in work zone

Plate 14: NPWS delegation visiting site

Plate 15: Remaining dead mangroves in Fish Fry Flats to be removed

Plate 16: Oblique aerial image, Fish Fry Flats (30/5/16)

Plate 17: Comparison photos, Area E – September 2015 (top) and June 2016 (bottm)

Plate 18: Technical Advisory Group (Will Glamore, Phil Straw, Arthur White)

Plate 19: Excavator and positrack removing felled mangroves

Plate 20: Phase 2 cleared area, eastern end of Wader Creek

Plate 21: Spoonbills utilising Fish Fry Creek

Design and commissioning of the Smart Gate and Mangrove Propagule Exclusion Device (MPED) continued throughout the period. The preferred supplier (AWMA) was chosen and discussions continue to refine the design in consultation with Dr Will Glamore.

6. Shorebird Monitoring

6.1. Overview

Kleinfelder was engaged by NCIG to monitor bird activity at Swan Pond and Fish Fry Flats during the mangrove removal works to determine if the activity is having a negative impact on birds within the immediate area. This monitoring continues on from shorebird monitoring conducted by Avifauna Consulting prior to habitat construction.

6.2. Methods

Bird counts were undertaken one morning per week by a qualified ecologist following the ecological pre-clearance inspections of the mangroves within the mangrove removal area. Bird counts commenced for half an hour between 7:00 am and 10:00 am. All birds observed foraging or roosting on the water, ground, or in trees, or flying over or Swan Pond and Fish Fry Flats were recorded.

6.3. Results

The number of individual birds counted at Swan Pond showed considerable variation from week to week (Figure 6). The total number of individuals recorded in the last three weeks was about half that recorded in the first three weeks of mangrove removal works, driven mainly by a reduction in the numbers of wading birds recorded. During the first three weeks of survey large numbers of Red-necked Avocets (*Recurvirostra novaehollandiae*) and Black-winged Stilts (*Himantopus himantopus*) were observed throughout Swan Pond.

A possible cause for the decline in the recorded numbers of wading birds is the timing of the survey. The availability of prey to wading birds is dependent on the tides, which will determine their distribution within the estuary. Surveys were conducted in the morning after conducting a pre-clearance inspection of the mangrove removal area, and not necessarily at the same tidal level. Therefore the lower numbers could be a result of survey times and foraging behaviour rather than disturbance caused by the activity. Additionally other factors such as strong winds and heavy rainfall in the region will also influence the distribution of waders within the estuary.

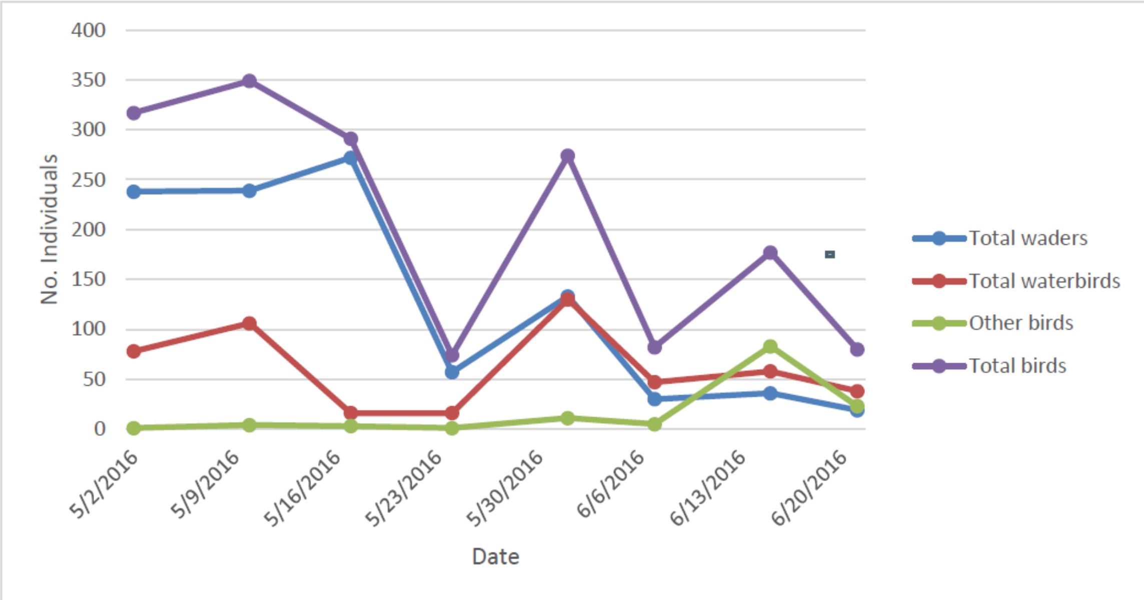


Figure 6: Number of individual waders, water birds and other species counted at Swan Pond during each monitoring event.

The number of individual birds counted at Fish Fry Flats also varied from week to week (Figure 7). No general pattern of decline can be seen in the Fish Fry Flats bird counts. However, after weeks of fluctuation, there was a decrease in the number of waterbirds recorded. This may be a result of the disturbance caused by mangrove removal works within the area. Continued monitoring will determine any long-term impacts resulting from the clearing activities.

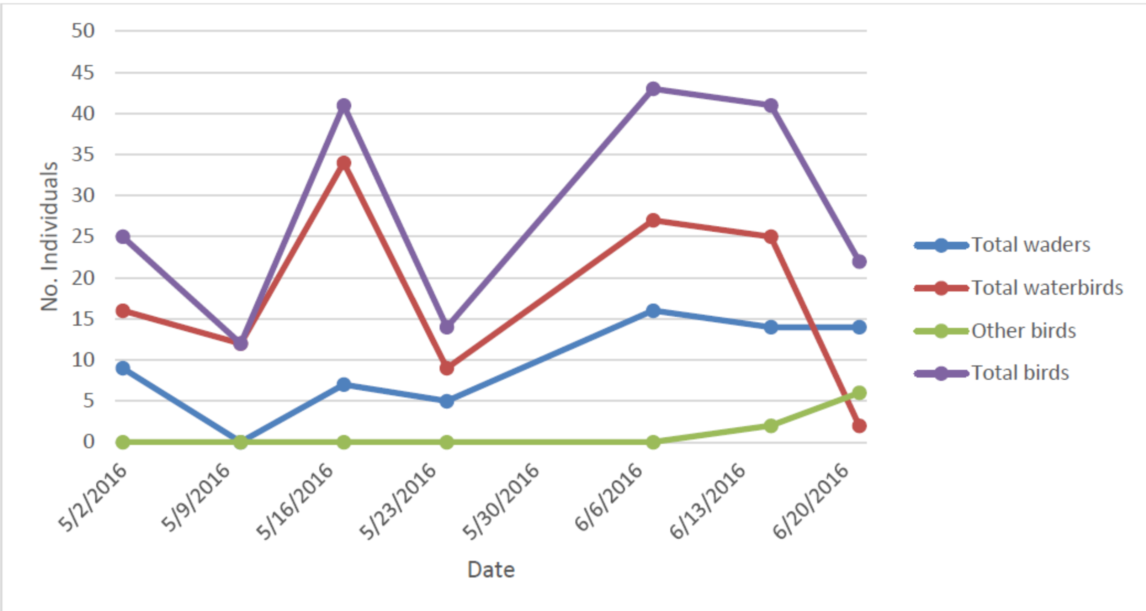


Figure 7: Number of individual waders, water birds and other species counted at Fish Fry Flats during each monitoring event.

The numbers of species observed each week at both Swan Pond (Figure 8) and Fish Fry Flats (Figure 9) remained generally constant, despite some slight variation.

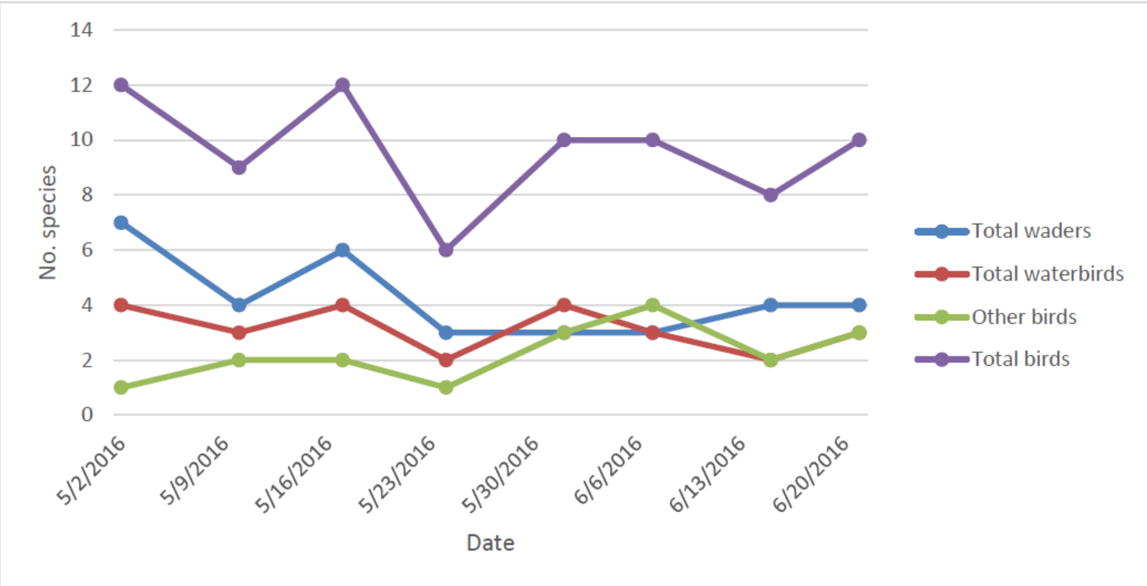


Figure 8: Number of wader, waterbird and other species recorded at Swan Pond during each monitoring event.

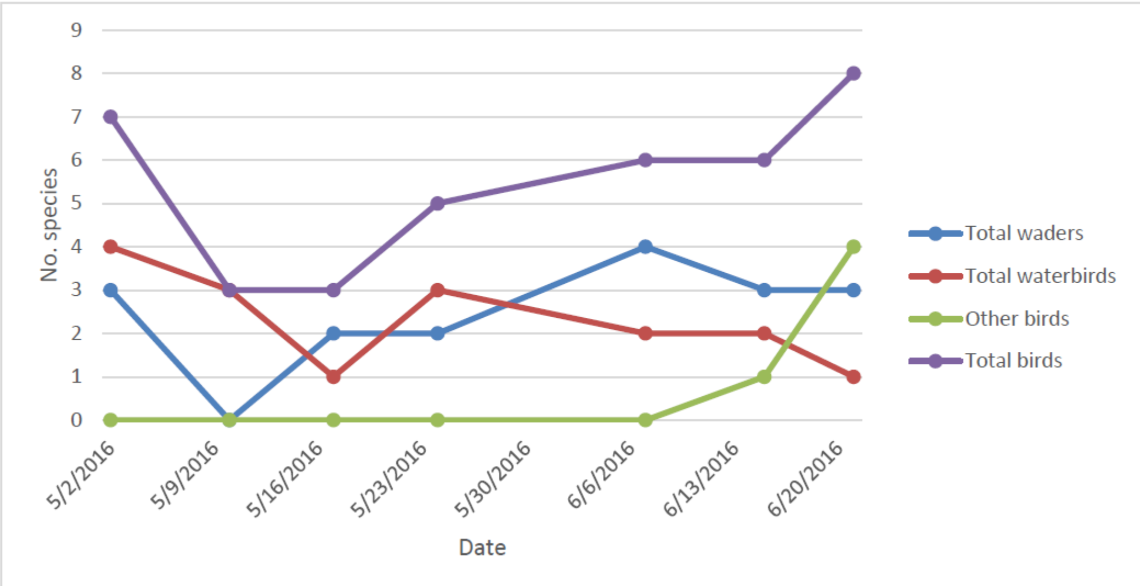


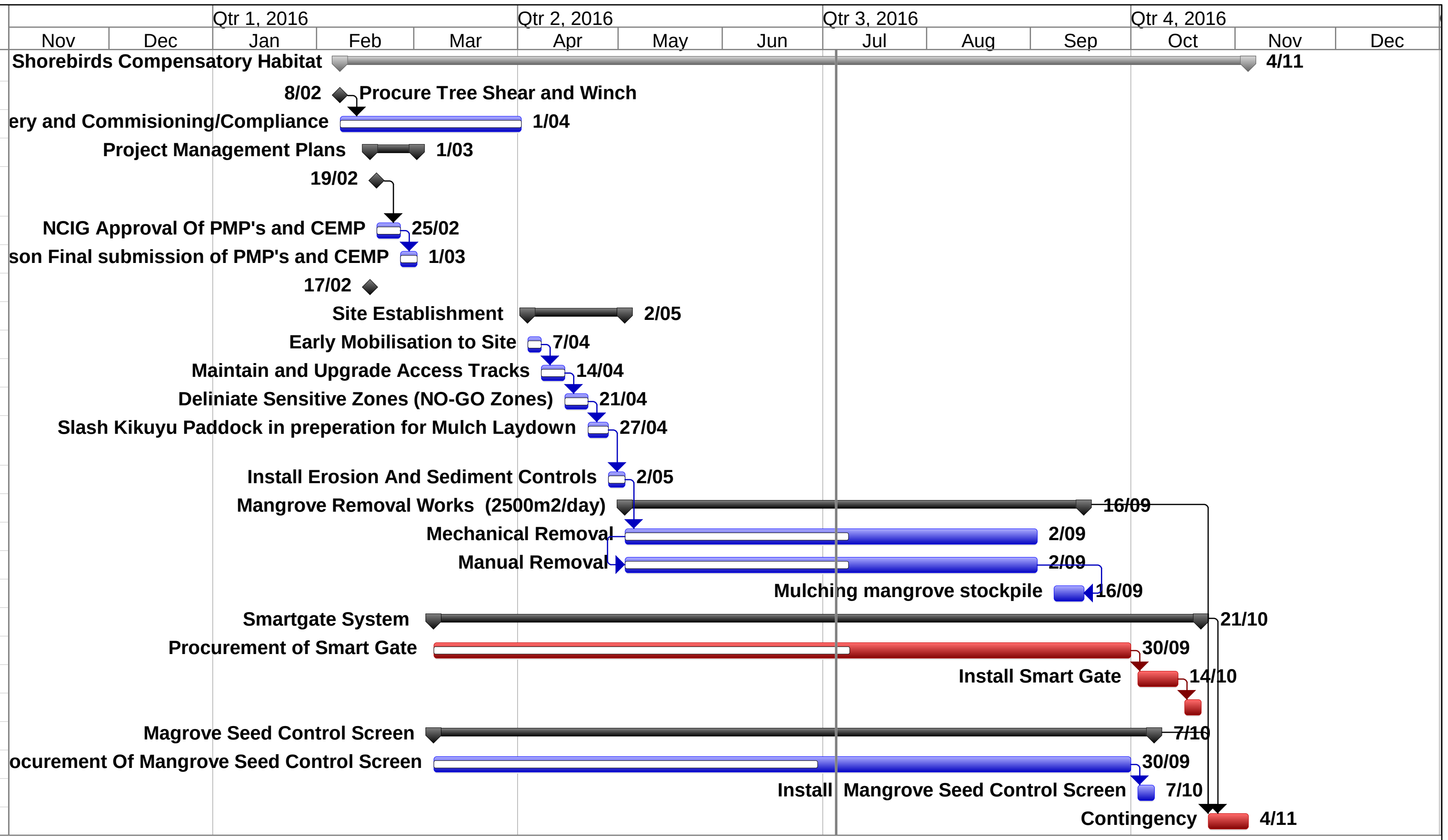
Figure 9: Number of wader, waterbird and other species recorded at Fish Fry Flats during each monitoring event.

The complete report, including full species list and counts can be found in Appendix C.

7. NCIG Compensatory Habitat Schedule

A copy of the NCIG Compensatory Habitat Schedule of Works for Migratory Shorebirds is provided as part of this report. This has been updated to reflect construction timing updated during the works.

ID	Indicators	Task Name	Duration	Start	Finish	Predecessors
0		**NCIG Shorebirds Compensatory Habitat**	**195 days**	**Mon 8/02/16**	**Fri 4/11/16**	
1	✓	Procure Tree Shear and Winch	0 wks	Mon 8/02/16	Mon 8/02/16	
2	✓	Delivery and Commisioning/Compliance	8 wks	Mon 8/02/16	Fri 1/04/16	1
3	✓	**Project Management Plans**	**10 days**	**Wed 17/02/16**	**Tue 1/03/16**	
4	✓	Submission of Robson Project Management Plans / CEMP	0 days	Fri 19/02/16	Fri 19/02/16	
5	✓	NCIG Approval Of PMP's and CEMP	1 wk	Fri 19/02/16	Thu 25/02/16	4
6	✓	Robson Final submission of PMP's and CEMP	3 days	Fri 26/02/16	Tue 1/03/16	5
7	✓	BBRA	0 days	Wed 17/02/16	Wed 17/02/16	
8	✓	**Site Establishment**	**21 days**	**Mon 4/04/16**	**Mon 2/05/16**	
9	✓	Early Mobilisation to Site	4 days	Mon 4/04/16	Thu 7/04/16	
10	✓	Maintain and Upgrade Access Tracks	5 days	Fri 8/04/16	Thu 14/04/16	9
11	✓	Deliniate Sensitive Zones (NO-GO Zones)	5 days	Fri 15/04/16	Thu 21/04/16	10
12	✓	Slash Kikuyu Paddock in preperation for Mulch Laydown	4 days	Fri 22/04/16	Wed 27/04/16	11
13	✓	Install Erosion And Sediment Controls	3 days	Thu 28/04/16	Mon 2/05/16	12
14		**Mangrove Removal Works (2500m2/day)**	**99 days**	**Tue 3/05/16**	**Fri 16/09/16**	
15		Mechanical Removal	89 days	Tue 3/05/16	Fri 2/09/16	13
16		Manual Removal	89 days	Tue 3/05/16	Fri 2/09/16	15SS
17		Mulching mangrove stockpile	7 days	Thu 8/09/16	Fri 16/09/16	16FF+2 wks
18		**Smartgate System**	**165 days**	**Mon 7/03/16**	**Fri 21/10/16**	
19	▦	Procurement of Smart Gate	30 wks	Mon 7/03/16	Fri 30/09/16	
20		Install Smart Gate	2 wks	Mon 3/10/16	Fri 14/10/16	19
21		Commision Smartgate	1 wk	Mon 17/10/16	Fri 21/10/16	20
22		**Magrove Seed Control Screen**	**155 days**	**Mon 7/03/16**	**Fri 7/10/16**	
23	▦	Procurement Of Mangrove Seed Control Screen	30 wks	Mon 7/03/16	Fri 30/09/16	
24		Install Mangrove Seed Control Screen	1 wk	Mon 3/10/16	Fri 7/10/16	23
25		Contingency	2 wks	Mon 24/10/16	Fri 4/11/16	14,18,22



Project: NCIG Shorebirds Compensato
Date: Tue 5/07/16

Task	Rolled Up Progress	Inactive Task	Manual Summary Rollup	Critical Split
Milestone	Split	Inactive Milestone	Manual Summary	Progress
Summary	External Tasks	Inactive Summary	Start-only	Deadline
Rolled Up Task	Project Summary	Manual Task	Finish-only	
Rolled Up Milestone	Group By Summary	Duration-only	Critical	

Appendix A – Green and Golden Bell Frog Compensatory Habitat Monitoring and Research Report Data (University of Newcastle).

Table 1. Dip-net and water quality surveys of the NCIG Compensatory Habitat Wetlands in September and October 2015. These surveys were conducted to assess the suitability of wetlands for prospective release of captive breed tadpoles and metamorphs. Gambusia were observed in wetlands in all stages, except stage 5, and high densities were observed in wetlands in stages 1, 2, 3, and 4, with lower densities in stages 6 and 7. Water quality was considered suitable (i.e. within the known threshold ranges for Green and Golden bell frog eggs and tadpoles). Abbreviations: Temperature Co– T; Dissolved Oxygen – DO; Salinity% – Sal%; Ephemeral waterbody – Eph.

Date	Stage	Pond	T	DO	Sal %	pH	Depth	Eph	Bred 2015	Dipnet
26/09/2015	1	1 (1-1)	17.2	15.3	1.92	8.47	1.4			*Gambusia*
26/09/2015	1	2 (1-2)	16.4	11.26	1.06	7.47	0.2			*Gambusia*
26/09/2015	1	3 (1-3)	16	13.24	1.28	7.85	0.4			*Gambusia*
26/09/2015	1	1b (1-4)	17.6	12.22	1.8	8.27	1.0			*Gambusia*
26/09/2015	1	1a (1-5)	16.6	12.18	1.71	8.19	0.0			1 *Lim peroni* tad
3/10/2015	2	4a (2-1)	22.6	9.6	1.76	7.64	0.2			*Gambusia*
3/10/2015	2	4 (2-2)	22.7	8.08	1.63	5.59	1.4			*Gambusia*
3/10/2015	2	4b (2-3)	24.1	7.25	1.52	5.86	0.4			large fish, *Gambusia*
3/10/2015	2	4d (2-4)	23.7	7.59	1.37	6.07	0.2			0
3/10/2015	2	4c (2-5)	23.6	10.47	1.3	6.26	1.4			*Gambusia*
26/09/2015	3	5 (3-3)	17.9	11.98	1.74	9.13	1.4			1 *Crinia signifera* tad, *Gambusia*
26/09/2015	3	5a (3-1, 3-2)	16.6	15.66	1.76	9.38	0.4			*Gambusia*
26/09/2015	3	5b (3-4)	17.6	13.92	1.7	9.3	0.2			*Gambusia*
26/09/2015	3	5c (3-5)	19	9.84	0.66	7.65	0.2			0
3/10/2015	4	11 (4-11)	23.2	16.31	3.69	8.05	1.0			*Gambusia*
3/10/2015	4	10 (4-10)	23.1	8.44	1.77	7.75	0.4			*Gambusia*
3/10/2015	4	9 (4-9)	22.4	9.11	2.23	7.43	0.2			0
3/10/2015	4	8 (4-8)	23.7	8.65	0.44	7.22	1.0			*Gambusia*
3/10/2015	4	7b (4-7)	23.1	9	0.16	6.14	0			*Gambusia*
3/10/2015	4	7a (4-6)	22.1	7.32	0.16	5.8	0.2			*Gambusia*
3/10/2015	4	7 (4-7)	23.6	9.13	0.16	6.14	0.6			0
3/10/2015	4	6c (4-3)	23.5	16.48	0.34	7.28	1.2			0
3/10/2015	4	6 (4-3)	23.2	12.73	0.34	6.79	1.2			*Gambusia*
3/10/2015	4	6b (4-2)	23.9	11.27	0.32	6.81	0.2			*Gambusia*
3/10/2015	4	6a (4-1)	23.4	10.02	0.32	6.42	0.8			*Gambusia*
4/10/2015	5	15e (5-5)	22.8	11.19	0.24	6.43	0.0			0
4/10/2015	5	15f (5-7)	23.3	11.06	0.3	6.31	0.0			0
4/10/2015	5	15g (5-6)	20.3	9.61	0.3	7.79	0.0			1 *Lim peroni* tad
4/10/2015	5	15h (5-8)	23.3	10.12	0.3	6.33	0.6			big fish
4/10/2015	5	16a (5-3)	20.6	10.02	0.15	8.01	0.2			0
4/10/2015	5	16b (5-4)	21.8	8.07	0.15	7.65	0.2			1 *Lim peroni* tad
4/10/2015	5	16c (5-2)	24.3	8.23	0.13	7.66	0.3			0
4/10/2015	5	16d(5-1)	25	8.3	0.12	7.94	0.4			0
5/10/2015	6	13 (6-4)	24.3	8.51	0.32	5.39	1.2			0

5/10/2015	6	12 (6-6)	24.5	8.23	0.21	7.57	0.2			0
5/10/2015	6	13a (6-4)	22.7	11.92	0.31	7.42	0.2			0
5/10/2015	6	14 (6-1)	25.1	11.32	0.21	4.73	0.4			*Gambusia*
5/10/2015	6	14a (6-2)					0.2			
5/10/2015	7	17 (7-1)	23.6	11.89	1.99	9.61	0.4			*Gambusia*
5/10/2015	7	17a (7-2)	23.4	8.38	2.01	8.7	0			*Gambusia*
5/10/2015	7	18 (7-3)	24.3	10.19	2.04	8.39	0.2			4 *Gambusia*

Table 2. Observation and capture details of Green and Golden Bell Frogs on the western end of Kooragang Island in the NCIG Compensatory Habitat and nearby wetlands. Wetlands adjacent to compensatory habitat highlighted.

Date	Pond	Sex	Calling	RECAP	PIT TAG	Easting	Northing	Weight (g)	SVL mm
8/1/2016	5.1	M	Y	N	956000003468888	378729	6365316	14.5	53.7
8/1/2016	5.1	M	Y	N	956000003445115	378729	6365316	21.5	53.1
8/1/2016	K27	M	Y	N	00078A9172	378651	6365054	21	58.1
11/1/2016	4.11	M	N	N	9000108001466693	379298	6365128	26.1	61.4
11/1/2016	4.11	M	Y	N	900108001466692	379295	6365128	25.9	60.9
11/1/2016	4.4	M	Y	N	900108001466734	378820	6365638	24.5	59.3
11/1/2016	5.1	M	Y	Y	956000003468888	378728	6365300		
11/1/2016	5.1	M	N	Y	956000003445115	378728	6365300		
13/1/2016	4.1	F	N	N	108001466678	378723	6365676	24	51.4
13/1/2016	7.1	F	N	N	108001466671	378552	6365104	21.3	60.9
13/1/2016	7.1	M	Y	N	108001466675	378631	6365032	16	56.7
13/1/2016	7.1	M	Y	N	108001466727	378631	6365027	28	58.9
13/1/2016	7.1	M	Y	N	108001466682	378634	6365018	17	58.7
13/1/2016	7.2	F	N	N	00078A9367	378676	6364971	25.5	60.8
13/1/2016	7.2	M	Y	N	108001466716	378676	6364971	23.5	55.8
13/1/2016	K27	M	Y	N	108001466687	378626	6365078	10.5	54.3
13/1/2016	K27	M	Y	N	108001466699	378641	6365067	18.1	59.3
13/1/2016	K27	M	Y	N	108001466703	378641	6365058	14.1	59.2
15/2/2016	5.1	J	N	N		378746	6365267	6.9	22.3
15/2/2016	5.1	J	N	N		328739	6365262	5.7	21.8
15/2/2016	5.1	J	N	N		378744	6366266	7.8	23.5
15/2/2016	5.1	J	N	N		378743	6365325	5.1	29.4
15/2/2016	5.1	J	N	N		378747	6365229	8.5	27.88
15/2/2016	5.1	J	N	N		378747	6365229	1.8	19.66
15/2/2016	5.1	J	N	N		378740	6365235	5.6	26.25
15/2/2016	5.1	J	N	N		378761	6365234	4.1	22.94
15/2/2016	5.1	J	N	N		378764	6365250	2.2	21.3
15/2/2016	5.1	J	N	N		378718	6365248	4.2	24.8
15/2/2016	5.1	J	N	N		378718	6365248	9	26.6
15/2/2016	5.3	J	N	N		378691	6365279	4.7	24.67
15/2/2016	5.3	J	N	N		378691	6365285	5.5	21.3

15/2/2016	5.3	J	N	N		378702	6365293	6.5	26.4
15/2/2016	5.3	J	N	N		378702	6365293	5.9	26.4
15/2/2016	5.3	J	N	N		378702	6365285	2.2	25.8
15/2/2016	5.3	J	N	N		378701	6365281	4.8	15.9
15/2/2016	5.4	J	N	N		6378714	6365302	4	21.41
15/2/2016	5.4	J	N	N		6378707	6365302	3.8	28.9
15/2/2016	5.4	M	N	N	108001466478	6378714	6365302	4	56.5
15/2/2016	5.5	J	N	N		378691	6365277	6.3	24.85
15/2/2016	5.6	F	N	N	000791EA89	378660	636530	35	77.3
15/2/2016	5.8	F	N	N	000792067D	378661	6365416	34	74.3
15/2/2016	5.8	J	N	N		378675	6365409	5.5	28.7
15/2/2016	5.8	M	N	N	000791E8C1	378653	6365416	17.5	60
15/2/2016	5.8	M	N	N	000791E8DD	378651	6365417	12	45.95
15/2/2016	5.8		N	N		378658	6365389		
15/2/2016	5.8		N	N		378658	6365389		
16/2/2016	3.1	F	N	N	00079206C1	378973	6366264	34.00	69.12
16/2/2016	3.4	J	N	N		378981	6366161	2.00	21.62
16/2/2016	3.4	J	N	N		378981	6366156	1.00	11.52
16/2/2016	7.1	M	Y	N	00078A90E2	378624	6365018	19.00	58.89
16/2/2016	7.1	M	N	N	00078A9082	378632	6365012	4.00	30.86
16/2/2016	7.3	F	N	N	00078A8FFE	378682	6364976	37.00	73.70
16/2/2016	7.3		N	N	00078A92C9	378674	6364968	23.00	59.50
16/2/2016	K27	J	N	N	00078A92DE	378672	6365046	14	54.5
16/2/2016	K27	MET	N	N		378672	6365046	7	28
16/2/2016	K27	MET	N	N		378672	6365046	2.7	29.7
16/2/2016	K27	MET	N	N		378672	6365046	3.7	26.2
17/2/2016	6.1	J	N	N		378493	6365361		
17/2/2016	6.1	MET	N	N		15142131	3250634	3	27.9
22/2/2016	4.10	F	N	Y	000791E977	379210	6365179	20.5	59.12
22/2/2016	4.10	M	N	N	00078A91EB	379238	6365172	18	54.1
22/2/2016	4.10	M	N	N	108001466639	379213	6365179		

Table 3. Observation of habitat use and association of Green and Golden Bell Frogs on the western end of Kooragang Island in the NCIG Compensatory Habitat and nearby wetlands.

Date	Pond	Sex	Calling	Easting	Northing	Habitat	Height from water (mm)	Distance from edge (mm)
8/1/2016	5.1	M	Y	378729	6365316	Pasp dial, water	0	0
8/1/2016	5.1	M	Y	378729	6365316	Pasp dial, water	0	0

8/1/2016	K27	M	Y	378651	6365054	Sprob, Sarcro	0	0
11/1/2016	4.11	M	N	379298	6365128	Bolb,Typha	30	0
11/1/2016	4.11	M	Y	379295	6365128	Typha	2	1.5
11/1/2016	4.4	M	Y	378820	6365638	Pasp dial, water	0	0
11/1/2016	5.1	M	Y	378728	6365300	Pasp dial, water	0	0
11/1/2016	5.1	M	N	378728	6365300	Pasp dial, water	0	0
13/1/2016	4.1	F	N	378723	6365676	Cynodon, Juncus usitatus	0	1
13/1/2016	7.1	F	N	378552	6365104	Typha	130	30
13/1/2016	7.1	M	Y	378631	6365032	Cynodon, Juncus usitatus	0	0
13/1/2016	7.1	M	Y	378631	6365027	Cynodon, Juncus usitatus	0	0
13/1/2016	7.1	M	Y	378634	6365018	Cynodon, Juncus usitatus	0	0
13/1/2016	7.2	F	N	378676	6364971	Typha	50	0
13/1/2016	7.2	M	Y	378676	6364971	Typha	80	0
13/1/2016	K27	M	Y	378626	6365078	Sprob, Sarcro	0	0
13/1/2016	K27	M	Y	378641	6365067	Sprob, Sarcro	0	0
13/1/2016	K27	M	Y	378641	6365058	Sprob, Sarcro	0	0
15/2/2016	5.1	J	N	378746	6365267	Carex app	5	1.5
15/2/2016	5.1	J	N	328739	6365262	Carex app	0	0.5
15/2/2016	5.1	J	N	378744	6366266	Pasp dial, pen clad	20	0.5
15/2/2016	5.1	J	N	378743	6365325	Pasp dial, pen clad	0	1
15/2/2016	5.1	J	N	378747	6365229	Pasp dial, water	0	0
15/2/2016	5.1	J	N	378747	6365229	Pasp dial, water	0	0
15/2/2016	5.1	J	N	378740	6365235	Pasp dial, water	0	0
15/2/2016	5.1	J	N	378761	6365234	Pasp dial, water	0	5
15/2/2016	5.1	J	N	378764	6365250	Pasp dial, water	5	5
15/2/2016	5.1	J	N	378718	6365248	Pasp dial, water	0	0.5
15/2/2016	5.1	J	N	378718	6365248	Pasp dial, water	5	0.5
15/2/2016	5.3	J	N	378691	6365279	Pasp dial, water	10	1
15/2/2016	5.3	J	N	378691	6365285	Pasp dial, water	10	1
15/2/2016	5.3	J	N	378702	6365293	Pasp dial, water	10	1
15/2/2016	5.3	J	N	378702	6365293	Pasp dial, water	10	1
15/2/2016	5.3	J	N	378702	6365285	Pasp dial, water	10	1
15/2/2016	5.3	J	N	378701	6365281	Pasp dial, water	10	1
15/2/2016	5.4	J	N	6378714	6365302	open water	0	0
15/2/2016	5.4	J	N	6378707	6365302	open water	0	
15/2/2016	5.4	M	N	6378714	6365302	open water	0	
15/2/2016	5.5	J	N	378691	6365277	Pasp dial, water	10	1
15/2/2016	5.6	F	N	378660	636530	Typha	100	3
15/2/2016	5.8	F	N	378661	6365416	Typha	100	0
15/2/2016	5.8	J	N	378675	6365409	Pasp dial, water	0	1.2
15/2/2016	5.8	M	N	378653	6365416	Typha	100	0
15/2/2016	5.8	M	N	378651	6365417	Typha	120	0

15/2/2016	5.8		N	378658	6365389	Pasp dial, water	0	2
15/2/2016	5.8		N	378658	6365389	Pasp dial, water	0	2
16/2/2016	3.1	F	N	378973	6366264	Kikuyu	30.00	250.00
16/2/2016	3.40	J	N	378981	6366161	open water	0.00	500.00
16/2/2016	3.40	J	N	378981	6366156	open water	0.00	300.00
16/2/2016	7.10	M	Y	378624	6365018	Kikuyu	600.00	1500.00
16/2/2016	7.10	M	N	378632	6365012	Rock	0.00	100.00
16/2/2016	7.3	F	N	378682	6364976	open water		1000.00
16/2/2016	7.3		N	378674	6364968	open water	300.00	1000.00
16/2/2016	K27	J	N	378672	6365046	Sitting on algae	0	0
16/2/2016	K27	MET	N	378672	6365046	Sitting on algae	0	0
16/2/2016	K27	MET	N	378672	6365046	Sitting on algae	0	0
16/2/2016	K27	MET	N	378672	6365046	Sitting on algae	0	0
17/2/2016	6.1	J	N	378493	6365361	cyp.	5	2
17/2/2016	6.1	MET	N	15142131	3250634	Kikuyu	0.4	0
22/2/2016	4.10	F	N	379210	6365179	Typha	100	0
22/2/2016	4.10	M	N	379238	6365172	Junc usitat	15	2
22/2/2016	4.10	M	N	379213	6365179	Typha	105	0

Releases of captive bred bell frog tadpoles and metamorphs into NCIG Compensatory Habitat, Ash Island, during the period of October 2015 to March 2016. The bell frog progeny released were produced from the captive breeding colony maintained at the University of Newcastle. The captive colony is entirely derived from bell frogs collected from Kooragang Island under licence from NSW NPWS. See also previous Quarterly Report (NCIG Bell Frog Release and Monitoring, Quarterly Report, April 2016).

Table 4 Numbers of green and golden bell frog (L. aurea) metamorphs released into NCIG compensatory habitat October 2015 - March 2016. VIE = implanted with coloured VIE markers. VIE colours indicated for stages: R (red); Pnk (pink); Grn (green); Purp (purple); Orange (Org); Yell (yellow). Total metamorphs released = 3780. Metamorphs produced from L. aurea breeding colony at the University of Newcastle.

Metamorphs														
	Stage 1	Stage 1	Stage 2	Stage 2	Stage 3	Stage 3	Stage 4	Stage 4	Stage 5	Stage 5	Stage 6	Stage 6	Stage 7	Stage 7
	VIE Red	No VIE	VIE R/Pnk	No VIE	VIE Grn	No VIE	VIE Purp	No VIE	VIE Pnk	No VIE	VIE Org	No VIE	VIE Yell	No VIE
2015-Oct														
2015-Nov														
2015-Dec										1090				
2016-Jan		896			201		306		403				312	
2016-Feb	208		35		54						275			
2016-Mar														

Table 5 Numbers of green and golden bell frog (L. aurea) tadpoles and metamorphs released into NCIG Compensatory Habitat from October 2015 – March 2016. Tadpoles produced from L. aurea breeding colony at the University of Newcastle.

	Tadpoles	Tadpoles	Metamorphs (All Stages)	Total
	Stage 4	Stage 5		
2015-Oct	400			400
2015-Nov		150		150
2015-Dec		3514	1090	4604
2016-Jan		1050	2118	3168
2016-Feb		745	572	1317
2016-Mar		1079		1079
Total	400	6538	3780	10718

Appendix B – NCIG GGBF Compensatory Habitat Project, Monitoring and Maintenance Report, May 2016 (Wetland Care Australia).

NCIG GGBF Compensatory Habitat Project

Monitoring and Maintenance Report

May 2016

Version	Author	Date
1	T.Mouton	31/05/2016

WetlandCare Australia
44 Bishopsgate Street
Wickham NSW 2293

Introduction

The Newcastle Coal and Infrastructure Group (NCIG) developed a 78ha Compensatory Habitat and Ecological Monitoring Program (CHEMP), to offset areas lost as a result of the NCIG CET. The compensatory habitat comprises 18 constructed ponds. WetlandCare Australia has prepared a Green and Golden Bell Compensatory Habitat Management Plan (GGBF CHMP) based on requirements contained in the CHEMP, which sets out the methodology of site management and monitoring requirements for the ponds. The GGBF CHMP has been approved by the Office of Environment and Heritage, and forms part of the NCIG project approval. This monitoring report contains a monthly summary of site works and monitoring results undertaken as part of the GGBF CHMP.

Works Undertaken

The program of monitoring and maintenance continued throughout April and May 2016. The following works were undertaken this period:

Monitoring

- Pond inspections and monitoring, involving:
    - Visual inspection of pond condition and structure
    - Water quality monitoring
    - Monitoring for evidence of pest species (feral animals and noxious weeds)

  Results from these inspections and management recommendations are contained in Appendix A.

Maintenance

- Slashing around the frog fence in Stage 1, and weed sweep through licence areas targeting priority weeds was undertaken in during May.

Appendix B contains the schedule of works undertaken during May, and works forecast for the following month in June. Appendix C contains details of target weed control areas.

Key Outcomes

Monitoring

<u>Water Quality</u>

- Salinity (Target range < 4 ppt tadpoles; < 6 ppt frogs)
    - All ponds were within the acceptable salinity range for tadpoles and frogs.
    - Pond Salinity ranged from 0.12 – 3.48 ppt
- pH (Target range 4-9)
    - All ponds were within the acceptable pH range for tadpoles and frogs.
    - Pond pH ranged 7.63 – 8.58.
- DO (Target range 4-17)
    - All ponds were within the acceptable DO range for tadpoles and frogs.
    - Pond DO ranged 4.03 – 10.58 mg/L. (See note in Appendix A regarding low reading in northern section of Pond 4)
- Depth
    - Water levels have remained relatively stable from previous monitoring
- Temperature (Target range 16-31^{0}C tadpoles; 4-35^{0}C frogs)

- Water temperature dropped in all ponds due to cooler conditions, however were within the temperature target range

Pest Species

- Gambusia were observed in 14/18 ponds.
- Visibility was poor in a number of ponds due to dark stained and/or turbid water, which made detection of Gambusia difficult. No Gambusia were observed in Ponds 4, 10, 17 due to poor visibility, however given previous results it is likely they are still present.
- Visibility in Pond 15 was ok, which was observed to be Gambusia free.
- A more comprehensive weed survey was undertaken during monitoring this period, in order to inform programmed weed control works. This survey covered areas outside the direct vicinity of ponds, within the broader licence areas. A number of small infestations of Alligator Weed, Juncus acutus, Blackberry, and Lantana were observed. These infestations are recorded in Appendix C, and have been targeted during spraying conducted in May.
- Fox activity increased since previous monitoring, with prints and/or scats recorded at 7/18 ponds (Stages 3, 4, 5, 6), compared to 1/18 in the previous period.

Other Observations

- Azolla was observed covering approximately 80% of the open water surface of the northern section of Pond 4.
- *Casuarina glauca* regrowth was observed within the buffer of Pond 18.
- Ponds 2, 5a, and 18 are nearing the upper limit of emergent vegetation coverage.

Maintenance

- Slashing 1m from the frog fence in Stage 1 was undertaken.
- Weed control was undertaken throughout NCIG licence areas, targeting weeds as detailed in Appendix C. Weeds targeted include Alligator Weed, Sharp Rush, Blackberry, and Lantana.

Discussion & Recommendations

The region has experienced prevailing dry conditions over the last month, however pond levels have remained relatively stable. Water quality results improved significantly during this period, with all parameters falling within acceptable limits. Dissolved oxygen levels showed particular improvement in a number of ponds compared to previous monitoring. This may be a result of dropping water temperatures in the ponds, which increases the solubility of oxygen, and reduction in organic decay.

One anomaly in the water quality results was in the northern section of Pond 4, which produced a low DO reading of 0.58 compared to 7.9 in the southern pond. The northern section is dominated by native aquatic vegetation (*Ceratophyllum demersum* – Hornwort and Azolla). This is potentially impacting DO concentrations due to over consumption of oxygen by plant respiration. Thinning of these aquatic species may be required to reduce BOD in this pond.

Casuarina glauca regrowth within the buffer of Pond 18 has been removed during weed control in May. Ponds 2, 5a, and 18 have reached the upper limit of emergent vegetation coverage (70%), predominantly *Typha sp*, and will require thinning prior to warmer months.

Fox activity has increased within pond stages. Numbers may be on the rise again as ground baiting has not been undertaken since December 2015, 5 months ago. Fox baiting should recommence as soon as practicable once this stage of monitoring has been completed at the end of June.

Appendix A – Monitoring Results

Date	10 May 2016
Breeding Season (Oct-Dec)?	Yes / **No**
Name of Inspector/s	Tim Mouton, Trent Neilson
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds
WEATHER	Warm/Sunny
Temperature	23.2
Total rainfall over preceding 3 days	0.4 mm
Total rainfall over preceding month	3.6 mm

WATER QUALITY INSPECTION

Parameter	**Target Range**	**1**	**2**	**3**	**4**	**5A**	**5B**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Target Condition	Permanent ponds wet	**Wet**			**Wet**	**Wet**	**Wet**	**Wet**		**Wet**			**Wet**		**Wet**			**Wet**		
Wet/Dry		Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet	Wet
Design Depth m		1.4	0.2	0.4	1.4	1.4		1.2	0.6	1.0	0.2	0.4	1.0	0.2	1.2	0.4	0.6	2.2	0.4	0.2
Measured Depth m		1.5+	0.5	1.2	0.5	0.5	1.5+	1.5+	1.4	1.4	1.1	0.9	1.4	1.2	1.5+	1.15	0.4	1.5+	1.1	0.6
Temp ^{0}C	T: 16-31 F: 4-35	19.5	19.3	19.1	17.1	23.1	19.6	18.9	18.6	18.8	19.1	18.2	18.7	17.2	17.9	17.0	17.2	18.0	17.2	16.6
pH	4-9	8.03	7.80	7.88	7.65	8.26	8.38	7.76	7.89	7.98	8.13	8.02	7.74	7.72	8.00	8.30	7.96	7.63	8.58	7.76
Salinity uS/cm		1436	1449	1655	2226	447	1666	377	195	473	1097	1182	5433	281	329	419	187	337	1422	2687
Salinity ppt	T < 4 F < 6	0.92	0.93	1.06	1.42	0.29	1.07	0.24	0.12	0.30	0.70	0.76	3.48	0.18	0.21	0.27	0.12	0.22	0.91	1.72
DO mg/L	4-17	4.03	7.53	4.75	0.58 /7.90	9.29	9.55	6.72	8.79	7.74	7.04	7.96	6.45	6.81	4.18	5.80	10.58	5.71	4.61	4.48
Turbidity NTU	Not critical	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% Open Water	Min. 30% Max 70%	75	30	80	65	30	80	60	75	100	100	80	70	85	60	60	75	75	95	30
Meets all Targets	Y / N	N	Y	N	Y	Y	N	Y	N	N	N	N	Y	N	Y	Y	N	N	N	Y

Notes: The northern section of Pond 4 showed a low DO reading of 0.58 compared to 7.9 in the southern pond. The northern section is dominated by native aquatic vegetation (*Ceratophyllum demersum* – Hornwort). This is potentially impacting DO concentrations due to over consumption of oxygen by plant respiration.

☞ **See Over**

WATER QUALITY ACTION				
POND	**Action Required**	**Due Date**	**Completion Date**	**Signed**
1,3,5b,7,8,9,10, 12,15,16,17	Ponds are above the maximum acceptable level of open water percentage. This can be addressed by additional macrophyte planting	Ongoing		
4	The northern section of Pond 4 showed a low DO reading of 0.58 compared to 7.9 in the southern pond. The northern section is dominated by native aquatic vegetation (*Ceratophyllum demersum* – Hornwort and Azolla). This is potentially impacting DO concentrations due to over consumption of oxygen by plant respiration. Thinning of these aquatic species may be required to reduce BOD in this pond.	Ongoing		
	Other Observations			
General	Water levels have remained steady with minor fluctuations.			

NB: All vegetation work eg. removing macrophytes/in-fill planting should be recorded on the Vegetation Inspection Sheet

Date	Breeding Season (Oct-Dec) Yes / **No**		Name of inspector/s Tim Mouton, Trent Neilson		
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds				
POND STUCTURE INSPECTION					
POND	**Is there evidence of leakage?**	**Is there evidence of erosion/sedimentation?**	**Action Required?**	**Define action**	**Date Complete**
1.	No	No	No		
2.	No	No	No		
3.	No	No	No		
4.	No	No	No		
5.	No	No	No		
6.	No	No	No		
7.	No	No	No		
8.	No	No	No		
9.	No	No	No		
10.	No	No	No		
11.	No	No	No		
12.	No	No	No		
13.	No	No	No		
14.	No	No	No		
15.	No	No	No		
16.	No	No	No		
17.	No	No	No		
18.	No	No	No		

All Actions Complete: Signed ________________ Date ________

Date	Breeding Season (Oct-Dec) Yes / **No**	Name of inspector/s Tim Mouton, Trent Neilson				
Site	**NCIG Ponds** / KWRP Ponds / Research Ponds					
POND NATIVE VEGETATION INSPECTION						
POND	**Emergent Vegetation % Cover of water body**	**Emergent Vegetation Density**	**Emergent vegetation Condition**	**Buffer Width**	**Buffer Density (Weed + Native)**	**Buffer Density (Native) %**
Target	**40-70% Cover of water body**	**> 50%**	**Good**	**1.5 m**	**> 50% total veg cover**	**> 50% native cover**
1.	25% Macrophyte	60	Very Good			
2.	70% Macrophyte	70	Very Good			
3.	20% Macrophyte	10	Average			
4.	35% Macrophyte	70	Good			
5A.	70% Macrophyte	40	Good			
5B.	15-20% Macrophyte	30	Average			
6.	30-40% Macrophyte	50	Good			
7.	20-25% Macrophyte	0	Average			
8.	0% Macrophyte	0	Very Poor			
9.	0% Macrophyte	0	Very Poor			
10.	20% Macrophyte	85	Very Good			
11.	30-40% Macrophyte	50	Very Good			
12.	15% Macrophyte	60	Average			
13.	40-50% Macrophyte	70	Very Good			
14.	40% Macrophyte	70	Very Good			
15.	25% Macrophyte	20	Good			
16.	20-25% Macrophyte	30	Good			
17.	5% Macrophyte	0	Very Poor			
18.	70% Macrophyte	60	Good			
Notes	Moderate increases in macrophyte densities were observed in the majority of ponds, in particular *Typha sp.* Ponds 2, 5a, and 18 are nearing the upper limit of emergent vegetation coverage, and may require management of *Typha sp.* should densities continue to increase. The northern section of Pond 4 was observed to contain an abundance of native aquatic vegetation (*Ceratophyllum demersum* – Hornwort and Azolla). *Casuarina glauca* regrowth was observed within the buffer of Pond 18.					

POND NATIVE VEGETATION ACTION REQUIRED			
POND	**Action Required**	**Due Date**	**Completion Date**
7, 8, 9, 17	Additional planting of macrophytes should be undertaken, within buffers and pond banks, within ponds showing poor growth and recruitment of macrophytes.	Ongoing	
2, 5a, 18	Ponds are nearing the upper limit of macrophyte growth and will require culling of Typha prior to warmer months.	September 2016	
18	Casuarina glauca regrowth is also present within the pond buffer which requires removal.	May 2016	May 2016

COMMENTS:

All Actions Complete: Signed _________________ Date ________

WEEDS	Alligator Weed Density Class	Juncus acutus Density Class	Blackberry Density Class	Action Required	Date Action Complete
POND				**See Maintenance Guidelines in NCIG GGBF CH POM**	
General				**Priority weeds requiring control, as detailed below, are mapped in Appendix C**	
1.					
2.		2		Scattered tussocks to the north and south of Stage 1	May 2016
3.					
4.	3	2		1 small tussock present at western extent of pond Moderate Alligator Weed infestation on the northern extent of Stage 4, looks to have been previously sprayed, possibly by NPWS	
5.	2			1 small patch on pond bank. This infestation has previously been sprayed and observed to be resprouting. Scattered tussocks of Juncus present over the eastern bund	May 2016
6.					
7.					
8.	2			Small patch of Blackberry was observed adjacent to rock cobble on western bank.	May 2016
9.					
10.			2	Patch of Blackberry on the eastern side of access track, between Ponds 9 and 10	May 2016
11.					
12.					
13.					
14.					
15.					
16.					
17.		3		Moderate infestation of Juncus present on the northern boundary of Stage 7 Patch of Lantana present to the south of Pond 17	May 2016
18.					

NB: Weed Density Classes. Class 2 = less than 1%. Class 3 = 1-10%. Class 4 = 11-50%. Class 5 > 50% **Actions Complete:** Signed _______________ Date ________

PREDATOR INSPECTION					
	Gambusia	Fox Evidence	Action Required	Action Required	Date Complete
POND	Yes/No	scats/prints/kills	Y/N		
1.	Yes	No		Gambusia dominant	
2.	Yes	No		Gambusia dominant	
3.	Yes	No		Gambusia dominant	
4.	No	No		Very poor visibility, potentially still present	
5.	Yes	Yes (tracks)		Gambusia moderate	
6.	Yes	No		Gambusia dominant	
7.	Yes	Yes (tracks)		Gambusia sparse (poor visibility)	
8.	Yes	Yes (scat)		Gambusia dominant	
9.	Yes	Yes (tracks)		Gambusia sparse (poor visibility)	
10.	No	No		Very poor visibility, potentially still present	
11.	Yes	No		Gambusia dominant	
12.	Yes	Yes (tracks)		Gambusia sparse (poor visibility)	
13.	Yes	Yes (tracks)		Gambusia dominant	
14.	Yes	No		Gambusia moderate	
15.	No	Yes (tracks)			
16.	Yes	No		Gambusia moderate	
17.	No	No		Very poor visibility, potentially still present	
18.	Yes	Yes		Gambusia very dominant	

Actions Complete: Signed ________________ Date ________

Appendix B – Works Program

	Timeline								
	Month	May				June			
	Week	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4
Projects	Task								
NCIG	Fox baiting								
	Alligator Weed spraying								
	Monitoring								
	Macrophyte buffer weeding								
	Slashing tracks & frog fence								
	Weeding sweep through site								

Appendix C – Weed Control Areas

Appendix C – NCIG Shorebird Compensatory Habitat Monitoring (Kleinfelder Consulting)

Swan Pond and Fish Fry Flats Bird Monitoring Report

Newcastle Coal Infrastructure Group

Migratory Shorebird Habitat Establishment
Ash Island, NSW

23 June 2016

Swan Pond and Fish Fry Flats Bird Monitoring Report

Migratory Shorebird Habitat Establishment

Ash Island, NSW

Kleinfelder Document Number: NCA16R42496
Project No: 20170226

Prepared for:

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Document Control:

Version	Description	Date	Author	Technical Reviewer	Peer Reviewer
1.0	Draft for client review	23 June 2016	F. Rainsford	L. Foster	C. Evans

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1. INTRODUCTION

Newcastle Coal Infrastructure Group (NCIG) are undertaking the establishment of compensatory habitat for migratory shorebirds at Ash Island, NSW. The establishment of the shorebird habitat is a condition stipulated under the *Environment Planning and Assessment Act 1979* (EP&A Act) for the NCIG Coal Export Terminal (CET) Project approval (06_0009) brought about by the NCIG CET High Capacity Optional Inlet Rail Spur and Rail Sidings (Northern Rail Spur) and the Rail Flyover Modification.

Kleinfelder was engaged by NCIG to monitor bird activity at Swan Pond and Fish Fry Flats during the mangrove removal works to determine if the activity is having a negative impact on birds within the immediate area.

2. METHODS

Bird counts were undertaken one morning per week by a qualified ecologist following the ecological pre-clearance inspections of the mangroves within the mangrove removal area. Bird counts commenced for half an hour between 7:00 am and 10:00 am. All birds observed foraging or roosting on the water, ground, or in trees, or flying over or Swan Pond and Fish Fry Flats were recorded.

2.1 WEATHER CONDITIONS

Weather conditions during survey events are provided in **Table 1** below.

Table 1: Weather conditions during the survey period at Williamtown.

Date	Min temp (°C)	Max temp (°C)	Rainfall (mm)	RH (%) at 9:00 am	Wind Direction at 9:00 am	Wind Speed (Km\hr) at 9:00 am
02/05/16	13.4	24.8	2.6	84	Calm	Calm
10/05/16	17	23.4	0.2	53	NW	31
17/05/16	11.8	26.7	0	60	NW	19
24/05/16	9.4	21.2	0	42	WNW	31
01/06/16	10.5	19	10.6	93	NW	13
07/06/16	12	19.1	0	55	NW	17
15/06/16	7	21.1	0	85	NW	17
21/06/16	13.5	17.8	0	51	WNW	54

Source: Bureau of Meteorology 2016.

3. RESULTS

The number of individual birds counted at Swan Pond showed considerable variation from week to week (**Figure 1**). The total number of individuals recorded in the last three weeks was about half that recorded in the first three weeks of mangrove removal works, driven mainly by a reduction in the numbers of wading birds recorded. During the first three weeks of survey large numbers of Red-necked Avocets (*Recurvirostra novaehollandiae*) and Black-winged Stilts (*Himantopus himantopus*) were observed throughout Swan Pond.

A possible cause for the decline in the recorded numbers of wading birds is the timing of the survey. The availability of prey to wading birds is dependent on the tides, which will determine their distribution within the estuary. Surveys were conducted in the morning after conducting a pre-clearance inspection of the mangrove removal area, and not necessarily at the same tidal level. Therefore the lower numbers could be a result of survey times and foraging behaviour rather than disturbance caused by the activity. Additionally other factors such as strong winds and heavy rainfall in the region will also influence the distribution of waders within the estuary.

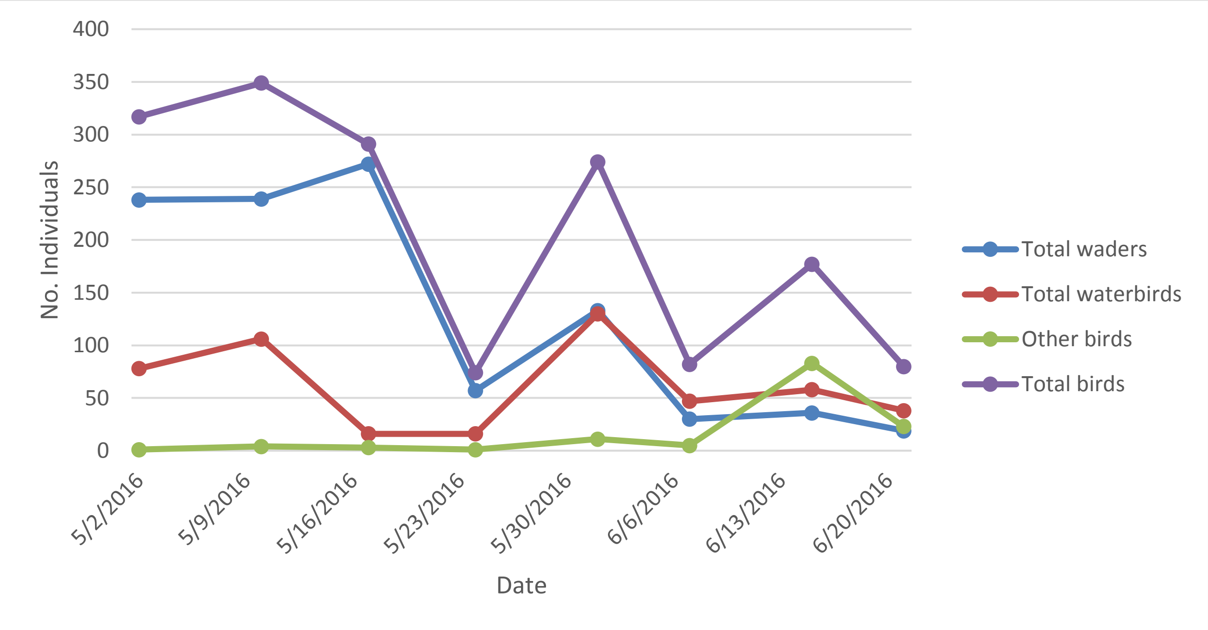


Figure 1. Number of individual waders, water birds and other species counted at Swan Pond during each monitoring event.

The number of individual birds counted at Fish Fry Flats also varied from week to week (**Figure 2**). No general pattern of decline can be seen in the Fish Fry Flats bird counts. However, after weeks of fluctuation, there was a decrease in the number of waterbirds recorded. This may be a result of the disturbance caused by mangrove removal works within the area. Continued monitoring will determine any long-term impacts resulting from the clearing activities.

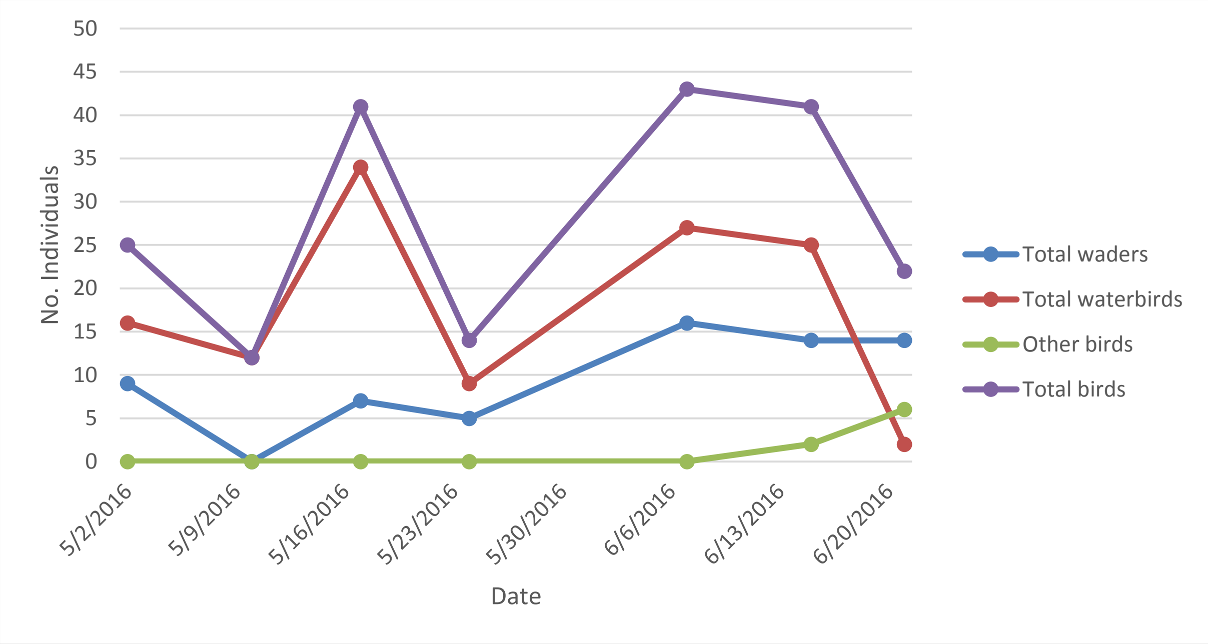


Figure 2. **Number of individual waders, water birds and other species counted at Fish Fry Flats during each monitoring event.**

The numbers of species observed each week at both Swan Pond (**Figure 3**) and Fish Fry Flats (**Figure 4**) remained generally constant, despite some slight variation.

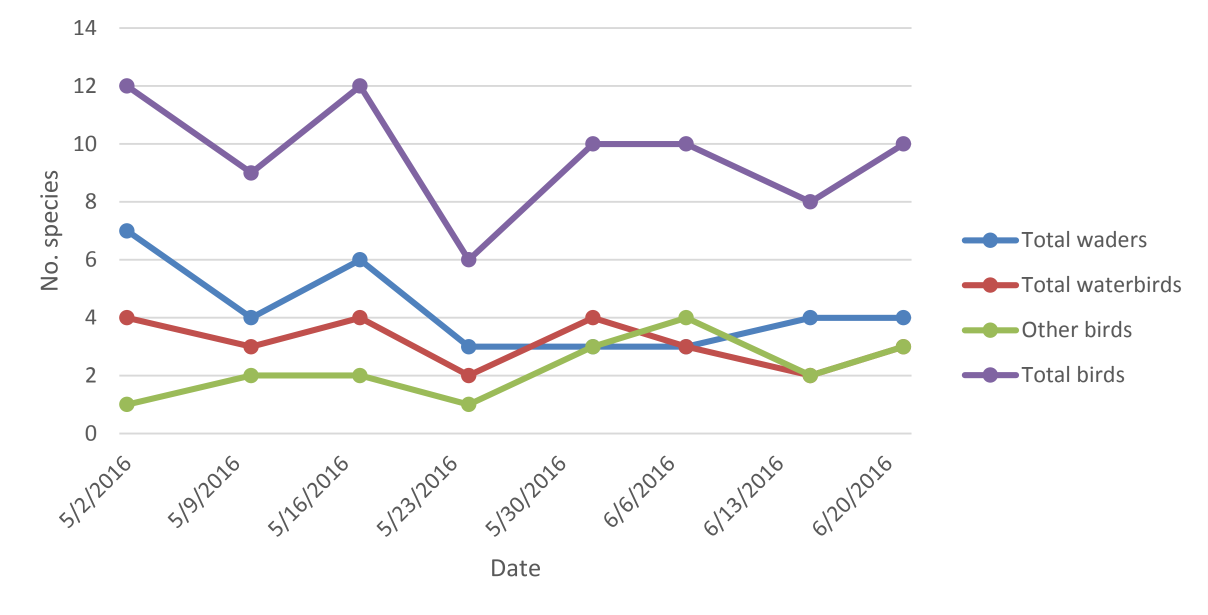


Figure 3. **Number of wader, waterbird and other species recorded at Swan Pond during each monitoring event.**

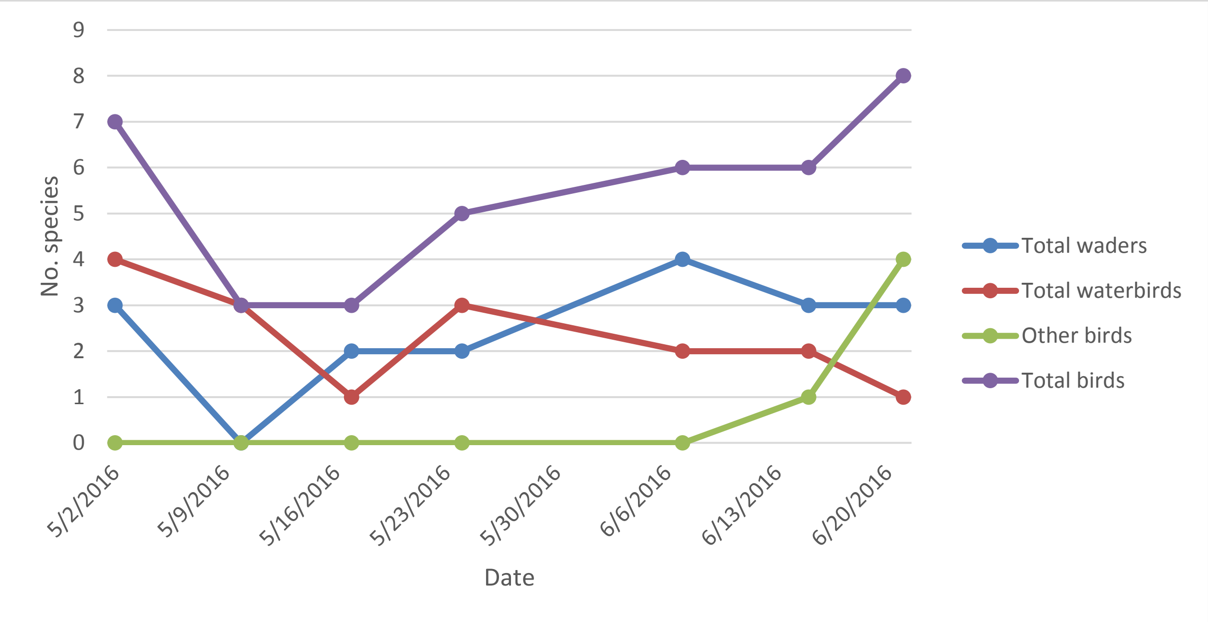


Figure 4. **Number of wader, waterbird and other species recorded at Fish Fry Flats during each monitoring event.**

A full species list and count of individuals for Swan Pond can be found in **Appendix 1**, and for Fish Fry Flats in **Appendix 2**.

4. MANAGEMENT RECOMMENDATIONS

Continued monitoring of bird activity within Swan Pond and Fish Fry Flats should continue throughout the duration of the mangrove removal works. Longer-term monitoring, as outlined in the Monitoring, Evaluation, Reporting and Improvement (MERI) Plan (Kleinfelder 2016), should determine the long-term impacts of the activity.

5. REFERENCES

Kleinfelder 2016. Monitoring, Evaluation, Reporting and Improvement (MERI) Plan for the Migratory Shorebird Habitat Establishment. Newcastle, NSW.

APPENDIX 1. BIRD COUNTS – SWAN POND

Family	Species Name	Common Name	02-05-16	10-05-16	17-05-16	24-05-16	01-06-16	07-06-16	15-06-16	21-06-16
Accipitridae	*Circus approximans*	Swamp Harrier						1		
Accipitridae	*Haliaeetus leucogaster*	White-bellied Sea-eagle	1							
Accipitridae	*Haliaeetus morphnoides*	Little Eagle		1						
Anatidae	*Anas castanea*	Chestnut Teal	64	93			53			
Anatidae	*Anas gracilis*	Grey Teal					65	29		
Anatidae	*Anas superciliosa*	Pacific Black Duck		4	3					
Anatidae	*Cygnus atratus*	Black Swan	6	9	5		8	17	52	24
Ardeidae	*Ardea ibis*	Cattle Egret								2
Ardeidae	*Ardea intermedia*	Intermediate Egret							1	2
Ardeidae	*Ardea modesta*	Eastern Great Egret	3		4	3				
Ardeidae	*Egretta novaehollandiae*	White-faced Heron	2		1			1	2	
Charadriidae	*Elseyornis melanops*	Black-fronted Dotterel	3		1					6
Charadriidae	*Vanellus miles*	Masked Lapwing	3	10	2	4	5	15	2	9
Columbidae	*Ocyphaps lophotes*	Crested Pigeon						2		
Corvidae	*Corvus coronoides*	Australian Raven						1		
Hirundinidae	*Hirundo neoxena*	Welcome Swallow					8		82	6
Laridae	*Chroicocephalus novaehollandiae*	Silver Gull								5
Laridae	*Gelochelidon nilotica*	Gull-billed Tern					4			

Family	Species Name	Common Name	02-05-16	10-05-16	17-05-16	24-05-16	01-06-16	07-06-16	15-06-16	21-06-16
Laridae	*Hydroprogne caspia*	Caspian Tern	2		1	4				
Monarchidae	*Grallina cyanoleuca*	Magpie-lark		3	1	1	2	1		
Motacillidae	*Anthus novaeseelandiae*	Australasian Pipit			2		1			2
Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican	6		7	12		1	6	9
Recurvirostridae	*Himantopus himantopus*	Black-winged Stilt	123	24	72	50	34	14	31	
Recurvirostridae	*Recurvirostra novaehollandiae*	Red-necked Avocet	80	201	192		94			
Sturnidae	*Sturnus vulgaris*	Common Starling							1	15
Threskiornithidae	*Platalea regia*	Royal Spoonbill	24							
Threskiornithidae	*Threskiornis spinicollis*	Straw-necked Ibis		4						

APPENDIX 2. BIRD COUNTS – FISH FRY FLATS

Family	Species Name	Common Name	02-05-16	10-05-16	17-05-16	24-05-16	07-06-16	15-06-16	21-06-16
Alcedinidae	*Ceyx azureus*	Azure Kingfisher							1
Anatidae	*Anas castanea*	Chestnut Teal	6	8	34		25	22	
Ardeidae	*Ardea intermedia*	Intermediate Egret							2
Ardeidae	*Ardea modesta*	Eastern Great Egret	1		4				
Ardeidae	*Ardea pacifica*	White-necked Heron						1	
Ardeidae	*Egretta garzetta*	Little Egret					2		
Ardeidae	*Egretta novaehollandiae*	White-faced Heron	1			1	4	6	6
Cacatuidae	*Calyptorhynchus funereus*	Yellow-tailed Black Cockatoo							2
Columbidae	*Geopelia striata*	Bar-shouldered Dove							1
Halcyonidae	*Todiramphus sanctus*	Sacred Kingfisher						2	
Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican	2			4			
Phalacrocoracidae	*Microcarbo melanoleucos*	Little Pied Cormorant	2	1		3	2	3	2
Phalacrocoracidae	*Phalacrocorax sulcirostris*	Little Black Cormorant	6	3		2			
Rhipiduridae	*Rhipidura albiscapa*	Grey Fantail							2
Threskiornithidae	*Platalea regia*	Royal Spoonbill			3		2		
Threskiornithidae	*Threskiornis moluccus*	Australian White Ibis				4	8	7	6
Threskiornithidae	*Threskiornis spinicollis*	Straw-necked Ibis	7						

APPENDIX 3. STAFF CONTRIBUTIONS

The following staff were involved in the compilation of this report.

Name	Qualification	Title/Experience	Contribution
Feach Moyle	BSc (Hons), ADAS	Principal Ecologist	Field surveys
Frederick Rainsford	BEnvSc & Mgt (Hons) GradCert Ornithology	Ecologist (Ornithologist)	Field surveys; report preparation
Luke Foster	BSc Env & Mgt MEnvSci&Mgt (Wildlife Ecology)	Ecologist (Mammologist)	Report review

APPENDIX 4. LICENSING

Kleinfelder employees involved in the current study are licensed or approved under the National Parks and Wildlife Act 1974 (License Number: SL100730, Expiry: 31 March 2017) and the Animal Research Act 1985 to harm/trap/release protected native fauna and to pick for identification purposes native flora and to undertake fauna surveys.

APPENDIX 6
GGBF ANNUAL REPORT ON 2015/16 FIELD SEASON ANNUAL POPULATION MONITORING PROGRAM FOR THE GREEN AND GOLDEN BELL FROG ON KOORAGANG ISLAND

Research Program on the Green and Golden Bell Frog (*Litoria aurea*) on Kooragang Island

Annual Report (2015-2016)

Conducted by the Amphibian Research Group, University of Newcastle, on behalf of *Port Waratah Coal Services, Newcastle Coal Infrastructure Group,* and *Hunter Development Corporation*

Report prepared by Colin McHenry, John Paul King, Bede Moses and Michael Mahony

October 2016

Summary points

1 Green and Golden Bell Frog population on Kooragang/Ash Island wetlands

- Standard 'whole island' surveys of 78 wetlands detected 539 GGBF. Robust modelling of survey results estimate with a high level of confidence that population size in these 78 wetlands is between 1,000 and 2,200 GGBF, with a likely range of 1,100 to 1,980. The best single figure estimate of population size in these wetlands is approximately 1,400 GGBF (although single figure estimates of population size omit the uncertainty in such estimates and should be treated with caution.
- Additional survey work at the NCIG Compensatory Habitat wetlands detected an extra 184 GGBF. These surveys employed a different methodology to the 'whole island' surveys and cannot be incorporated into the population estimate obtained by Robust Modelling. Nevertheless, they provide valuable information on the population of GGBF in the Northwestern part of the island.

2 Reproduction and habitat selected

- Breeding was recorded in seven of the 78 wetlands surveyed in the 'whole island' surveys. Breeding was observed in an additional two wetlands during other surveys during the season. In several cases the numbers of breeding pairs and the consequent number of tadpoles were large (K104 and K96), while in other cases only one or a few adult pairs were observed (K7A, K58B).
- Most breeding was associated with the large summer rainfall in early– to mid–January.
- It is notable that in six of the nine sites where breeding occurred involved brackish ephemeral wetland habitat. Surveys prior to the rainfall showed that these sites were dry, and not occupied by GGBF. Adult males and females migrated to these sites following the rain and the evidence is that they specifically selected these ephemeral sites over nearby permanent wetlands.
- Occupancy of wetlands by the GGBF is relatively high on KI/AI. GGBF were observed at 42 of the 78 wetlands surveyed indicating that the habitat quality of these wetlands are suitable to support the foraging and sheltering of the frog.

3 Distribution of GGBF are associated with habitat mosaics that include:

- Sheltered permanent wetlands (e.g. K22-23, K29, K108, K104). Note that, of these, only K108 is *Gambusia*-free. By sheltered here we are referring to the 'cells' in the Industrial Zone that are below the landscape surface, and which may have a localised microclimate (research in progress on these variables)
- Nearby brackish seasonal and/or ephemeral wetlands:
  - For K22-23, these may include K63, K50, K21.
  - For K29, these may include K106A, K106B, K106C.
  - For K108, these may include K111, K112, K113, K114.
  - For K104, these may include K104A, and the unnamed ephemeral wetlands by the side of the road along Pacific National Drive (northern half)
  - For NCIG wetlands 4-1 & 7-1, this included K7A and K58B.
- Access to wetlands that lack *Gambusia* is likely to be important for successful reproduction.
  - For frogs in the K29 zone, K106A and K106B provide this.
  - For frogs in the K22-23 zone, most nearby wetlands have *Gambusia*. The frogs may use ephemeral flooded grassland that we did not survey. Note that K106A and K106B are close to K22-23.
  - For K104, this is probably K104A in normal years. The extreme rainfall this year resulted in the main wetland at K104 rising to a height where it connected with the flooded section of access road, so *Gambusia* were able to infiltrate K104A. K104A is expected to

dry out each year, and in more 'normal' years should provide *Gambusia*-free ephemeral habitat.

- Vegetation found to be associated with GGBF in permanent wetlands was a mix of tall emergent Macrophytes fringing large areas of open water, which in some instances, is interspersed with clumps of tall emergent flora tolerant of brackish conditions. Dominate emergent Macrophytes include, *Juncus acutus, Schoenoplectus littoralis, Phragmites australis* and to a lesser extent *Typha orientalis.*
- Vegetation found to be associated with GGBF in permanent wetlands was a mix of low saltmarsh and brackish species, which in some instances, were fringed by stunted emergent flora tolerant of brackish conditions, (i.e. *Juncus acutus, Schoenoplectus littoralis, Phragmites australis* and to a lesser extent *Typha orientalis.*). The body of the wetland is generally low and dense in structure, these wetlands were dominated by *J.kraussii, Sporobolus virginicus, Bolboschoenus caldwellii,* and *Sarcocornia quinqueflora.*

4 GGBF observations in the northern relative to GGBF occupation observed across the study site:

- In terms of wetland habitat the northern zone is smaller than both the central and industrial zones. Relative wetland areas to available land mass (which is a proxy measure for landscape connectivity) differs greatly between these three areas. For example; Northern zone has a wetland area of 11.47ha relative to 377ha of land mass; Central zone has a wetland area of 16.57ha relative to 293ha of land mass; and, Industrial zone has a wetland area of 55.47ha relative to 346ha of land mass. Clearly the industrial area is both large in wetland area (4 times that of the northern zone) and better connected. Whilst not entirely plausible yet given the small amount of data held for the northern section, when comparing relative areas and search times between the northern and the industrial zone shows that the northern section is not as poorly occupied as one would first believe. For example, 3451 min of search time at 11.47 ha (Northern section) equates to 301min per/ha and yielded 34 unique adult GGBF's. By comparison, the industrial zone had 16,636 min of search time of 55ha which equates to 302min per/ha (surprisingly similar) and yielded 97 unique adult GGBF's. Given that the northern zone has only been occupied by GGBF for the past two seasons, it has already achieved more than one third of the number (relative to individuals caught per search time per area) as the established Industrial zone and can be viewed cautiously as a small success that will hopefully expand over the coming two seasons.

- Two sites of breeding were observed (K58B and K7A) and both were in ephemeral wetlands that were charged during the January rains. The evidence was that only a small number of adult pairs were involved in breeding. Nonetheless this is the second season in a row that breeding has been recorded in the north zone.
- We consider it most likely that the adults involved are from stock introduced to the NCIG Trial Habitat Plot and in the NCIG Compensatory Habitat Wetlands. It is not possible that the adult females were the product of the previous year's (201/2015 summer) breeding events in the NCIG trial or NCIG Compensatory wetlands.
- Lack of *Gambusia*-free ephemeral wetlands.

- Conversely, the high numbers of GGBF within the Industrial Zone site are linked to:
  - The presence of permanent wetlands with nearby seasonal/ephemeral wetlands
  - Access to *Gambusia*-free wetlands
  - A 'disturbed' vegetation profile with large areas of open water.

5 Timing of surveys at 'over-wintering' wetlands is important:

- We probably missed the main numbers of frogs at K108 and K29 because these were first surveyed after the summer rainfall.

6 Constructed wetlands are effective.

- Both designs used at the Industrial Zone - the plastic tubs at the Cluster wetlands, and the landscaped settlement wetlands at the HDC capping – are effective for bell frogs.
- Although small in area, the C1 cluster wetland supports relatively high densities of adult frogs and 2 of the 6 tubs had tadpoles (in large numbers).
- The HDC wetlands are larger, but given that they were only installed in 2015 it is impressive that they were used by GGBF during the 2015-2016 summer season. Adults were detected at three of the six new wetlands, and large numbers of tadpoles were seen at one. These wetlands are *Gambusia* free and within a short distance of the resident population in the rail loop wetland (K108).
- Note that a single adult GGBF was observed at the C2 cluster in late December, but no frogs were observed there in the subsequent Visual Encounter Surveys.
- Largest numbers of GGBF in the National Park were in K22-23. Numbers were low in mid-December, before the summer rain events, but there were large numbers of males calling in the nearby flooded grassland in mid-January.

7 Connectivity is important:

- The lack of frogs at the C2 cluster wetland, and the western HDC capping wetlands (K117, K118), emphasise the importance of connectivity between wetlands (the mosaic habitat model, and overcoming isolation by distance).
- C2 and K117-118 are somewhat further away from wetlands that are known to support large numbers of frogs.
- Conversely, the northern cluster wetlands (C1) and the eastern HDC capping wetlands (K111-114) are all close to wetlands with large numbers of GGBF. In particular, they are each close to 'over-wintering' wetlands: C1 to K29 ('the Cell'), and K111-114 to K108 (the 'Rail loop' wetland).
- This pattern may change in the next couple of seasons, however. Until recently, the closest wetlands to C2 have been K100W and K100E; these wetlands have never supported large numbers of GGBF. K108 is a long way from C2, but the new HDC capping wetlands now provide suitable wetlands between C2 and K108. The new wetland K112 in particular is close to C2, and whilst this was the only one of the four new eastern HDC wetlands that did not appear to have frogs this season, it is close to K111 (which did have GGBF) and is a similar construction. We predict that K112 will be used by GGBF next year, and that as a result C2 may become colonised by enough adults to sustain reproductive activity similar to that observed at the other cluster wetlands.
- For the new western HDC wetlands (K117-118), the nearest wetland where GGBF were detected is K49A. We did not find frogs at the pond immediately to the south (K46). Other nearby wetlands (K46, K47, K105B) were not surveyed; at present, whether there are enough nearby frogs to colonised these new wetlands is unknown.

8 Most of the Kooragang GGBF are in wetlands in the northern part of Industrial Zone

- The wetlands with the highest abundance of frogs are K104, C1, K29, K22, and K23, all of which lie along the existing corridor. Additional wetlands in this corridor that have GGBF are K103, K106A, K106B, K106C, and K105A. Between them, these wetlands accounted for 92% of frogs detected (1183 out of 1283).

Contents

1. Introduction

1.1 Background to the study

Annual monitoring of the Green and Golden Bell Frog (*Litoria aurea*) (GGBF) population on Kooragang and Ash Islands (from here on to be referred to as the study site) has been undertaken for the previous five years. Overall this program aims to investigate three specific questions relating to GGBF population ecology on the island, including:

1. What is the estimated population size of the GGBF on Kooragang Island?
2. What is the demographic composition of the GGBF population on Kooragang Island?
3. How do GGBF utilise the landscape on Kooragang Island?

Since inception, surveys have continued to utilise two main field techniques in a consistent manner so that a long-term picture GGBF population ecology can be obtained. Essentially these two methods include; 1) Capture-mark-recapture (CMR) and, 2) visual encounter surveys (VES) ((Clulow 2012, 2013, 2014, Campbell 2015). Over the period that monitoring has been undertaken the scope of the program has been expanded to address questions surrounding GGBF persistence in some habitats but not others and to inform best habitat creation practice.

Throughout this work we refer to Kooragang Island and Ash Island (KI/AI) and readers are often confused by these terms since no current channel separates the historic islands. Mosquito Creek which passes between the north and south arm of the Hunter River once separated Kooragang Island to the east from Ash Island to the west. Construction of the industrial railway along with other reclamation works in the 1950 and 60s meant that the two historic islands are now combined. We continue to use the combined name KI/AI since it best reflects the natural and historical situation.

1.2 Background to the problem

The green and golden bell frog decline

The GBBF was once common and widespread throughout the east coast of Australia from northern New South Wales to southern Victoria and its adjacent tablelands (Pyke and White 2001). Since the 1960s a decline was observed and the GGBF is now known to have undergone a dramatic reduction in its distribution and abundance (Mahony et al, 2013; White and Pyke 1996; Pyke and White 2001). Today, the GGBF persists in less than 10% of its historical distribution, and occupies about 40 known sites (Mahony et al, 2013; White and Pyke 1996). Populations that were once reported on the Central Tablelands appear to be extinct, having not been observed since the early 1970s (White and Pyke 1996; White and Pyke 1999), and until a recent rediscovery of a small population in Queanbeyan (Patmore 2001; Wassens and Mullins 2001), they were believed to be extinct in the Southern Tablelands, having not been observed there since 1980 (Osborne, Littlejohn et al. 1996). In addition to those in the highlands, many populations have also been lost along the foothills and coastal plain of the Hunter, Sydney and Shoalhaven regions where they were once common (Daly 1995; White and Pyke 1996; Mahony 1999). This reduction has resulted in the species being listed as endangered in New South Wales under the *Threatened Species Conservation Act 1995* and as vulnerable nationally under the *Environment Protection and Biodiversity Conservation Act 1999.* Two key populations are named for the

Lower Hunter region, one of which occupies Kooragang Island (DECC 2007, there named Kooragang/Ash Island).

Causes of the decline and disappearance of bell frog populations

There is considerable evidence that the GGBF was once common in the Hexham Swamp/Kooragang Island area of Newcastle (Hamer et al., 2004). The species apparently declined rapidly in the 1980s and by the 1990s the only confirmed breeding site south of the Hunter River was in the 2HD wetlands at Sandgate. This population disappeared some time prior to 2006, leaving only the population in the Hunter Region on Kooragang/Ash Island.

More broadly the range contraction of the threatened bell frog species occurred rapidly, suggesting a causal agent that was able to act over short time periods was involved (Hamer et al., 2009). They disappeared from nearly all inland, high altitude areas of their respective ranges (Courtice and Grigg, 1975, Hamer et al., 2009, Mahony, 1999a, White and Pyke, 2008, White and Pyke, 1996), although they lived alongside a suite of co-occurring frog species that did not appear to decline. These consistencies with the disease hypothesis suggest that chytridiomycosis may have played a role in bell frog declines and, if so, that the effects of this disease must be less severe in areas where bell frogs have persisted (Mahony et al, 2013). The NSW National Parks and Wildlife Service Draft Recovery Plans for *L. aurea* lists disease (specifically chytridiomycosis) as a threat to the persistence of these species, and several observations of infection and die-offs are referred to therein (DEC, 2005a, DEC, 2005b, NSW NPWS, 2001).

Bell frogs are highly susceptible to the amphibian Chytrid fungus that causes the disease chytridiomycosis. Experimental exposure of *L. aurea* to the Chytrid fungus results in 100% of individuals showing terminal signs of chytridiomycosis in captivity (Stockwell et al., 2010). Although the impacts of disease are expected to be more severe in captive environments, such high susceptibility in *L. aurea* hosts suggests that the Chytrid fungus has the potential to constrain population size and cause extinctions. Multistate modelling of the Kooragang Island *L. aurea* population supports this, showing significantly lower over-winter survival rates in infected individuals (0.1) than uninfected (0.56) which was predicted to cause the population to decline at twice the rate of an otherwise uninfected population (Stockwell, 2011). These studies indicate that large-scale unobserved seasonal die-offs may occur in bell frog populations during cold periods when both bell frog detectability and survey frequency are low. In addition, the chytrid fungus has been implicated as the causal agent in the overwinter extinction of a reintroduced *L. aurea* population in the Hunter Region of NSW (Stockwell et al., 2008). Such die-offs and extinctions have serious implications for the ability of remaining isolated populations to persist with infection, particularly in the presence of demographic and environmental stochasticity (Stockwell, 2011).

The existence of a link between the GGBF persistence in coastal environments and sensitivities of the causal agent Chytrid to salt has been suggested several times (Berger et al., 2009, Mahony, 1999a, White, 2006) and significant negative correlations have been found in bell frog habitat between infection loads and the salinity of water bodies (Stockwell, 2011). An inhibitory effect of 3-4 ppt sodium chloride on fungal growth and infective capacity has also been confirmed experimentally (Stockwell, 2011). These results suggest that bell frogs may currently persist in areas with a saline influence as they act as environmental refuges from the effects of the Chytrid fungus. The addition of salt to water bodies, both in captivity and in an experimental reintroduction site has also been found to increase bell frog survival rates in the presence of Chytrid (Stockwell, 2011), suggesting that this may be used in management.

Apart from Chytrid, the two most commonly cited causal agents for the bell frog decline are habitat modification and predation by the introduced mosquito fish *Gambusia holbrooki*. Many historic bell frog sites have been altered, particularly through filling and drainage of wetlands and floodplains for agriculture, trampling of waterways by feral horses and pigs and urban and industrial development (Clancy 1996, Daly 1996, Van De Mortel and Buttemer 1996, Lewis and Goldingay 1999, White and Pyke 1999). Correlations between the loss of suitable habitat and bell frog population extinctions have been made and appear to be exacerbated by the loss of connectedness between habitat and the subsequent impacts of demographic and environmental stochasticity, and low levels of genetic exchange on small populations (Goldingay , White and Pyke 1996, White 2006).

The mosquito fish (also known as the plague minnow) is known to prey upon the eggs and tadpoles of many frog species including the green and golden bell frog (Morgan and Buttemer 1996) and can significantly reduce survivorship, both in laboratory-based experiments (Morgan and Buttemer 1996; Pyke and White 2000) and in the field (White and Pyke 2008). In addition, bell frog tadpoles appear to be completely naïve to the presence of mosquito fish, showing no avoidance or refuge seeking behaviours (Hamer et al. 2002). The timing of the earliest bell frog declines coincided with the expansion of mosquito fish populations throughout NSW (White and Pyke 1996) and numerous sites where bell frogs remain are associated with an absence of the mosquito fish (White and Pyke 1996; Lewis and Goldingay 1999; Pyke, White et al. 2002). The converse also occurs, and there are many locations where GGBF have disappeared and mosquito fish are absent (Mahony et al. 2013), which has led to the conclusion that the fish are not the major driver of the widespread population declines. Furthermore, there are several studies that report the co-occurrence of bell frog tadpoles and mosquito fish (Hamer 2002, Sanders et al. 2015).

In addition to the direct effects of predation, the presence of mosquito fish in permanent water bodies may also have resulted in a shift in the type of habitat utilised for breeding. Bell frogs appear to have bred in permanent water bodies more frequently in the past than they do now and this may be because ephemeral water bodies that dry frequently do not sustain populations of mosquito fish (Pyke and White 1996; Hamer, Lane et al. 2002; Pyke, White et al. 2002). However, breeding in ephemeral water bodies carries the risk of wetland drying before tadpoles can metamorphose and unlike many other species, bell frog tadpoles do not appear to be plastic in their development rate, being unable to metamorphose more rapidly in response to declining water levels (Hamer, Lane et al. 2002).

1.3 Research objectives

Conservation efforts to mitigate the effects of habitat loss and other pressures causing GGBF decline often involve the management, restoration or creation of habitat, which depends upon a thorough understanding of habitat requirements and population demography. Research efforts have attempted to characterize particular features of habitat that bell frogs use (Pyke and White 1996, White and Pyke 1996, Penman 1999, Christy and Dickman 2002, Pyke et al. 2006).

However, as discussed above, it may be that the habitat where bell frogs are observed are not the preferred habitat of the frog, and that the presence of an introduced predatory fish causes the frogs to select other habitats, some of which may be sub-optimal for their development. However, each habitat study found bell frogs to be associated with a different suite of variables, suggesting that it may be a generalist in its habitat requirements. The GGBF is an opportunistic colonising species with high dispersal ability and fecundity (Pyke et al. 2002, Lane et al. 2007) which also suggests that it should readily establish populations in suitable habitat. This has caused confusion as to why the species never seems to occupy all seemingly appropriate water bodies in a particular area where it is present, and why occupancy of wetlands (presence/absence) can change regularly both within a season and from season to season.

Five attempts have been made to create bell frog habitat to date, using similar habitat templates (Mahony et al, 2013; Pyke and White 1996), and only one has resulted in the establishment of a breeding population (Pyke et al. 2006, Stockwell et al. 2006b). Although these studies have increased our knowledge of various aspects of GGBF biology and ecology, the low rate of success in establishing populations illustrates our current lack of understanding regarding the habitat preferences and requirements of this species. Given the development pressures placed on much of the existing bell frog habitat, this urgently needs to be resolved. Despite the intensive research effort that has gone into understanding bell frog habitat requirements, very little has included a temporal (across time) component and this may prove to be vitally important in this understanding. Similarly, the unit of study focused upon in these investigations has consistently been the individual water body. However, bell frog habitat selection may be based on smaller or larger scales than this. Therefore, an understanding of how bell frogs utilize a landscape temporally and spatially is required if their distribution is to be understood and habitat effectively managed or created.

The specific medium to long-term objectives of the Kooragang and Ash Islands (KI/AI) GGBF population ecology research program is to enhance our understanding of the species ecology, population dynamics and demography through sustained annual breeding season surveys (2010/2016). This ongoing research enables us to build a picture of the GGBF population on KI/AI both spatially and temporally, which in turn provides important information to assist in understanding the population dynamics, and one day improve the long-term resilience of GGBF populations.

In particular, to make habitat creation and enhancement work effectively for the GGBF it is necessary to have a detailed understanding of the structure of the bell frog population as it currently exists on KI/AI.

This required repeated surveys similar to the past years and involves a combination of capture-mark-recapture (CMR) and visual encounter survey (VES) techniques. In addition to the surveys that were carried out in water bodies over the past five years, water management wetlands created within the NCIG rail loop by Hunter Development Corporation (HDC) were included this year's surveys.

This work was performed in the context of other ongoing work on the GGBF at Kooragang Island, in particular at the BHP Compensatory Habitat Wetlands and NCIG Compensatory Habitat wetlands. These sites were not surveyed as part of this project (survey of these whilst using similar methods, they are applied and varying intensities and are therefore not directly comparable).

Specific objectives:

1. What is the estimated population size of the green and golden frog on Kooragang Island?
2. What is the demographic composition of the GGBF population on Kooragang Island?
   2a What are the proportions of juveniles, adult males, and adult females?
   2b How much recruitment is known, and where is it occurring?
3. How do GGBF utilise the landscape on Kooragang Island?
   3a What is the distribution of GGBF on Kooragang Island?
   3b What factors affect distribution, abundance, and recruitment?

2. Methods

2.1 Wetland sample sites

Within the study site all wetlands are included in sampling if they have been surveyed since the establishment of early monitoring programs on the Island (i.e. A. Hamer study site (Hamer 1998), or newly created, or they have been identified since that time as providing habitat for GGBF. Since the programs commencement (2010/2011) 56 additional wetlands have been included. To maintain consistency identification and sample site nomenclature follows Hamer's numbering scheme and has been extended to the additional wetlands; refer to Figure 2.1 for details of zones and numbering.

For ease of reference the site is presented as three distinct geographical zones; 1) Northwestern, 2) Central, and 3) Southern. Each containing a range of wetland types at varying sizes, a description of these is shown diagrammatically in Figure 2.1 and outlined below:

1. Northwestern: this zone includes the National Park from the Sandgate bridge in the south to Scott's Point in the north overall, and has an area of 377ha. Within this zone there are 17 wetlands sampled as part of this program. Whilst not included in this program an additional 18 wetlands are also sampled here as part of the NCIG compensatory habitat creation program and provide additional landscape information for this zone. Overall the zone has experienced a range of disturbance histories, including, grazing, clearing, draining, impounding, flood gating and other types of human development
2. Central: this zone also includes part of the National Park Estate. It ranges from the south where wetland sample sites are found adjacent to Bell Frog Track, to north at Milam Rd and terminating at the north arm of the Hunter River. Overall this zone has an area of 293ha, of which 90% is mangrove forest community. Within this zone there are 23 wetlands sampled as part of this program. Not including wetlands within the tidal regime there are an additional 5 wetlands within this area not sampled. Compared to the Northwestern zone this zone has been less impacted by human activity (mapping of disturbance history currently underway by JP King). Nonetheless, there is evidence of historic disturbance, including histories, clearing, draining, impounding, flood gating and other types of human development
3. Southern: Wetlands in this zone are located on industrial and commercial lands leased or owned by organisations undertaking a range of business activities on the site. Within this zone there are 38 wetlands sampled as part of this program, with a wide variety of types and sizes represented in the overall area of 346ha. Not including wetlands within the tidal regime there are an additional 5 wetlands within this area not sampled. As could be expected given the industrial/commercial nature of this zone it has both historically modified and continues to be a modified and disturbed part of the site. Nonetheless, the wetlands within this zone are easily delineated and in numerous cases removed from industrial activities. More so than the northern zone this zone presents a strange juxtaposition, where there are defined established wetlands surrounded by heavy industrial activities, which often are continually modifying their landscape. Compared to rest of the site, this has undergone the greatest level of historical disturbance and continues to be impacted by human activity (mapping of disturbance history currently underway by JP King). Disturbance including: clearing, draining, impounding, filling, rail construction, creek re-alignment and terminations, flood gating, large scale shoreline modification and many other types of human development

Wetland Overview - Kooragang Island survey area

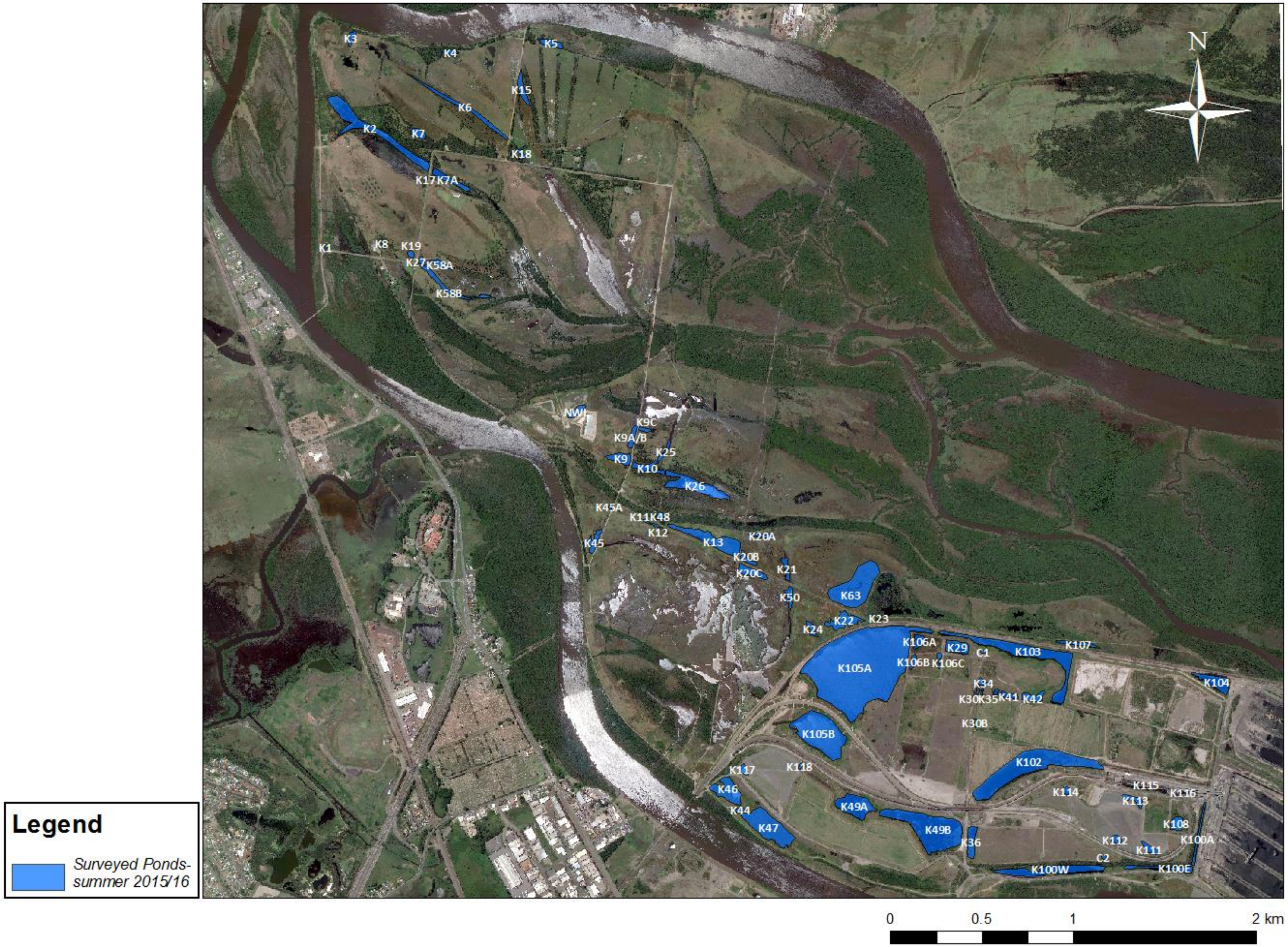


Figure 2.1: Wetlands on Kooragang Island / Ash Island that have been the focus of the annual monitoring surveys conducted by the University of Newcastle since 2010-11. The designation of wetland numbers was updated in May 2016. The 78 wetlands surveyed in the 'whole island' surveys of 2015-16 are all shown (see Appendix A), along with three wetlands (K7A, K44, and K47) that were not included in these surveys in this year.

In terms of Jurisdiction, all wetlands sampled on the site fall under the following 6 categories.

- National Parks and Wildlife (NPWS): 40 wetlands (North and Central zones)
- Port Waratah Coal Services (PWCS): 22 wetlands (Industrial Zone)
- Newcastle Coal Infrastructure Group (NCIG): 3 wetlands (Industrial Zone), plus 18 wetlands in the NCIG compensatory habitat.
- Hunter Development Corporation (HDC): 7 wetlands (Industrial Zone)
- Wetlands previously managed by BHP, but which are now managed by HDC (BHP): 3 wetlands (Industrial Zone)
- Road & Maritime Service (RMS): 3 wetlands (Industrial Zone).

2.2 Incorporating changes to land tenure into monitoring program

In mid-2016 we were informed that land within the industrial zone was under the management of the Port of Newcastle (State Environmental Planning Policy No 74. 2003—Newcastle Port and Employment Lands under the Environmental Planning and Assessment Act 1979. The new planning framework reflects that the port has a private, rather than a public, operator, and the Port of Newcastle lease). This includes a strip of land approximately 100 m wide to the west and north of the industrial railway, and therefore includes significant wetlands occupied by the GGBF population especially wetlands K22, K23, K24 and K107 which have been monitored for the past five years and historically were included in monitoring by Hamer (2002). The K22-K23 wetlands provide one of the only persistent wetlands for breeding over a period of more than 10 years monitoring.

The inclusion of the responsibility for lands under the management of the Port of Newcastle changes the number of wetlands that are listed on lands under agency or corporate environmental responsibility. We have not adjusted the data analysis provided here to reflect this recent change in responsibility but this will be updated in future reports.

2.3 Long-term monitoring approach

The Island wide monitoring of the GGBF distribution and abundance has followed a standard method for five years and was established to enable tracking of these population attributes against time. In the past two years significant habitat compensatory projects and other landscape works have occurred on the site that materially should effect the distribution and abundance of the GGBF population. To include these activities in the island wide monitoring would provide a bias of the outcomes, since additional wetlands would be included. However, not to include these additional wetlands fails to capture the entire population, and most importantly, to enable an assessment of the effectiveness of mitigation strategies in increasing distribution and abundance of the GGBF population. Our approach is not to have the island wide monitoring as a static process that investigates the occupancy of wetlands and population abundance in a predefined set of wetlands, but to make it flexible to the landscape changes that have occurred. It remains possible to assess the changes that occur on the original set of wetlands that were surveyed, and in so doing assess whether there has been changes in occupancy and abundance at these sites over time. In this report we include population estimates in for two compensatory habitats but report them separately to the island wide survey. The overall population estimate is obtained by combining the values. The additional population estimates are for the compensatory wetlands constructed by NCIG in the northwest zone of the island, and the wetlands constructed in the central zone of the island by BHP-Billiton. Finally, several newly constructed wetlands created by HDC following capping works within the NCIG rail loop area were included in surveys.

To maintain consistency among years in the island wide VES the same wetlands that have been surveyed over a five year period were included in the surveys of the summer of 2015/2016. Thus VES in the northwest region of the island were conducted at wetlands that existed prior to the construction of the NCIG compensatory habitat wetlands. A similar situation occurred in the Central region of the island where constructed wetlands were completed by BHP-Billiton just prior to the summer season of 2015/2016. Our approach to conducting surveys at the same set of wetlands that have been surveyed over the past five years was to prevent a confounding or bias in the population estimate for the island. For example, it would be possible to keep adding wetlands to a survey and potentially inflate the population estimate over time. A population estimate relies on a sampling method and it is not a complete census. Conversely, the construction of new wetlands is designed specifically to increase the population size by providing additional wetland habitat, and eventually to make the bell frog population more resilient. Furthermore, additional wetlands (albeit partially designed as stormwater management and sediment wetlands) have been constructed as capping works proceed in locations within the industrial region zone (e.g. HDC capping works within the NCIG rail loop), and these to have the potential to add resilience to the population by adding wetlands and providing connectivity within the landscape.

So that the outcomes of the compensatory actions can be captured in the island wide population estimate and their effect on connectivity can be assessed, each of the compensatory sites is investigated in detail and the outcomes can be added to the outcomes of the island wide survey. This is achieved by using VES information that is conducted using the same methods as applied in the island wide surveys. Additional ecological information such as population demography, observed breeding, water quality and habitat observations can be sourced from reports specific to the compensation sites.

2.4 Survey techniques

There were two types of survey used:

i. Visual Encounter Survey (VES)
ii. Capture-Mark-Recapture (CMR)

Both survey types involved systematic, surveying by between 2-6 people, at night surveys using >150 lumen LED head torches. Surveys started by listening for calls, and then making a call and listening for a response, prior to commencing the survey. The survey itself involves walking slowing through the wetland and surrounding terrestrial habitat, paying careful attention to vegetation as GGBF tend to associate with vegetation (mainly various species of reeds). Where wetlands were too deep for wading, we used small personal watercraft (e.g. canoes).

Recording of Climatic conditions

Climatic variables were recorded at regular intervals during each night of surveying. We recorded: temperature, dew point, wet bulb temperature, barometric pressure, average wind speed, maximum wind speed, & relative humidity, using a multi-probe instrument (Kestrel).

Frogs

<u>For each survey</u>, each surveyor recorded

i. Start and end times of survey,
ii. Any frogs (GGBF or other species) heard calling
iii. Water depth (qualitative)
iv. Presence/absence of *Gambusia*
v. Other non-target species of frog seen

vi. For each GGBF encountered:
- Time
- Habitat structure (Tree, Reed, Grass, Rock, Ground, Aquatic)
- Height from ground/water surface
- Distance from water's edge (where in terrestrial habitat)
- Size (adult/juvenile)
- Was animal observed calling?
- Other details

We attempted to capture all GGBF observed. This was done using a thin plastic bag (sandwich bags), or, if the vegetation structure made using the bags too difficult, by hand. Captured frogs were labelled with a capture code, and tied in the bag with sufficient air. If the frog was touched during capture, we washed hands with disinfectant gel. The capture sight was marked with flagging tape. Capture rate was 677 of 1,283 of frogs encountered (53%)

Captured frogs were processed as follows:

i. Scanned using a Passive Induction Transponder (PIT) reader to see if the frog had been previously chipped.
ii. If the frog had a PIT tag, the number was recorded.
iii. Visual inspection of frog for injuries, recent toe clippings, nuptial pads (to identify males from females).
iv. Snout-Vent-Length was measured using callipers.
v. Body weight was measured using a 10g, 60g or 100g spring balance (Pesola). The frog was weighed in the bag, and then the bag was weighed separately.
vi. The frog was swabbed for chytrid fungus by the standard protocol used by the UoN Amphibian Research Lab (2 strokes on each side of the animal for each of: flank, inguinal region, posterior thigh, palms of hands, soles of feet).
vii. If the animal had not been previously tagged:
    - A small tissue samples (piece of webbing from a foot) was taken using a biopsy punch and stored in 70% ethanol.
    - A PIT tag was injected subcutaneously into the lower back and manipulated into the inguinal region.

Tadpoles

Tadpoles were collected in the field and identified in the lab, using the key in Anstis (2002).

Metamorphs were identified on the basis of size.

Data Recording

Tissue samples and swabs were marked using the bar code from the PIT label. Processing took approximately 10 person minutes per frog. An example of the datasheet used to record data during processing is shown (see **Appendix A**). Frogs were returned to their point of capture after completion of the survey.

In Visual Encounter Surveys, the entire wetland was surveyed for a maximum of 30 minutes. Care was taken not to overlap surveys by each person, or to search the same area more than once. We attempted to keep a uniform survey speed at each wetland, although that did vary between and within wetlands depending on vegetation density. Any frogs captured were processed at the end of the survey, and frogs were then released at their point of capture.

In Capture-Mark-Recapture sampling wetlands were surveyed intensively typically for 3 to 4 consecutive nights. For long-term population data comparisons wetlands were chosen for CMR sampling based on their known status as important GGBF wetlands and their inclusion in previous populations estimations. To effectively capture a suitable representation of individuals from a wetland in some cases necessitated multiple surveys per night over consecutive nights. When multiple surveys per night are required at a wetland, frogs were processed as early as possible the next day and released that evening. As a consequence the next survey would commence the following evening (i.e. a 2 day gap between consecutive surveys).

A single survey would take as little as 30 minutes in smaller wetlands and more than 90 minutes in larger wetlands. In all cases processed frogs were released at the point of capture.

Effectively there is no stopping rule or constraint applied with CMR sampling, thus there was no maximum search time; rather, CMR sampling aims to survey the maximum number of GGBF individuals physically possible within time and budgetary constraints.

2.5 Search effort

We surveyed 78 wetlands; 17 in the Northwest region of the Island, 23 in the Central region, and 38 in the Southern region (Industrial Zone) (Figure 2.2).

- Total search time was 5,305 minutes (85 hours).
- Total search effort (people x time) was 15,060 person-minutes (251 person.hours).

- There were 2 rounds of surveys; the first in December to mid-January, the second from late January to February. During each Round, one VES was performed at each wetland, and a CMR survey was performed at K22-23, K29, and K104.

- Search effort was consistent between wetlands. Search effort was not determined by wetland area, as we had a maximum search time of 30 minutes at each wetland (for VES). For large wetlands such as K105 ('Deep pond'), we targeted areas of good potential habitat (i.e. emergent macrophyte stands on the eastern shoreline).

- This is the first year that K104 has been included as a CMR site. In previous years, the three CMR sites have been K22-23 (these two wetlands counted as one site for CMR because of their proximity to each other), K29 ('the Cell'), and K29 ('the Rail Loop'). K29 was intended as a CMR site for the 2015-206 surveys, and we commenced a CMR survey in the first round in early January, but detection rates were too low (13 frogs in 888 person-minutes of search effort) to produce a useful recapture rate (>20%) - accordingly, we used K104 as a CMR site instead.

- Delays in Industrial Zone inductions (ropes training for K29, NCIG inductions) meant that the first round was not completed until mid-Jan. As there was a large rain event in early January, that delay meant that we did not survey some wetlands before frogs had dispersed from over-winter sites to ephemeral wetlands. This is expected to have affected observations and occupancy in K29 and K108 in particular, which are postulated to be over-wintering sites.

In addition, we include the outcome of VES surveys at the NCIG compensatory wetlands in the northwest zone of the island, and at the BHP-Billiton compensatory wetlands in the central region (James and Mahony 2016).

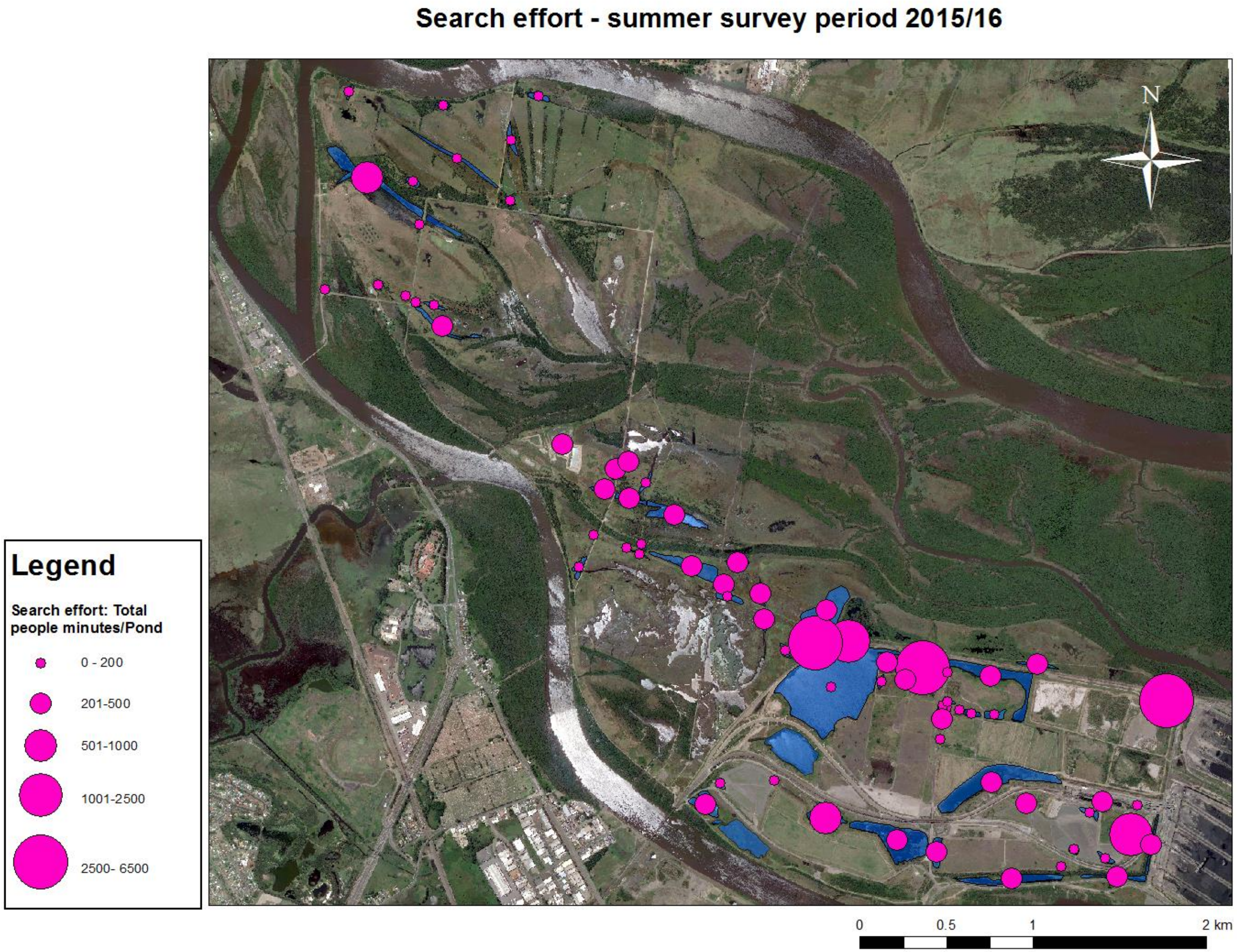


Figure 2.2: Search effort (person.minutes) across the 78 wetlands surveyed as part of 'whole island' monitoring in 2015-16. Data includes VES and CMR surveys.

NCIG compensatory wetlands:

- There were four rounds of surveys; the first in November, the second in December, the third in January and the fourth in February.
- There are seven clusters of wetlands (Figure 2.3) and a total of 18 wetlands that are either independent or connected by wide channels. Following heavy rainfall the wetlands that make up a cluster are interconnected. In each cluster there is a mix of ephemeral and permanent wetlands.
  During each survey round, one VES was performed at each wetland, and a CMR survey was performed across the wetland complex.

BHP-Billiton compensatory wetlands (data on population estimate is referenced from an independent report commission by BHP-Billiton).

- There were two rounds of surveys both conducted in January 2016.
- There are four clusters of wetlands (Figure 2.4) and a total of 9 wetlands that are either independent or connected. In two of the clusters the wetlands are permanent and the other two they are ephemeral.
- During each survey round, VES was performed at each wetland, and a CMR survey was performed across the wetland complex.

Figure 2.3. NCIG compensatory wetlands.

Figure 2.4. BHP-Billiton compensatory wetlands.

2.6 Methodological approaches used to address objectives

2.6.1 Population size and apparent survival were estimated using a robust modelling approach (Pollock's robust design).

Robust modelling of population size is based upon data from Capture-Mark-Recapture (CMR) surveys. In essence, repeated CMR surveys at a wetland provide data on the ratio of captured to uncaptured animals in a population, allowing an estimate of total population size (Figure 2.5).

In practice, there are several factors that might affect the number of frogs detected at a wetland on a given night, and the population size actually living at the wetland is only one of those factors (albeit an important one!). Temperature, humidity, wind speed may all affect the number of frogs that are active during a survey and which can therefore be potentially detected between recapture surveys. An animal may become more elusive after it has been captured for the first time – i.e. there is a difference between the capture probabilities of an animal on its first capture and subsequent recaptures – which can be a problem for straightforward population estimates. The statistical approaches of robust modelling approaches are able to account for the effects of these parameters, given sufficiently high quality CMR data. A more detailed overview of the Robust Modelling approach is given in **Appendix C**.

For Capture-Mark-Recapture to be analysed using Robust Modelling, sets of surveys need to be conducted over multiple periods at each location. A basic survey period is termed a primary period; within each primary period, a series of surveys (secondary surveys) are conducted over a short time; these secondary surveys should ideally be no more than 48 hours apart, and should continue until the recapture rate within one survey is at least 20% (and ideally up to 70%).

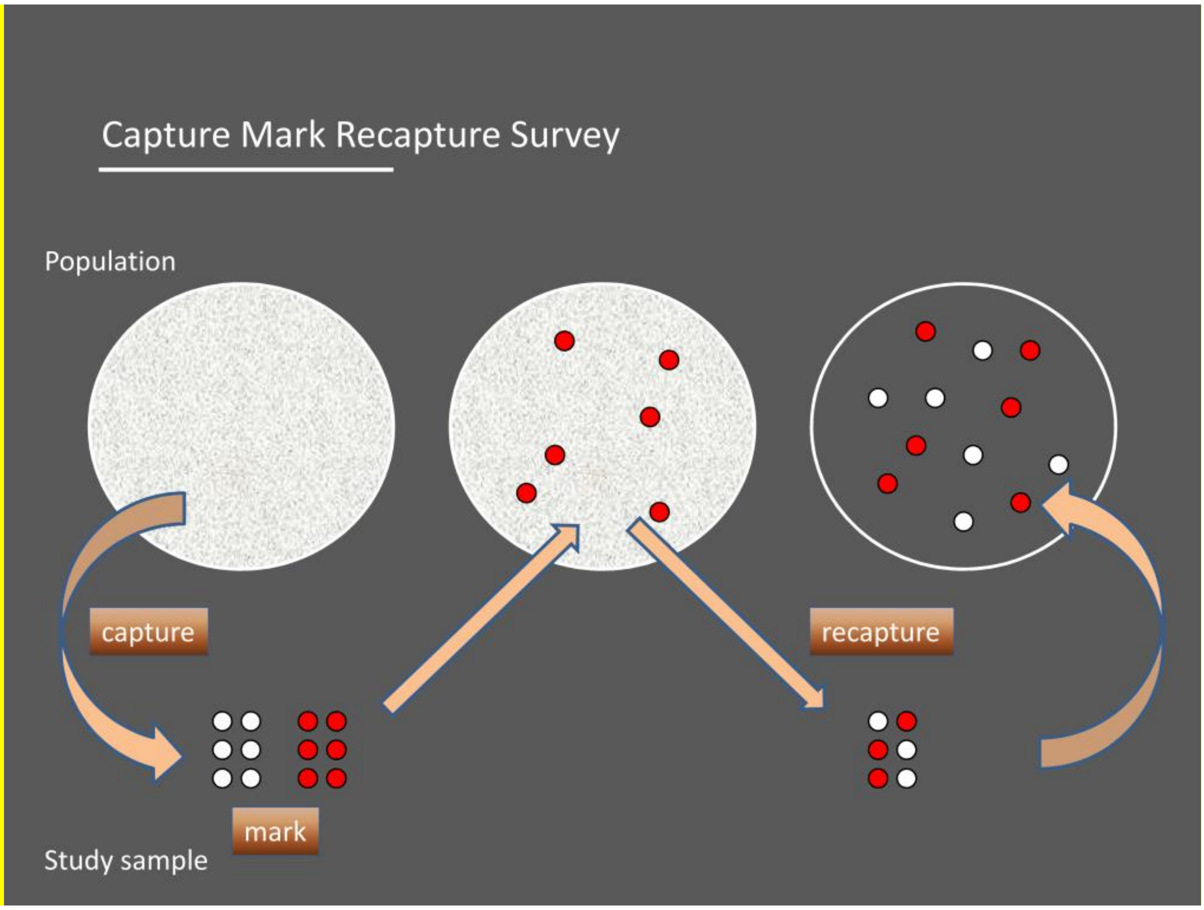


Figure 2.5. A simple illustration of capture-mark-recapture survey (based on two capture events only). Left circle: nothing is known about the population size, then during the first capture event animals are caught, marked and released. Middle circle: the number of marked animals within the population is known. During the second capture event marked and unmarked individuals are caught. Right circle: the population size can be estimated based on the proportion of marked individuals caught during the second capture event. *Note that this is an over-simplistic depiction of current mark-recapture methods, with Robust Design allowing far more powerful modelling to be completed incorporating closed methods (as depicted here) and open methods in conjunction with one another.

Using the survey techniques outlined in Section 2.2, we compiled CMR data from three locations over two primary survey periods.

- K22-23 (the two wetlands were treated as a single population, based on data from previous years)
- K29 ('The Cell')
- K104

The 1st primary period was December 2015 (K22-23) and January 2016 (K29 and K104), and the 2nd primary period was conducted in February 2016 at all locations (see Table 2.1)

A fourth CMR survey was initiated at K108 ('The Rail Loop'), and a single primary survey period was commenced in January 2016. Because of low recapture rates, the CMR survey was not completed at this wetland.

	Primary period 1			Primary period 2		
Wetland	Date	no. 2° surveys	Final recap. rate (%)	Date	no. 2° surveys	Final recap. rate (%)
K22-23	14-17 Dec 2015	4	75%	23-25 Feb 2016	3	66%
K29	13-19 Jan 2016	3	0%	10-12 Feb 2016	3	67%
K104	9-19 Jan 2016	5	21%	16-18 Feb 2016	3	40%
K108	7-9 Jan 216	3	0%	NA		

Table 2.1: Surveys and recapture rates at 4 wetlands where CMR surveys were initiated. See text for discussion.

Note the low recapture rate in the first primary period for K29.

On its own, robust modelling provides estimates for specific wetlands. In order to extrapolate these into population estimates for the whole island, we use VES survey data.

This approach to population estimates relies upon a consistent survey method across all wetlands to be included in the analysis. As the VES and CMR surveys in the NCIG compensatory wetlands and the BHP-Billiton compensatory wetlands were conducted using different survey methods, they cannot be included in the quantitative estimate given in this report – however, the results of those surveys are included qualitatively in the interpretation and discussion of overall GGBF numbers on Kooragang Island

2.6.2 Assumptions applied to survey effort and population modelling

We assume that survey efforts were consistent across the entire monitoring season. In reality, there are several important sources of variation:

Within and between individuals: survey effectiveness can vary among observers. GGBFs are generally cryptic, and difficult to see in the different vegetation structures that they are sitting in. To overcome detection bias we used a core of experienced observers within the survey teams but this remains an important methodological limitation.

Within and between sites: GGBF are cryptic and are difficult to see; moreover, they are well camouflaged in a variety of vegetation types. They are particularly difficult to spot in dense vegetation, and so wetlands with dense reeds (many of the wetlands on the northwest part of Kooragang, such as K1, K8, K19, K7, K18, K15, K5, K4; also K13, K20, K24, K108, K46) are expected to have low detection rates for a given abundance of frogs. The highest probability of detection seems to be in wetlands that have a narrow band of *Juncus acutus* surrounding open water that is >3 metres across and >1 metre deep (e.g. K23; southern side of K104); during summer, the frogs sit on the edge of the vegetation. Parts of a wetland with dense *Typha* and especially *Phragmites* may hold large numbers of GGBF, but have low detection rates. Weather conditions also influence detection probability; warmer nights with low wind speeds seem to be better for detecting GGBF (although this is difficult to demonstrate quantitatively). Temporal variation in frog detectability can occur across one evening (frogs seem to be more detectable past 1 hour after sunset), across consecutive nights (with weather), and across the season; the evidence is that some wetlands (e.g. K23, K29, K108) are over-wintering sites, from which frogs disperse to ephemeral wetlands during the mid-summer and then return to towards autumn.

So that we could account for the inherent bias produced by habitat complexity all surveys were timed, and the survey effort calculated as part of the detection probability. Thus if a particularly complex habitat was being surveyed the entire wetland was surveyed and the time taken recorded. We also calculated wetland size and perimeter length so that we could assess frog density.

Limiting bias created by different weather patterns and seasonal conditions is more difficult to account for in analysis. To limit the effect of different weather patterns we aimed to accomplish a complete survey of all wetlands in a two to three week period, thus limiting the impact of short term climate variations. To overcome seasonal effects the surveys were replicated twice, one in mid-summer and one in late summer/early autumn. Despite this design the summer season of 2016 was punctuated with several large rainfall events that occurred in the middle of and before timetabled surveys. Such events do effect bell frog detection and occupancy at wetlands. Detection of bell frogs is increased when males are actively calling, and during these times they are more active around the edge of wetlands and on the water surface, making visual encounter easier. Associated with large rain events bell frogs disperse from permanent wetlands and move to ephemeral wetlands. In some situations this may only be a matter of metres and in others it may involve distances of tens of metres. For example, at permanent wetland K104 an ephemeral wetland occurs adjacent to the permanent wetland and the frogs disperse only a short distance, whereas at K22 the frogs move over 70 metres to K63, which covers a large area.

2.6.3 Demographic composition and effective population size

To construct the age-class structure of the bell frog population we determined the age of individual frogs collected by using a growth curve for bell frogs developed on Kooragang Island (see Hamer et. al., 2007 for a description of the method used to construct and verify the growth curve). This approach relies on knowing the relationship between body length, measured as snout to vent length (SVL), and the age of the frog. Since bell frogs have seasonal reproduction (the summer season when reproduction occurs and tadpoles usually metamorphose) most individuals can be placed in a yearly cohort, although animals that overwinter as tadpoles and metamorphose early in the season are known and add a level of complexity to identifying cohorts. Thus it is possible to assign all individuals to size-classes and express the population demography in age cohorts. In addition to body length the body mass of frogs can be related to age and can also be related to animal condition.

Body length (measured as SVL) was used to assign individual frogs into one of two classes juvenile or adult based on the analysis of Hamer et al. (2008).

Specifically, adulthood is defined as the capacity to reproduce and for males this is attained in their first year (i.e. within the first 12 months since they metamorphosed and at a SVL of >44 mm), and for females it is attained in their second year (i.e. greater than 18 months of age or what is typically referred to a second year female, meaning that she is in the second year of life, and SVL > 68 mm). Adult bell frogs are sexually dimorphic; females reach a large body size and mass than the equivalent aged males.

To provide an age-class structure for the entire bell frog population on Kooragang Island the age of all individuals collected in CMR surveys from all wetlands were combined. For frogs that were recaptured during the season, the age at first capture in the season was calculated. For the small group of frogs that were recaptured from the previous summer season (2015/2016) the growth and age were closely scrutinised to assess that validity of the age calculation

For analysis of the age-class and gender-class structure of the population all frogs were first grouped by gender and then into age-classes based on a six month time scale. Juveniles were considered separately since their gender is unknown with the exception of juvenile females early in their second year. In this case, frogs ≥ 44 mm body length if male, would typically have well developed nuptial pads (secondary sexual character which indicates that testes are functional and sperm is being produced), and are classed as an adult male. However, if they are a female they have not yet reached sexual (reproductive) maturity and are not classed as adult until they reach a body length ≥ 68 mm. Thus a frog which has a body length > 44 mm without nuptial pads, is classed as a juvenile female (typically 12 to 18 months old).

Age-class determination:

- Nuptial pads apparent → adult male (typically > 44 mm SVL)
- Body length < 44 mm and nuptial pads not apparent → Juvenile (sex unknown)
- Body length > 44 mm, nuptial pads not apparent → juvenile females
- Body length > 68 mm, nuptial pads not apparent → adult female.

For the purpose of reducing the demographic information on GGBF to the most important determinant of persistence, the survival of rate of adult females is crucial (Pickett et al 2013). From the perspective of population studies the effective population size is the number of individuals in a population who contribute offspring to the next generation. The effective size of a population, N_e, determines the rate of change in the composition of a population caused by genetic drift, which is the random sampling of genetic variants in a finite population. The importance of N_e as an evolutionary factor is emphasized by findings that N_e values are often far lower than the census numbers of breeding individuals in a species. Species with historically low effective population sizes, such as isolated populations of threatened species, show evidence for reduced variability and reduced effectiveness of selection in comparison with other species (Charlesworth 2009). In an ecological sense, the size of a population can be measured by simply counting the number of adults in a locality. From the perspective of the GGBF population on Kooragang Island the census value is obtained by the population estimate suing robust CMR methods. Effective population size is considered as the number of adult females and males in the population, although the number of offspring is limited directly by the number of adult females. Adult males are important in the genetic determination of effective population size since they are involved in transmission of genetic diversity.

Here we focus on the number of adult females observed in CMR and VES surveys since they truly represent the effective demographic population size. In comparison the numbers of juveniles or eggs that are laid and grow into tadpoles do not provide a direct indication on the status of the population. This is not to say that recording their numbers and distribution is not important since they provide critical understanding of vital population rates such as fecundity and mortality in the embryonic and larval stages used on Population Viability Analysis (PVA).

3. Results

3.1 What is the estimated population size of the green and golden frog on Kooragang Island?

Study Site not including NCIG Wetlands

Frogs detected	1,283
Frogs captured	677
Unique frogs captured	539

NCIG Wetlands

Frogs detected	297
Frogs captured	185
Unique frogs captured	184

Total

Total Frogs detected	1,580
Frogs captured	862
Unique frogs captured	723

Frogs detected include all observations that are made in VES surveys and is a greater number than frog captured, since about 47% frogs that are observed escape capture. Frogs that are captured are marked and because the surveys are replicated many are recaptured is subsequent surveys, such that unique frogs captured is a lower number than unique frogs detected. The number of unique frogs captured represents the true number "known alive" and is the minimum number of frogs at the site.

3.1.1 Population estimate of wetlands surveyed using Capture-Mark-Recapture

Mark-recapture surveys resulted in 108 captures of bell frogs in K22-23, 378 captures in K104, and 25 captures in K29 the two primary survey periods. A total of 14 captures were made in K108 in January 2016. A low rate of recaptures in the first primary period (January) at K29 and K108 (Table 2.1) meant that data from these wetlands could not be included in the subsequent analysis.

Robust modelling was conducted and analysed using the program MARK. The survival, capture/recapture probabilities and population size estimates were best represented by different base models for each wetland (**Error! Reference source not found.**).

Rank	Model	AIC_c	ΔAIC_c	weight (*w*)	Model likelihood	No. of parameters
	K22-23					
#1	ϕ(.) *G"=0 p(.) c*(t) f0(t)	-67.18	0.00	0.54	1.00	10
#2	ϕ(.) *G"=0 p=c*(t) f0(t)	-65.77	1.41	0.27	0.50	10
#3	ϕ(.)*G"=0 p=c*(.) f0(t)	-64.02	3.15	0.11	0.21	5
#4	ϕ(.) *G"=0 p(.) c*(.) f0(t)	-63.55	3.63	0.09	0.16	6
#5	ϕ(.) *G"=0 p=c*(.) f0(.)	-53.19	13.98	0.00	0.00	4
	K104					
#1	*ϕ(.) G"=0 p=c(.) f0(.)*	-1082.86	0.00	0.53	1.00	4
#2	*ϕ (.) G"=0 p=c(.) f0(t)*	-1081.27	1.58	0.24	0.45	5
#3	*ϕ(.) G"=0 p=c(t) f0(t)*	-1079.67	3.19	0.11	0.20	9
#4	*ϕ(.) G"=0 p(.) c(.) f0(t)*	-1079.47	3.38	0.10	0.18	6
#5	*ϕ(.) G"=0 p(.) c(t) f0(t)*	-1076.27	6.59	0.02	0.04	9

Table 3.1: Candidate set of models, ranked by ascending ΔAICc, used to estimate apparent survival probability (ϕ), capture (p) /recapture (c) probability, and number of uncaptured individuals in each wetland population (f0) of green and golden bell frogs captured from wetlands K22-23 and K104 on Kooragang Island between December 2015 and February 2016. Net immigration/emigration (G") was set to zero. (.) indicates that the value of a parameter was constant, (t) that it varied with time.

	1st Primary Session			2nd Primary Session		
Wetland Model #	N-hat (pop. size)	95% confidence intervals Lower	Upper	N-hat (pop. size)	95% confidence intervals Lower	Upper
K22-23						
#1	111	55	469	220	81	981
#2	66	85	165	114	85	165
K104						
#1	459	383	565	380	303	486
#2	445	367	558	393	309	515

Table 3.2: Population estimates for the K22-23 and K104 wetlands surveyed using Capture-Mark-Recapture, analysed by Robust Modelling. Results from the two best models as ranked by AICc scores (c.f. Table 3.1) are presented. N-hat values are population estimates for each wetland, listed by each model for each round. For each wetland, both models show an increase in population number for K22-23 from Dec-Jan (Round 1) to Feb (Round 2), but a decrease at K104. Confidence intervals are reasonably tight for both K104 models (essentially, N-hat +/- 100), but the first ranked model for K22-23 has a much larger range of confidence intervals (-50 up to + 750) than model #2.

Population estimates for these two wetlands in each primary session are shown in Table 3.2 for the best two ranked models. For **K22-23**, the N-hat values (population estimate) are similar for the top two ranked models. The range of confidence is very wide for the first ranked model, but lower for the second ranked. These models differ in one factor; probability of capture is fixed in model #1, but varies with time in model #2. Since probability of recapture varies with time in both models, there is *prima facie* nothing less plausible about the second ranked model; given the smaller range of variation it is used in the Island-wide population estimate below.

The N-hat values for **K104** are even more similar for the top two ranked models; the 95% confidence range is also similar. These models differ in one factor; that the size of the uncaptured population is fixed, or varies with time. Either is plausible but having this factor varying with time is consistent with the factor used for the K22-23 models and so the second ranked model is used in the population estimates for the whole island.

3.1.2 Using VES data to convert CMR results into an island wide estimate of GGBF population on Kooragang Island

Visual Encounter Survey results were calibrated against CMR data by comparing VES and CMR data from K22-23. VES surveys at this wetland were conducted in December 2015 (Round 1) and late February 2016 (Round 2). Visualisation of that data showed that the most reliable predictor of detection amount was search time (as opposed to number of people x search time) (Figure 3.1). Comparing numbers detected per minute of search time to the Robust Modelling derived estimate of population size (Table 3.3) produced estimates of the factor relating the number of frogs seen per minute with the number of frogs in the population (Table 3.4).

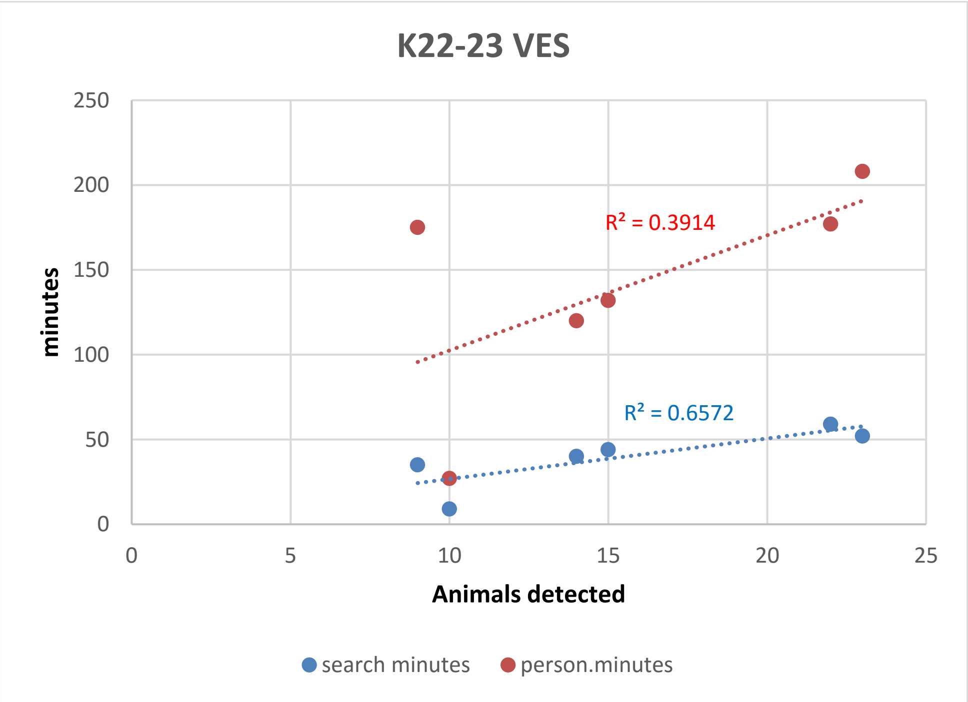


Figure 3.1: Correlations between search metrics and animals detected in K22-23 wetlands. Search minutes, rather than person minutes, was the most reliable predictor of animals detected (evaluated by R^2 values).

			pop estimate			detected	Conversion factor detected/time/pop est.		
	Wetland	**VES date**	lower	N-hat	upper	**/ time**	lower	N-hat	upper
Round 1	K23	7/09/2015	55	65	90	0.35			
Round 1	**K22-23**	**9/12/2015**	**55**	**65**	**90**	**0.26**	**213.9**	**252.8**	**350.0**
Round 1	K23	11/12/2015	55	65	90	1.11			
Round 2	**K22-23**	**23/02/2016**	**85**	**114**	**165**	**0.37**	**228.0**	**305.7**	**442.5**
Round 2	**K22-23**	**24/02/2016**	**85**	**114**	**165**	**0.34**	**249.3**	**334.4**	**484.0**
Round 2	**K22-23**	**25/02/2016**	**85**	**114**	**165**	**0.44**	**192.2**	**257.7**	**373.0**

Conversion factor

	lower	N-hat	upper
min	192.2	252.8	350.0
mean	220.8	287.7	412.4
max	249.3	334.4	484.0

Table 3.3: Conversion factors for generating population estimates based on numbers of frogs detected in VES. Data from six Visual Encounter Surveys of K22-23 provide a metric of frogs detected per minute of search time (detected /time). Two of those surveys only looked at one of the wetlands (i.e. K22 or K23) and are discounted from this process. For the surveys that looked at K22-23 together, dividing 'detected/time' by the different estimates of population size (lower 95% confidence limit, N-hat, upper 95% confidence limit) gives four values for a **conversion factor** which converts number of frogs detected during VES of a wetland into an estimate of population size for that wetland. The minimum, maximum, and mean values of these conversion factors are shown in the sub-table to the lower right.

In order to produce a range of estimates for the sum of population size at the wetlands surveyed by VES, five values of the conversion factor were used; (i) the minimum value of 'detected/time' divided by the lower 95% confidence value of the population estimate for K22-23; (ii) the mean 'detected/time' value divided by the lower estimate; (iii) the mean 'detected/time' value divided by the N-hat value; (iv) the mean 'detected/time' value divided by the upper 95% confidence estimate of population size; (v) the maximum 'detected/time' value divided by the upper confidence estimate (Table 3.3).

Applying these conversion factors to the VES data from the island wide monitoring provides estimates of population size for wetlands surveyed by VES only (Table 3.4)

	min-lower	**mean-lower**	**mean-N-hat**	**mean-upper**	**max-upper**
Round 1	616	708	922	1322	1551
Round 2	607	698	909	1303	1529

Table 3.4: Estimates of total population size for Kooragang Island wetlands surveyed using VES only (i.e. all wetlands except for K22-23 and K104). See text and Table 3.3 for explanation of the values in the five columns. The best estimate for population size at these wetlands is a little over 900 frogs; it is very likely that the population size is between 600 and 1550, and quite likely that the number is actually between 700 and 1320.

Summing the robust modelling estimates for rounds 1 and 2 at K22-23 and K104 gives a range of estimated population size for these two wetlands (values are based upon model #2 in both cases) (Table 3.5)

		lower	N-hat	upper
Round 1 (Dec-Jan)	K22-23	55	65	90
	K104	367	445	558
	total	422	510	648
Round 2 (Feb)	K22-23	85	114	165
	K104	309	393	515
	total	394	507	680

Table 3.5: Population estimates (N-hat) for K22-23 and K104 for each round, together with lower and upper 95% confidence values. The N-hat values suggest that there is a total of approximately 500 green and gold bell frogs at these two wetlands, and that the actual number is likely to be between 400 and 680.

Combining the estimates for the VES and CMR surveyed wetlands provides a range of estimates for the actual population size across all 78 wetlands surveyed on Kooragang Island over the 2015-2016 season (Table 3.6).

	min-lower	mean-lower	mean-N-hat	mean-upper	max-upper
Round 1	1,038	1,130	**1,432**	1,970	2,199
Round 2	1,001	1,092	**1,416**	1,983	2,209

Table 3.6: Estimates of total population size across all surveyed wetlands. See text for discussion.

The survey work indicates that there were approximately 1,400 green and golden bell frogs across the 78 surveyed wetlands during the 2015-16 season. It is important to note, however, that this figure is not a definitive population count; it lies within a range of likely estimates of the population size. It is not accurate to say that there are 1,400 frogs in these wetlands – rather**, it is accurate to say that there is a very highly likelihood that there are between 1,000 and 2,200 GGBF** in those 78 wetlands, and that it is quite likely that the actual figure is somewhere between 1,100 and 1,980. **Note that this population estimate does not include wetlands not surveyed, e.g. the NCIG CHEMP wetlands**, and that a total population estimate for the whole island should include the best estimates of bell frog numbers at those wetlands. A discussion of that total population figure is provided in the discussion (**Section 4**).

3.2 Demographic composition

3.2.1 What are the proportions of juveniles, adult males, and adult females?

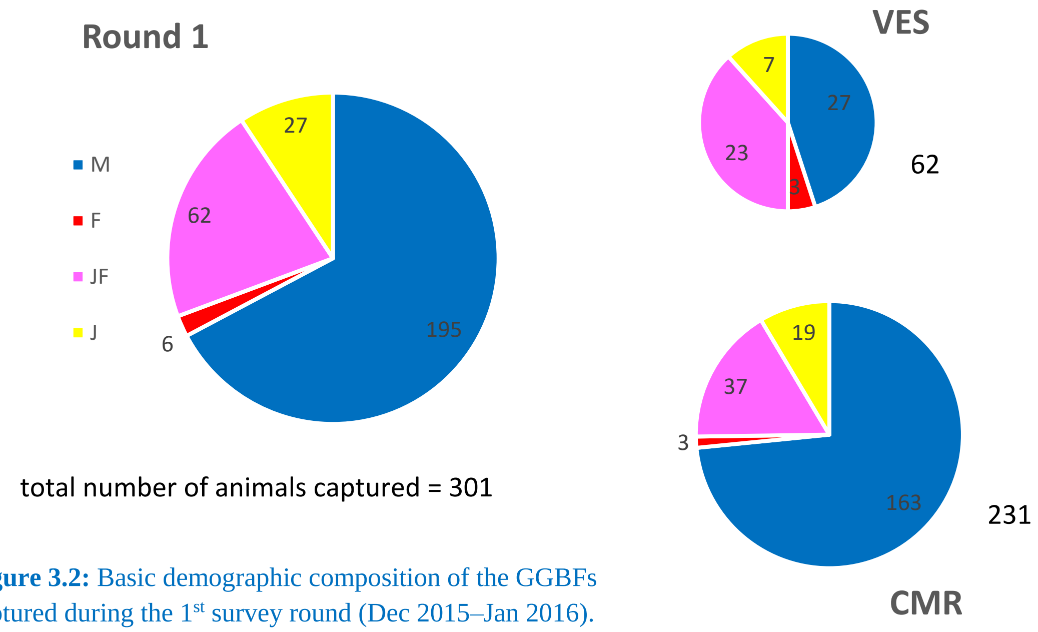


Figure 3.2: Basic demographic composition of the GGBFs captured during the 1st survey round (Dec 2015–Jan 2016).

Detection showed a bias towards males in the first round of surveys (December 2015–January 2016) (Figure 3.2), and towards females in the second round (January-February 2016) (Figure 3.3). A high proportion of juveniles towards the end of the second round (largely due to the CMR at K22-23 in late February) possibly indicates animals that were spawned in the early part of the season, prior to the rain of late December–early January.

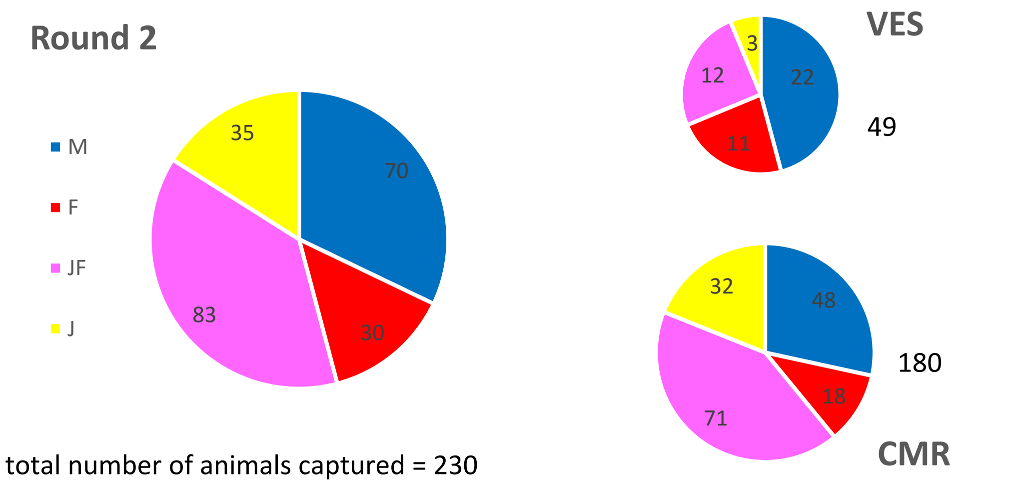


Figure 3.3: Basic demographic composition of the GGBFs captured during the 2nd survey round (Jan–Feb 2016).

The high proportion of males (74%) encountered in the round 1 CMR were mainly from K104, and were observed shortly after the early January rain when male calling behaviour was very high. Mainly males were encountered at large wetlands with open water; K104, K111, K113, K114, C1, K29, K105, K23, K25, and NWL.

Females dominated those wetlands that are postulated to be 'overwintering' sites (K29, K108), or smaller ephemeral wetlands (K8, K19, K17 in the Northern zone; K9A/B, K26, K20A, K21, K50 in the Central zone; K106B, in Industrial Zone). Small numbers of females were found at K102, K115, K116, K100A, and K100E.

Juveniles dominated captures at two wetlands: K22 and K9. A single juvenile was found at each of K58B and K103. Size classes indicate that most adult frogs are very young, i.e. between 6 and 12 months old. There is a small cohort of 1-2 year-old adults, and an even smaller cohort of >2 year-olds.

3.2.2 Size and age class frequency analysis

Histograms showing the frequency of different size and age classes can be used to visualise the cohort structure of the population (Figure 3.4).

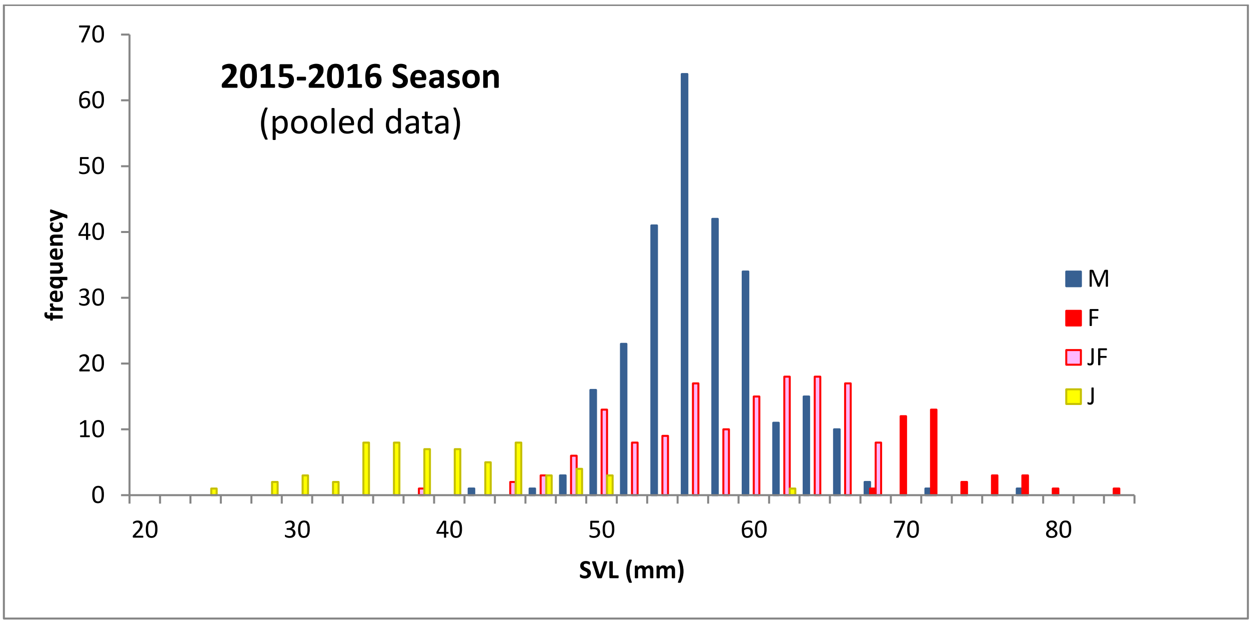


Figure 3.4: Visualisation of age cohorts by frequency analysis, using size classes as a proxy, for all 539 GGBFs captured during the 2015-2016 whole-island monitoring. Results do not include animals captured at the BHP or NCIG compensatory habitats. The chart shows the number of animals within 2 mm size (SVL) categories, broken down by the four groups (juvenile, juvenile female, adult male, adult female) shown in Figures 3.2 and 3.3 above.

More adult males are recorded than adult females, and adult females are larger than adult males. Several annual cohorts can be elucidated and their frequencies are normally distributed as expected for population measures. Juveniles represent individuals “born” in the season with an average size of 34-36 mm SVL. Juveniles with approximately 44-48 mm SVL indicate an early metamorphosing group and may represent the outcome of a spawning in early spring or possibly a group of overwintering tadpoles that metamorphosed early in spring of 2015. The adult males can be divided into two frequency peaks: one centred around 56 mm SVL representing one year olds, and the second around 64 mm SVL, representing 2 year old males. There are a small number of males (~78 mm SVL) that possibly represent three year olds. Among the females there are three cohorts; first year females (classed as juvenile females since they are not capable of reproduction) with an average size of 62 mm SVL, second year females with an average of 72 mm SVL, and group of third year females with an average of 78 mm SVL. The size frequency of females does not fit an expected normal curve frequency distribution, and this is most likely due to the small sample sizes for older adult females.

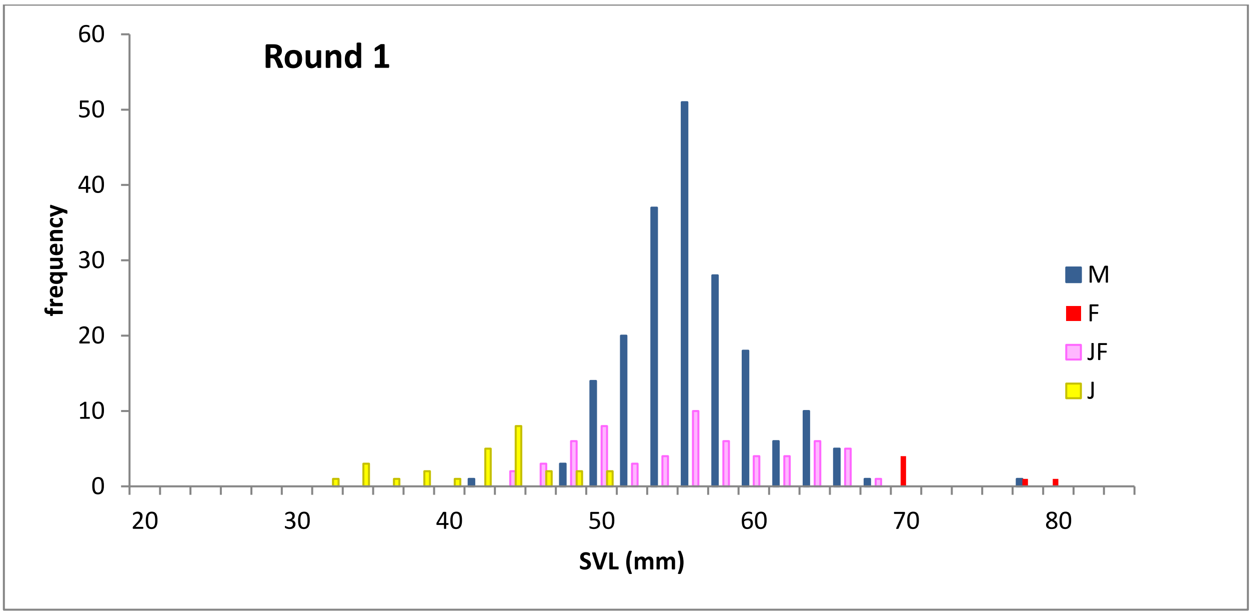


Figure 3.5: Frequency analysis of size classes for animals captured in the first survey round (December 2015-January 2016). See text for discussion.

Early in the season the size and age class structure of the population (Figure 3.5) was dominated by adult males (~56 mm SVL) which represent the first year cohort, and less abundant are second year males (~64 mm SVL). Females are less abundant and three age cohorts can be distinguished; a group of first year juveniles with an average size of 50 mm SVL, a group of juvenile females early in their second year (~56 mm SVL), but not yet adults, and a very small number of second year adult females. A small cohort of juveniles (44 mm SVL) were also present.

Evidence from several studies reveals that the difference in frequency of adult males and females is not due to a higher mortality of females in comparison to males; rather it is due to the higher detection probability of males in surveys (Hamer et al. 2008). Males occupy habitat around wetlands since this is where females must come to breed. Males use a mating call to attract females and in the GGBF they are observed to form choruses, and studies have shown that early in the season males are attracted to wetlands where chorusing is occurring (James et al. 2015, James 2016). Females do not move to wetlands until they are physiologically ready to mate, and therefore they are more dispersed in the landscape.

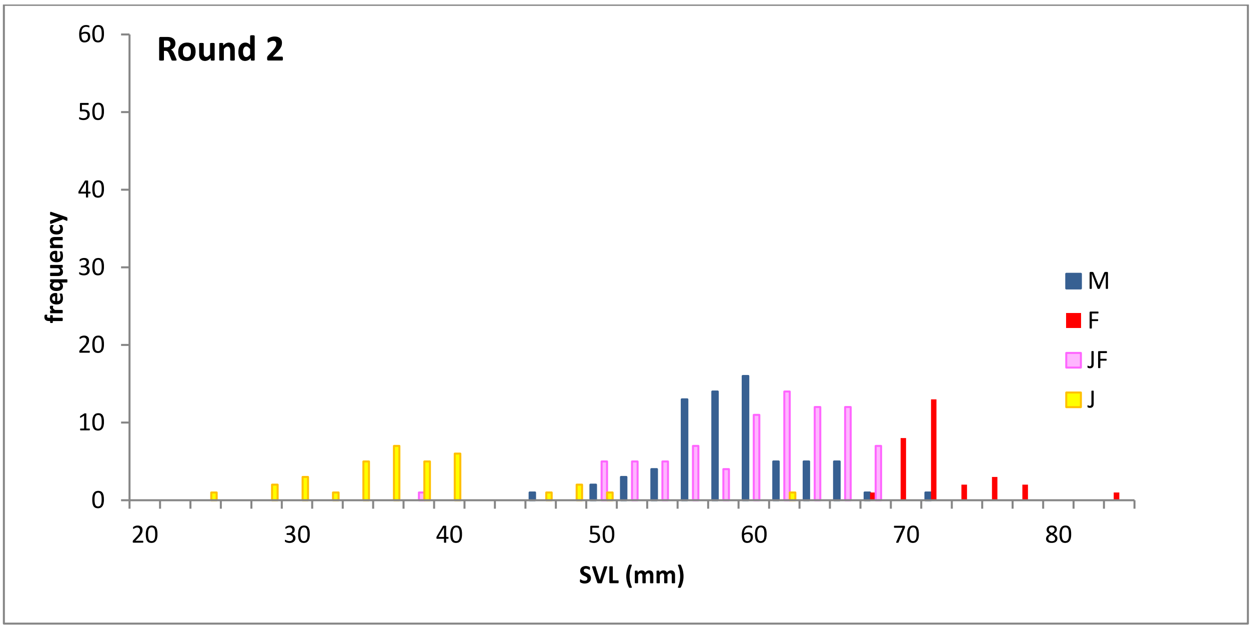


Figure 3.6: Frequency analysis of size classes for animals captured in the second survey round (January–February 2016). See text for discussion.

Size and age class structure had changed markedly by the second round surveys (Figure 3.6) which occurred in late summer. A new cohort of juvenile frogs with an average size of 36 mm SVL was present and these represent the offspring from a breeding event earlier in the season. Among the adult males, the first year cohort had grown and the average size was 60 mm SVL, and the second year cohort ~64 mm SVL. Juvenile females were found in almost equal abundance to the adult males and they also reveal evidence of growth over the summer season with the average size 64 mm SVL. Similarly, a larger number of adult females in their second year, with an average size of 72 mm SVL, were observed. The differences in female frequencies when compared to the earlier season surveys reflect a higher attendance at wetlands by females. At the same time there is a drop in the frequency of observation of males in the later season survey and males have moved away from wetlands at this time. Potential explanations are that the breeding season is coming to a close and males move away to forage, an observation that is supported by evidence that male choruses occur less frequently.

3.3 Persistence and movement

3.3.1 Persistence

In total, eighteen of the frogs captured in the 2015-16 season had PIT tags from previous seasons (Figure 3.6). Nine (seven males, one female, one unknown) of these were tagged one year previously, eight (seven males, one unknown) two years previously, and one (a male) was tagged in three years prior in August 2013. Persistence (recaptures between seasons) of individuals marked in the previous season (2014/2015) is low in captured animals during this season (3.3%).

Known persistent individuals were strongly biased towards males, which could be due to the higher detection probability for calling males in VES surveys around wetland. Adult females used habitats away from wetlands and are therefore not detected as readily in VES surveys.

All of these frogs were recaptured in 2015-16 in the same wetland they were originally captured.

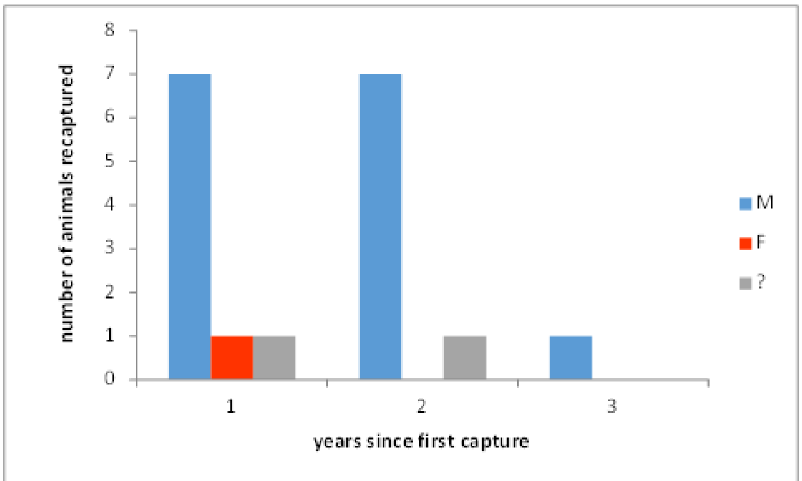


Figure 3.7: Observations of animals captured in the 2015-16 season that had been tagged in previous seasons.

3.3.2 Movements recorded for marked animals

Overall movement observations made of marked animals (e.g. animals >40 mm SVL) between wetlands was small relative to within wetland observations. For example, within the current 2015-16 season adult movements were only recorded between K22 and K23 (supporting the decision to treat these two wetlands as one single area in the Capture-Mark-Recapture analysis). On several occasions frogs were found along the road linking these two wetlands, again highlighting movement patterns between these wetlands. This was especially true in the second round in late February, where frogs were recorded in trees fringing the road linking wetland K22 and K23. Presumably these trees form a refuge during movements between wetlands.

Marked juvenile animals were released within the NCIG constructed wetlands in January and February 2016 to monitor dispersal of juvenile animals in the constructed landscape (John Paul King pers. obs.). In total, 15 movements were recorded ranging from only 30 meters between adjacent wetlands and up to 300 meters across various terrain, which in some cases included road crossings.

3.3.3 Movement to ephemeral wetlands

The movement of adult frogs from permanent to ephemeral wetlands during recharge events is an important component of the reproductive behaviour of GGBFs and may also be important in general dispersal movements. The physical structure of the habitat matrix including factors such as locality of ephemeral wetlands to occupied permanent wetlands and the number of wetlands may influence use of ephemeral wetlands.

In spite of targeted and intensive sampling to detect marked animals moving between these habitats, no large distance migrations were detected in adults throughout this season. There must have been numerous small migrations from permanent wetlands to nearby ephemeral wetlands, especially at the time of maximum male calling, but the source wetlands from which these animals come were not detected in the sampling.

Various parts of these results are consistent with the understanding that GGBF spend the winter in permanent wetlands, but move out to surrounding ephemeral wetlands following summer rain.

For example, movements between K22-23 and K63 are likely given results obtained this season. At K22-23 large numbers of frogs were recorded in early-mid December, but low numbers during VES in late January to early February. Appreciable numbers were not detected again until late February. Conversely, frogs were not recorded in K63 prior to wetland recharging in January but following this event were recorded in a large calling chorus, and eventually metamorphs were identified at this wetland in late February but no adults were present at this time. Given that both K22 and K23 are permanent wetlands occupied by large numbers of adults and are very close to K63 (40m and 100m respectively), and that K63 was shown to be a successful breeding wetland, that it may have been the source of juvenile frogs returning back to K23 and K23 would not be implausible.

In three separate locations adult movements from permanent to adjacent ephemeral sites coincided with major wetland recharge events (Table 3.7). A similar pattern of movement was also recorded in the NCIG constructed wetlands.

Table 3.7 details movements and evidence of breeding recorded during this season. This observed pattern is consistent with animals moving out of permanent wetlands to nearby ephemeral wetlands following the summer rain of early January, and moving back to the permanent wetland K22-23 with the approach of autumn. For example, a large calling chorus were recorded in K63 after the rain event had recharged this ephemeral wetland. Subsequently, large numbers of juveniles were detected at these wetlands in late February; and the evidence is that these animals were moving from nearby ephemeral wetlands where they had recently metamorphosed. We found no evidence of tadpoles or metamorphs at K22 or K23, although very small juveniles were recorded at these wetlands in the last days of the final CMR surveys in late February.

The permanent wetland K108 had very low numbers of frogs in mid-January. This was the first survey, and occurred after the early January rain event. In previous years this wetland has had high numbers of GGBF, and it is possible that when we surveyed it the frogs had already dispersed to surrounding ephemeral wetlands (e.g. K111, K112, K113).

Permanent wetland	Initial change in Permanent wetland occupancy	Adjacent ephemeral wetland	Adjacent ephemeral wetland type	Distance from permanent wetland (metres)	Initial change in ephemeral wetland occupancy
K22 & K23	Mid to late Jan adult occupancy reduced	K63	Brackish, relic saltmarsh habitats	40-100	Late Jan increase in adults resulting in successful breeding being recorded in Feb
NCIG Stage 4-1, 4-2 & 4-3	Mid to late Jan adult occupancy reduced	K7A	Brackish, relic saltmarsh habitats	55	Mid to late Jan increase in adults resulting in successful breeding being recorded in Feb
NCIG Stage 7-1 & 7-2	Mid to late Jan adult occupancy increased in both NCIG Stage 7 and K58B	K58B	Brackish, relic saltmarsh habitats	35	Mid to late Jan increase in adults resulting in successful breeding being recorded in Feb
NCIG Stage 4-10, & 4-11		Unnamed wetland associated with the mangrove corridor adjacent to 4-10 & 4-11	Brackish, relic saltmarsh habitats	135	Mid to late Jan increase in adults which did not result in successful breeding being recorded.

Table 3.7: GGBF movements recorded in the NCIG constructed wetlands. See text for discussion.

Similarly, the permanent wetland K29 had lower numbers of frogs than have been found in previous years. Our first survey was in mid-January, after the large rainfall event. We found very low numbers in mid-January, but higher numbers during the second survey in mid-February. During that second survey most of the frogs were found on the bank surrounding the wetland. We suspect that these were returning to the wetland from surrounding ephemeral wetlands (e.g. K106A, K106B, K106C, K103).

In addition to visual detection, calling was heard at numerous wetlands, especially in January and early February.

- Large choruses were heard at K104, C1, K103, K106C, and K105A, K58B.
- Calling was also heard along Bell Frog Track (K13/K20A, K20C), and in K25.
- Calling was heard from the new HDC wetlands within the rail-loop (K111, K113, and K114), and near K108.
- Calling was also heard from some wetlands that were not part of the survey:
    - In small flooded waterways on either side of Pacific National Drive, between K100A and K104 (north of the NCIG gates).
    - North of the mangrove that runs immediately north of the PWCS rail, in the region of K23 to K107
    - North of K13
    - East of K26
    - West of K9A/B
    - NCIG Stage 4,5,7
    - K2
    - K7a

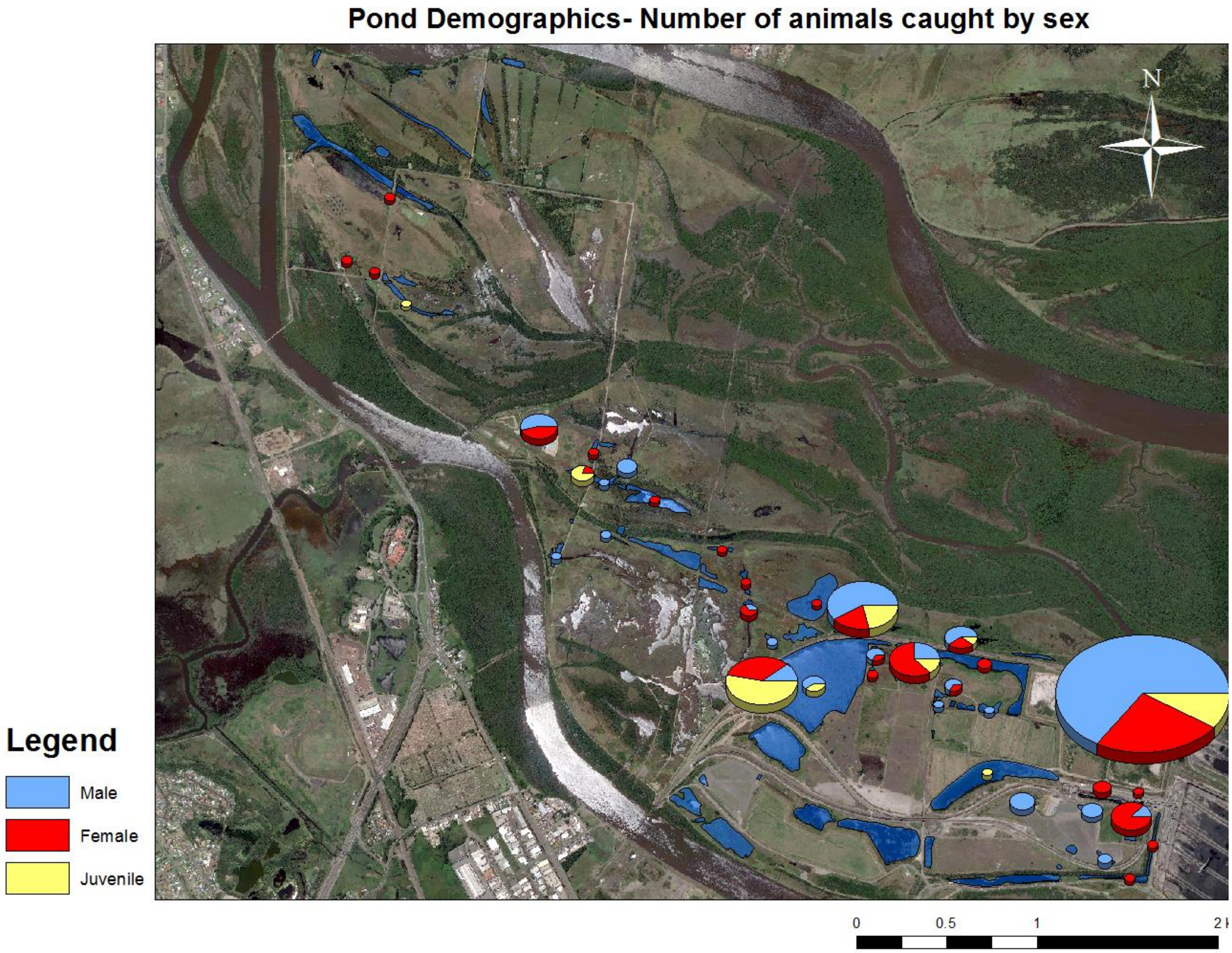


Figure 3.8: Basic demography of captured frogs, visualised by distribution across Kooragang Island. Data displayed includes captures from both rounds; VES and CMR data are pooled. The data shows that the area around the northern rail corridor of the industrial site is significant for the Kooragang Island GGBF population; the three largest circles correspond to K22, K23, and K104. The high proportion of juveniles at K22 are mainly animals that moved into this wetland from surrounding ephemeral wetlands – probably K63 – in late Feb 2016.

Note that the demographic categories used here are not identical to those used in Section 3.2 above; here, juvenile and adult females are shown together as 'Females'.

3.4 How do green and golden bell frogs utilise the landscape on Kooragang Island?

Note: the demographic categories used in this section are not identical to those used in Section 3.2; here, adult and juvenile females are categorised together as 'females'.

3.4.1 What is the distribution of GGBF on Kooragang?

The distribution of GGBF captured during all surveys, presented by basic demographic categories (i.e. Juvenile, Male, Female), are shown in Figure 3.8. Capture rates are shown as 'Search Sensitivity' (animals captured per unit of search effort) and serve as a proxy for the abundance of animals at the different wetlands surveyed (Figure 3.9). Green and Golden Bell Frogs were found more frequently in the Industrial zone, somewhat less so in the Central Kooragang zone, and to a lesser extent in the

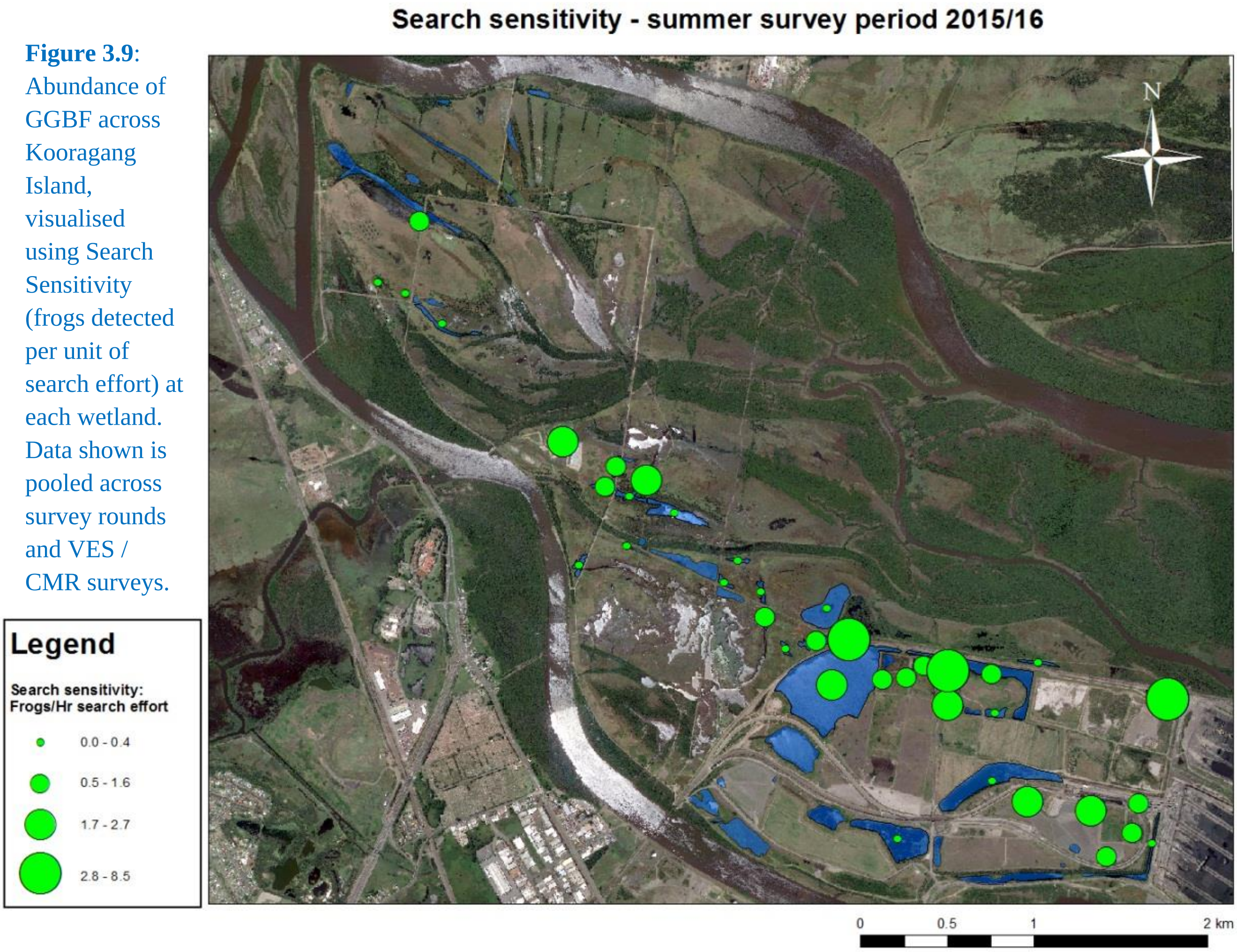


Figure 3.9: Abundance of GGBF across Kooragang Island, visualised using Search Sensitivity (frogs detected per unit of search effort) at each wetland. Data shown is pooled across survey rounds and VES / CMR surveys.

Northwest zone of the Island.

Visual Encounter Surveys detected 4 frogs in the Northwest, 129 in the Central zone, and 298 in Industrial Zone. Corresponding Search effort was 1,631 minutes, 3,403 minutes, and 5,023 minutes respectively. Net detection rates were 0.0025 frogs per person-minutes for Northwest Kooragang, 0.0379 frog/p-mins for Central Kooragang, and 0.0593 frogs/p-mins for Industrial Zone (or, 408 person minutes to find a frog in the Northwest zone, 26 person-minutes in Central zone, and 17 person-minutes to find a frog in the Industrial Zone).

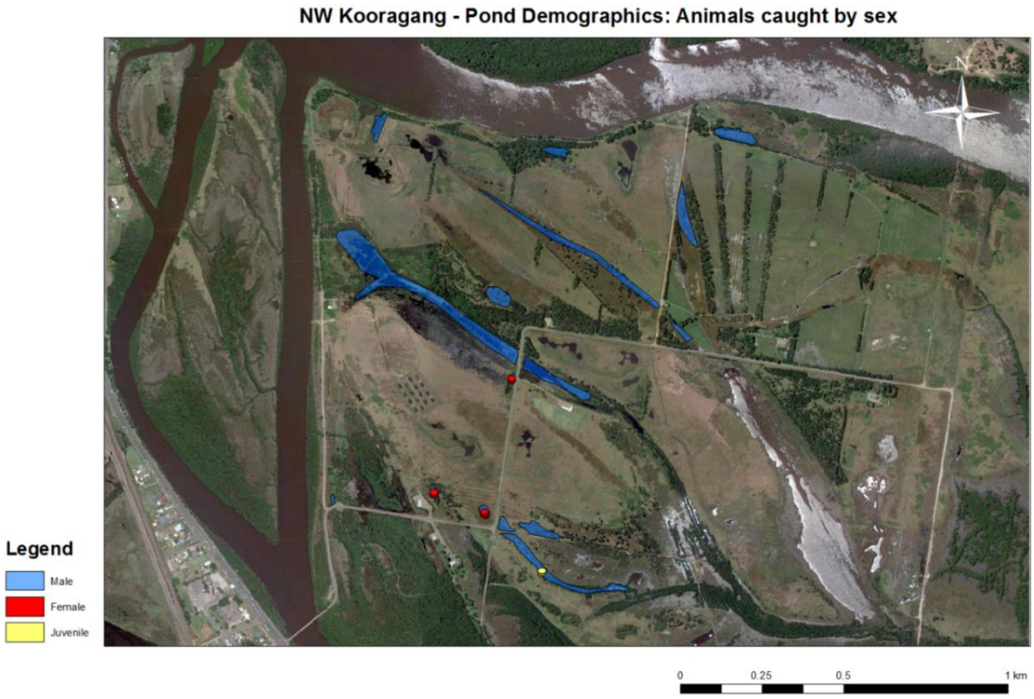


Figure 3.10: Distribution and basic demographics of captured GGBF in the **Northwestern** part of Kooragang Island. (Note. This only includes observations in the wetlands that have been historically surveyed in this zone, and does not include the observations and counts made in the 18 NCIG compensatory wetlands – see above).

The outcome of VES in the northwest zone follows the trend of the last season (2014/2015). Detection and distribution of bell frogs has increased in this zone, although the numbers are low relative to occupied wetlands in the southern zone. Surveys conducted in 2012/20013 and 2013/2014 (Clulow et. al. 2012, 2013, 2014) failed to detect bell frogs in VES surveys in the 14 "natural" wetlands (Figure 3.10). There are several possible reasons for the low numbers but most likely is the observation that these "natural" wetlands are classed as annual ephemeral or decadal ephemeral, and they do not provide permanent foraging and sheltering freshwater habitat. One of the largest wetlands (K2 and K17), which remained fully charged during the 2015/2016 summer season, is known to dry complete in years with below average rainfall. Indeed, in these years of low rainfall the only permanent freshwater wetland in the northwest zone is K3 and this wetland was historically modified and increased in size within the last 10 years. We have used the term "natural" wetland here since these wetlands are within natural swales and interconnected drainage depressions that are apparent in recent and older aerial photographs. However, the drainage and surrounding terrestrial habitats have been considerably modified over time by agricultural practices, road and drainage construction, such that their hydrology has been modified in ways that are difficult to quantify.

Construction of numerous large permanent freshwater wetlands within this zone as part of the NCIG Compensatory Habitat program for the GGBF (NCIG CH) should provide permanent freshwater habitats that have previously been absent in this zone. There is evidence that the frogs observed in this zone in the VES surveys are due to the reintroduction of bell frogs to the NCIG trial site and also to the compensatory wetlands. The occurrence of two breeding events in this zone in the 2015/2016 summer season (wetlands K58B and K7) are most likely due to the growth and maturation of juveniles/tadpoles released in the reintroduction program. The low numbers of frogs observed in the VES indicates that it will take some time for a robust population of bell frogs to be established in this zone.

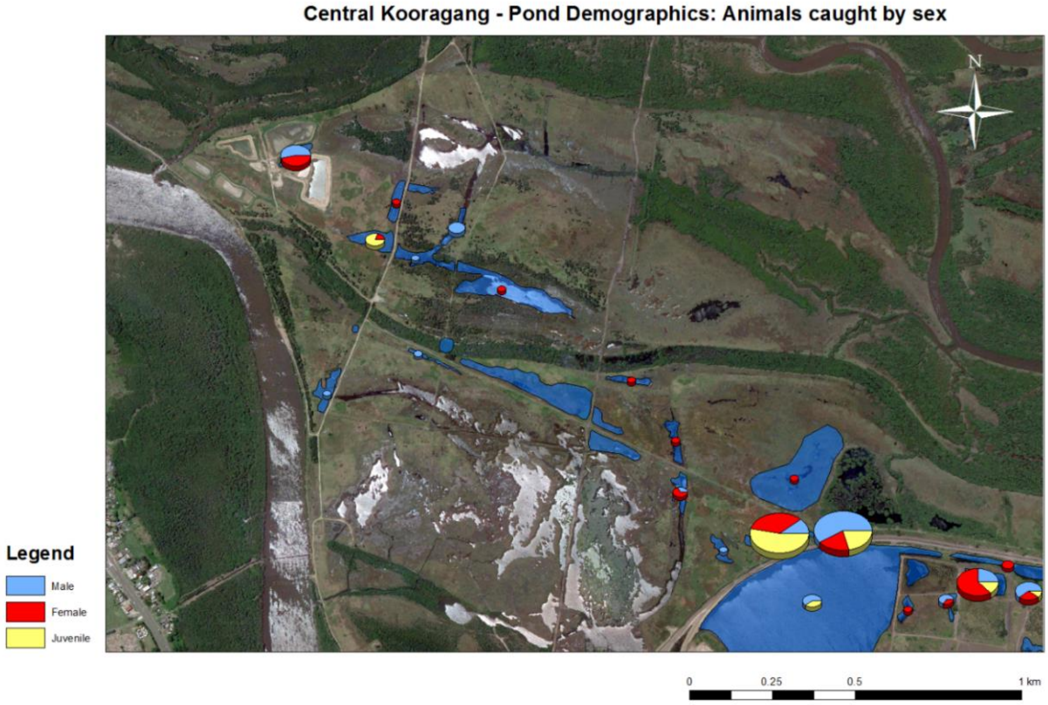


Figure 3.11: Distribution and basic demographics of captured GGBF in the **Central** part of Kooragang Island. (Note. This only includes observations in the wetlands that have been historically surveyed in this zone, and does not include the observations and counts made in the 18 11 BHP-Billiton NCIG compensatory wetlands – see above).

In the Central zone (Figure 3.11), VES detected frogs mainly in three zones:

i. K22-23 (which has been a hotspot for years)
ii. K9-K10-K25-K26 complex
iii. NWL.

In visual encounter surveys, K22-23 had the highest numbers (32 and 53 respectively), followed by NWL (19). Taken together, the K9-K10-K25-K26 complex had 13. Search effort was 869, 279, and 808 person-minutes respectively. Numbers were low in the other wetlands (mainly centred around Bell Frog Track; K11, K12, K48, K13 K20B, K20C, K21, K50); 13 frogs for a search effort of 1,447 person-minutes.

Occurrence of frogs in the Northern Wetland (NWL) was not unexpected since frogs have been detected there in the two previous island wide surveys (Clulow et. al. 2014; Campbell et. al., 2015). The area surrounding this ephemeral wetland has been extensively altered with the construction of the BHP-Billiton compensatory wetlands. These constructed wetlands provide permanent freshwater in a zone that lacks permanent freshwater, and they also provide a link between the northwest and eastern zones. Completion of the construction of these wetlands coincided with the commencement of the summer season of 2015/2016 and there is no reason that these wetlands would add to the island population estimate at this time. As with the NCIG compensatory habitat the BHP-Billiton constructed wetlands are subject to intensive monitoring and the outcome is reported separately. However, population estimates for these wetlands is included to the overall island population estimate.

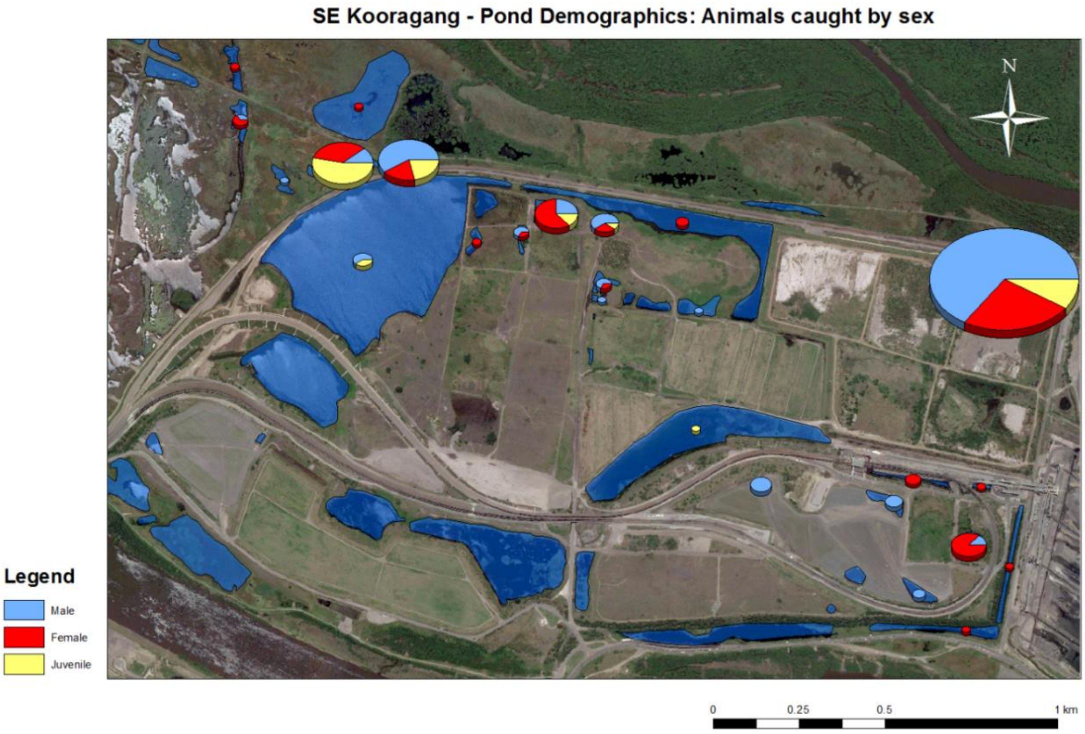


Figure 3.12: Distribution and basic demographics of captured GGBF in the **Southern** part of Kooragang Island.

In the Southern Zone (Figure 3.12), frog distribution is highest along the 'northern' rail corridor (K105A, K106, K29, K103, C1, K104), and around K108 ('the Rail Loop') and the new HDC wetlands (K11, K112, K113, and K114) within the NCIG rail loop.

Abundance was low in the 'southern' corridor along Cormorant Road (K100A, K100E, K100W, C2, K36), the old 'BHP' wetlands (K49A-B), and the wetlands in the SW corner (K46); total of 10 frogs detected for 1,322 person-minutes search effort. Apparently the new HDC wetlands on that western side (K117, K118) have yet to be colonised by GGBF. Note that we did not survey K44, K47, or K105B.

In the centre of this zone (along the NCIG conveyor dump house), we detected one frog in the large 'boomerang' wetland K102, but 8 frogs in the two NCIG 'conveyor 'wetlands (K115 & K116). We did not test for water quality, but it is doubtful that these conveyor wetlands would be considered high quality habitat - nevertheless, GGBF apparently make use of them.

3.5 Factors that affect distribution, abundance and recruitment

3.5.1 Recruitment

Evidence of recruitment at a wetland was limited to the presence of tadpoles and/or metamorphs. Eggs are difficult to detect, while calling indicates reproductive intent but not necessarily a result.

- Tadpoles were detected at six wetlands: K9C, C1, K106A, K106B, K58B and K113 (the latter being one of the new HDC wetlands within the NCIG rail loop)

- Metamorphs were detected at seven wetlands: K106A, K106B, K104, C1, K63, K7A and K58B

Note that the observation of metamorphs at K7A is not part of the standard island-wide survey, but is surveyed as part of a research project on the NCIG constructed wetlands. K63 is part of the island-wide survey but the observation of metamorphs at this wetland was made as part of the above research project (John Paul King's ongoing PhD studies). As the analysis of recruitment is qualitative rather than quantitative these observations are included here; however, the data prepared for the interim report indicate that recruitment was detected at 7 rather than 9 wetlands.

Taken together, this indicates two instances of recruitment in the North: two in the Central zone, and five in the Industrial Zone.

- There was a large recruitment of metamorphs observed in K106A and K106B; on February 11 2016 we detected large densities of tadpoles and metamorphs in shallow flooded grass. We estimated density to be >5 per square meter, i.e. >10,000 tadpoles and metamorphs across these two wetlands.

- The artificial wetlands in the southern zone also supported bell frog recruitment, with good numbers of tadpoles in two of the C1 wetlands (Cluster wetlands – six equal-sized landscaped aquaculture wetlands), and also in one of the new HDC wetlands (K113).

- Note that calling and tadpoles were reported by NICG staff in a small ephemeral 'puddle' by the road near the conveyor dump station (K120). We were unable to find GGBF tadpoles at this wetland but the habitat is consistent with GGBF presence, calling was heard in the area, and there are nearby wetlands where frogs occur (K102, K115, K113, K114).

- Mating pairs were seen at K104A (the rail service road on the north edge of K104 that tends to form long lasting ephemeral wetland) following heavy rain in early January, but no evidence of tadpoles or recruitment of metamorphs and/juveniles were recorded. Water levels were high enough in K104 to connect with K104A and *Gambusia* were seen in K104A. We postulate that this ephemeral wetland is usually free of *Gambusia* and that the large rainfall event in early January 2016 which resulted in the invasion of *Gambusia* to the ephemeral wetland may not be a common event. A metamorph and several juveniles were detected in the main part of K104 during February.

- Brackish swale sites in the northern zone were favoured for breeding sites this season (K7A & K58B). These ephemeral wetlands are adjacent to NCIG wetlands 4-1 and 7-1 respectively. In both cases recruitment of metamorphs and/juveniles was recorded. This behaviour follows a consistent pattern observed across the study site this season where GGBF occupying permanent wetlands (i.e. K23) dispersed into adjoining brackish ephemeral wetlands (in the case of GGBF in K23 to K63) to breed following the charging of these wetlands in January.

3.5.2 Chytrid

Ecological studies provide strong indications of the abiotic and biotic factors that affect GGBF distribution and abundance. At a landscape scale, the effect of the chytrid fungus disease has led to widespread reduction of the population in NSW, and range contraction to a small number of locations, contrasting with a previously widespread distribution across the state. Remaining population strongholds are generally coastal and many are on disturbed (industrial or ex-industrial) sites. The Kooragang Island population is an important one. Chytrid-linked mortality is highest in adults, and deaths occur during winter months. Various abiotic factors may mitigate the impact of chytrid; salinity, water quality, and ambient temperatures have all been linked. In terms of demography, chytrid appears to increase annual mortality to the extent that very few animals survive their second winter; however, females become reproductively mature at 2 years old. In chytrid-free populations, a significant proportion of the population is between 3 and 5 years old.

The ecological characteristics of GGBF are those of a 'weed' species; they seem to prefer disturbed habitats and are capable of prolific reproduction in suitable conditions.

Although the Kooragang Island population of GGBF is heavily infected with chytrid fungus (Stockwell et al. 2013, 2016), the fungus appears to affect all parts of the island. Thus, the distribution of frogs across the island may thus be primarily determined by other factors (although these may of course interact with the effects of the fungus in different ways). Three potential factors are:

- Wetland hydrology,
- Vegetation,
- Presence and abundance of the plague minnow *Gambusia*.

The effects of these factors are assessed in the following sections.

3.5.3 Wetland classification and hydrology

We have classified the wetlands investigated in this report following the Australian and New Zealand Environment and Conservation Council (ANZECC) system for classification of wetlands, which is based on that used by the Ramsar Convention for describing Wetlands of International Importance. All wetlands on the study site are under the group defined as “marine and coastal zone wetlands”, and within this group there are six wetland types found in the study area as shown in Table 3.8 below. Of course the study site is not an undisturbed system, and as such, the condition and/or classification of each wetland sampled in the study site is a variant of this classification system (something that will be quantitatively assessed over the coming 12 months).

	Marine and coastal zone wetlands					
	Decreasing Salinity →					
Wetland Types	Estuarine waters; permanent waters of estuaries and estuarine systems of deltas.	Intertidal marshes; includes salt-marshes, salt meadows, saltings, raised salt marshes, tidal brackish and freshwater marshes.	Intertidal forested wetlands; includes mangrove swamps, nipa swamps, tidal freshwater swamp forests.	Brackish to saline lagoons and marshes with one or more relatively narrow connections with the sea.	Freshwater lagoons and marshes in the coastal zone.	Non-tidal freshwater forested wetlands.
Examples of modification recorded in the study site	These are largely relic systems that once had a permanent connection with the marine environment but still retain saline influences through residual salinity. Whilst mangrove swamps are not directly involved in the sampling program, they are frequently adjacent to relic systems that support GGBF and therefore play a role in the study site. In addition, the removal of tidal flow, impoundment, excavation, reworking of the soil profile, dissection by roads and rail lines, filling with tailings and slag encompass the range of modifications to these wetland types in the study site.				Freshwater lagoons are absent from the study site. Marshes have been modified through impoundment, and dissection by roads and rail lines	A relative new addition to the communities of the site being absent from historical aerial photographs. Increase likely being a function of increased fresh water influence through tidal restriction and impoundment of local catchment flow.
Examples of wetlands sampled in this program	K7A, K48, K50, K23, K102, K100A	K58 A & B, K26, K13, K20, K13, K106 A&B, K29, K9A,B,C, K104	None sampled	K63, K107, K22	K6,K2,K7	None sampled

Table 3.8: Classification of wetland types present on Kooragang Island. See text for discussion.

Hydrology is the most important environmental driver of wetlands (Pressey and Adam, 1995). The hydrological regime that supports wetlands varies with wetland type, zone and associated environmental factors such as climate. In human impacted landscapes the historical changes to soil profiles, elevation, and changes to flow, such as impoundment, all impact on the present day regime. Within the study site there has been over a century of disturbance that has influenced the hydrological regime present today. The data presented here is preliminary and ongoing work will be undertaken over the coming 12 months to better define the hydrological characteristics of the study site. Notwithstanding, the wetlands of the study site fall into the following broad hydrological groups:

- Permanent, i.e. always holding water
- Seasonal, i.e. holding water during the summer of most years but drying out at some point in the year
- Decadal, i.e. usually holding water year-round, but drying out in very dry years (e.g. El Nino events).
- Ephemeral, i.e. periodically hold water for short periods of time (less than a season) and by definition, such environments are highly temporally variable as conditions fluctuate, often unpredictably, between flooding and drying.

Pressey and Adam (1995)

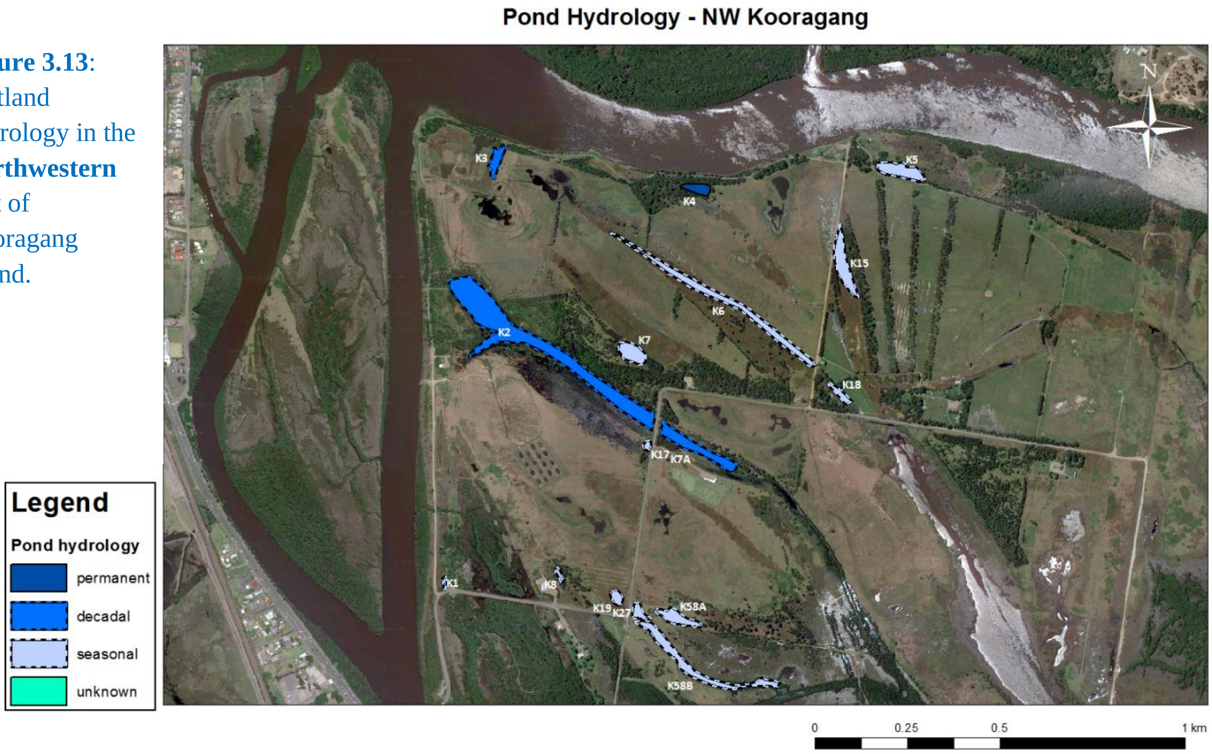


Figure 3.13: Wetland hydrology in the **Northwestern** part of Kooragang Island.

Pond Hydrology - Central Kooragang

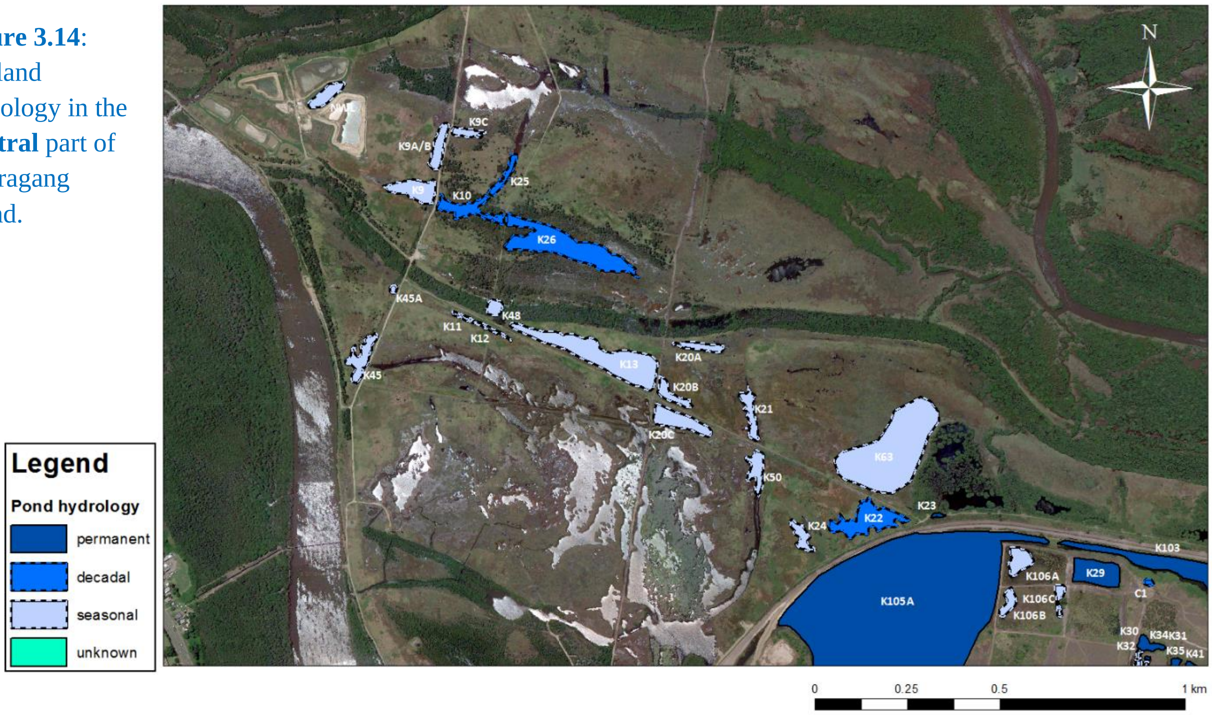


Figure 3.14: Wetland hydrology in the **Central** part of Kooragang Island.

Pond Hydrology - SE Kooragang

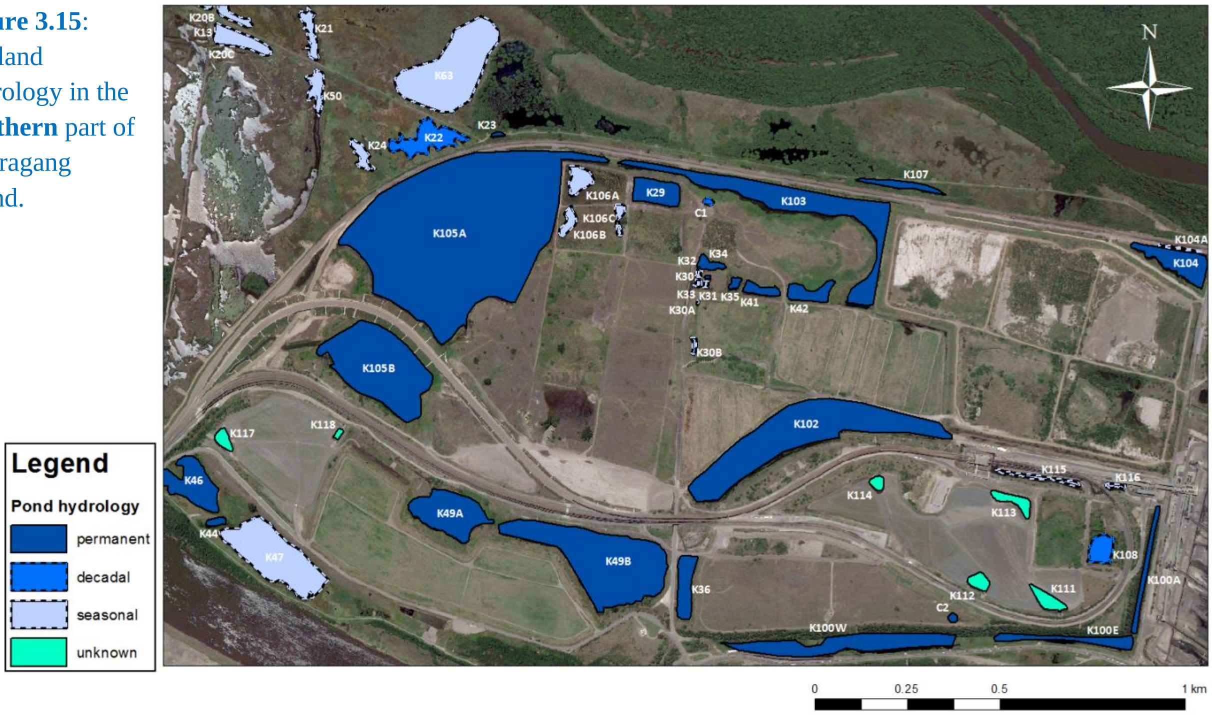


Figure 3.15: Wetland hydrology in the **Southern** part of Kooragang Island.

3.5.4 Vegetation communities and occupation by GGBF

Relationships between vegetation and occupation by GGBF of semi, permanent and ephemeral wetlands have been investigated across the distribution of the species over the last 20 years (Hamer et al 2002, JP King PhD in progress). Previous works on the study site have shown that the dominance of four flora species in a wetland (*Juncus kraussii, Schoenoplectus litoralis and Sporobolus virginicus*), and the absence of four (*Azolla sp., C.coronopifolia, Pennisetum clandestinum and Triglochin procerum*) and a diverse assemblage of bank flora species are related to GGBF occupation (Hamer et al 2002). More recently the introduced wetland flora species Juncus *acutus* has also been found to be positively associated with GGBF occupation on the study site (JP King pers. obs.).

Whilst the relationships between GGBF occupation and wetland flora species has been established for a long time (Hamer et al 2002), there remains an unresolved relationship between these flora species, the relic saline inundation that historically supported communities and wetland hydroperiod and GGBF occupation. Although research is underway to resolve this, there is evidence coming to light that supports a relationship between brackish wetland conditions and occupation by GGBF, especially in the case of breeding wetlands where relic saltmarsh flora communities remain (JP King, PhD in progress).

Brackish wetlands that overlay landforms that are relic saline influenced communities, for example, K22, K23, K104, K63, K106A&B are characterised by the presence of *J. acutus , J. kraussii, S. litoralis and S. virginicus, Bolboschoenus caldwellii, Sarcocornia quinqueflora, Phragmites australis* and to a lesser extent *Typha orientalis.* By comparison unoccupied wetlands are influenced by a sweet of flora species commonly associated with freshwater ephemeral conditions, such as *Azolla sp., C. coronopifolia, Pennisetum clandestinum, T. procerum and Paspalum distichum.*

During this season GGBF were only occasionally found more than 5 metres away from the wetland edge, the exceptions being:

- at K9, where they were found in dense but flattened grasses (possibly flattened by kangaroos),
- on the railway maintenance road between K22 and K23, where they were found in the branches of *Acacia longifolia* and *Chrysanthemoides monilifera subsp. Rotundata.*
- at K29 ('the Cell'), where they were found at the top of the embankment surrounding the wetland.

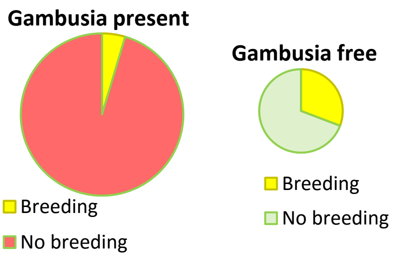
Non constructed wetlands (= ’natural wetlands’) confirmed as breeding sites this season (K9C, K106A, K106B, K58B, K7A and K63) are in all cases ephemeral relic saltmarsh communities, which once recharged remain inundated for approximately 6 weeks (JP King, PhD in progress). Floristically these communities are dominated by a mixture of *Sarcocornia quinqueflora, Bolboschoenus caldwellii, S.virginicus, and Triglochin striatum* and to a lesser extent *Phragmites australis*. Structurally these wetlands are open with areas of bare ground and when inundated flooded water submerges much of the grasses producing a structurally complex waterbody. Overall, the flora species present are low in height (<300mm) and generally taller species, such as *P. australis* are low and marginal, presumably due to a residual salinity gradient in the soil (Winning and Saintilan 1971, Winning and Saintilan 2009).

Constructed wetlands where tadpoles were detected include HDC site K113. This ephemeral wetland is dominated by planted grasses or have been colonised by local species. Species recorded include *Bolboschoenus fluviatilis, J.kraussii, Polypogon monspeliensis,* and *B,caldwellii.* Structurally these wetlands are open with extensive areas of bare ground and when inundated flooded water submerges much of the grasses and produces a structurally complex waterbody.

3.5.6 Relationship between GGBF occupancy and the presence/absence of *Gambusia*

Gambusia (plague minnows, mosquito fish) are present across the Island (Figure 3.16); recent widespread flooding in April 2015 apparently allowed them to disperse to wetlands that had previously been free of *Gambusia*. Whilst *Gambusia* are too small to predate on adult GGBF, they are capable of attacking eggs, tadpoles, and metamorphs (Morgan and Buttemer XXX; Pizzatto et al XXX).

- *Gambusia* were detected in 59 wetlands; only 19 of the surveyed wetlands are considered to be free of *Gambusia*.
- GGBF breeding was detected in three wetlands that have *Gambusia* (K9C, K104, K58B). Four of the seven wetlands with GGBF breeding were *Gambusia* free (K106A, K106B, K113, C1). Given the small numbers of *Gambusia*-free wetlands across the island, this suggests a link between breeding success and the absence of *Gambusia*, i.e. 31% of *Gambusia*-free wetlands had breeding compared with 5% of wetlands with *Gambusia* present (Figure 3.16).
- The four wetlands with the highest number of tadpoles/metamorphs were the four wetlands that are free of *Gambusia*. In particular, the very high numbers of tadpoles and metamorphs at K106A and K106B are noteworthy as these are large, shallow ephemeral wetlands with no *Gambusia* present.

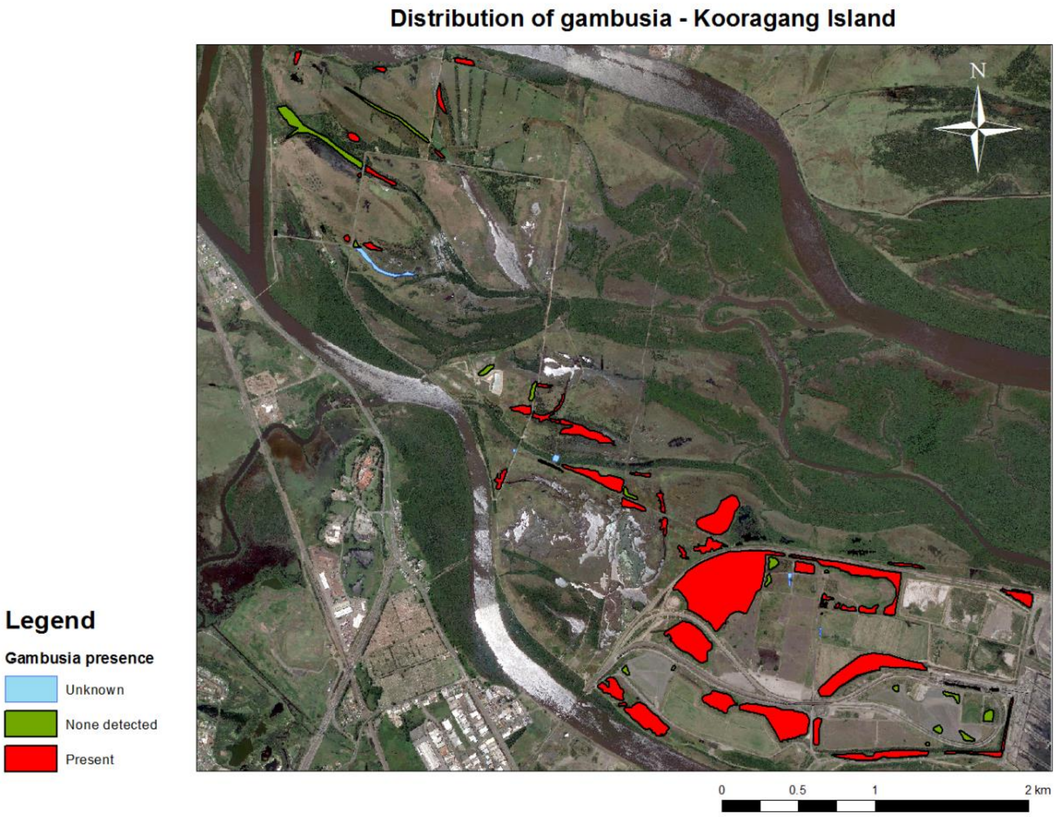


Total ponds with

Breeding	*Gambusia* present	No *Gambusia*
none	56	15
tads/mets	3	**4**
	59	19

Figure 3.16: Above left: Charts summarising the incidence of GGBF breeding in *Gambusia*-infested vs Gambusia-free wetlands.

Below: Wetland hydrology in the **Southern** part of Kooragang Island.



3.5.7 Other factors:

The effect of other factors on GGBF habitat use and breeding, such as weather, is difficult to uncouple. Night-time temperatures were consistently mild (low 20s °C) across the survey season, with only a small number of nights that were above 25°C or below 20°C.

4.0 Discussion

The annual island wide survey of the status of the GGBF population on Kooragang/Ash Island shows that the population remains relatively stable (Figure 4.1), with a slight increase in the estimated population estimate from the 2014/2015 survey. It is likely that the increased population size is due to the inclusion of wetlands constructed as part of compensatory habitat in the northwest, central zone and additional wetlands in the southern zone. A major rainfall event in early January of 2016 was associated with breeding in seven wetlands.

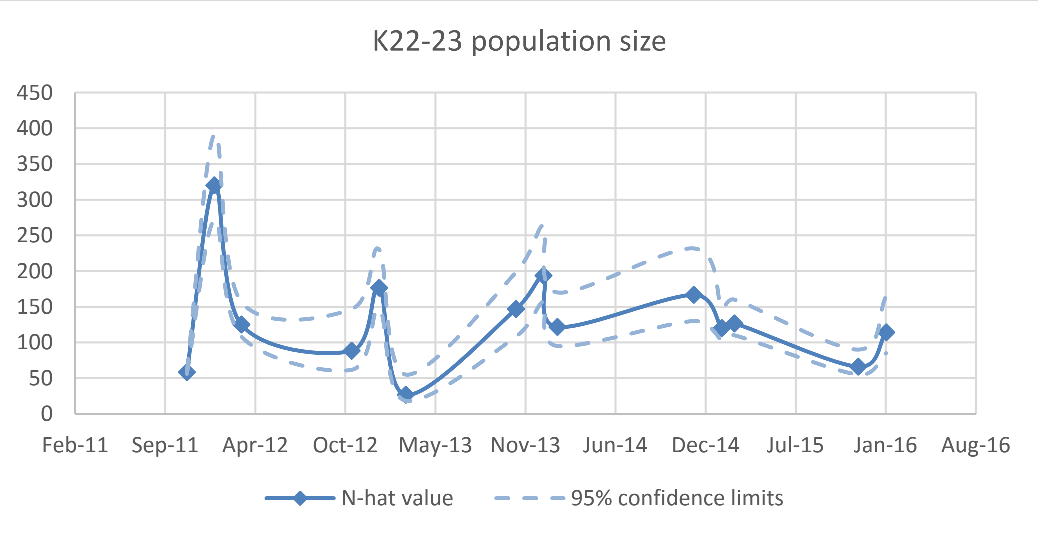


Figure 4.1: Estimates of population size (N-hat values – solid line) for the K22-23 wetlands from the summer of 2011-12 until 2015-16. Upper and lower 95% confidence limits are shown as dashed lines. Each group of 2 or 3 data points represents primary survey periods within a single season; there are 5 such groups. Within season variation is high. Estimated population size at K22-23 in 2015-2016 is slightly lower than the mean value for previous seasons.

4.1 Estimated and effective population size

The population estimate for GGBF on Kooragang Island has remained relatively constant over the past five years. Similarly, the distribution of the bell frogs on the island has remained somewhat constant with a group of wetlands showing high levels of occupancy over time, and conversely others rarely supporting frogs. What is least understood is that the population estimate and distribution alone can be misleading when considering a threatened species population. Perhaps as important is the demography of the population. In this case the important metric is the number and distribution of adult females in the population. Less than 2% of the population are adult females, and it is these frogs that are responsible for the annual reproduction that maintains the population. Greater than 80% of the population is made up of first year frogs, juvenile males and females, indicating that the population experiences rapid turnover. This turnover is not as drastic as an annual but comes close to that. In an annual species there are no adults over one year of age and if reproduction fails in one year the whole population would disappear. In a bi-annual species there are some adults over one year of age and if breeding fails in one year there are still some surviving adults a year later that could breed and maintain the population. In the latter case a series of poor years, perhaps due to unfavourable climate conditions could have a significant impact on the total population size and distribution. Thus in the Kooragang/Ash Island population the annual production of eggs which lead to tadpoles and new juveniles is based on only between 20 and 50 adult females that are in their second year. Why is it that the population has so few reproductive females? The most parsimonious answer is that the amphibian disease chytridiomycosis increases mortality to the extent that the chance of an individual frog, male or female, reaching two years of ages is less than 0.005%. Bell frogs are known to be highly susceptible to chytridiomycosis and the disease is widespread on Kooragang Island (Stockwell 2013), and its density is maintained by non-susceptible frog species.

The age class structure of the bell frog population on Kooragang/Ash Island is not the natural situation for this species. Comparison of the age-class demography of the bell frog population on Kooragang Island population with that on Broughton Island reveals that the number of adults on Broughton Island is an order of magnitude higher and furthermore there are females that are up to five years of age in the population (Campbell et al. 2015). The one significant difference between the populations on Kooragang Island and Broughton Island is that the chytridiomycosis does not occur on Broughton Island (Stockwell et. al. 2015). In the absence of the disease there is a higher rate of survivorship and frogs live longer, which in turn means that there is a higher reproductive output and a higher density of frogs in the wetlands on Broughton Island.

An intriguing question is to ask how the bell frogs manage to persist on Kooragang Island despite the presence of the disease organism which has caused the frog to disappear from almost all other region in its former distribution. We postulate that there is some form of habitat or environmental facilitation that occurs on Kooragang Island that swings the balance slightly in favour of the frog. Understanding how that habitat facilitation operates is key to maintaining the population and strengthening its resilience. This annual island wide monitoring investigation provides a critical view of the habitats that are used, the sites where successful breeding and recruitment occur, and the favoured wetlands used for foraging and sheltering by adults. Landscape features such as habitat connection and diversity are also seen to play an important role in persistence of the population. Lastly, while the predatory fish *Gambusia* is not considered to be the primary cause of the decline of the bell frog across its range (Hamer et. al. 2006), there is good evidence that predation on eggs and tadpoles has the capacity to reduce recruitment to the juvenile stage, and when overall survival is limited this loss may be significant.

As discussed above, great importance in conservation biology is put on two features of a population, its abundance and distribution. Abundance can be expressed as the census count or population estimate where a sampling strategy is used and relies on specialised field methods. An often non-discussed component of abundance is the population demography which breaks down the abundance into classes such as the age and gender structure of the population. Population demography provides special insights into the stages of a life cycle where mortality occurs which limits the overall abundance and distribution. For amphibians this has an additional layer since they have two stages in their life cycle, the aquatic embryo and tadpole stages, and the terrestrial juvenile and adult stages. The population estimate presented here reflects only the numbers in the terrestrial stage, juvenile and adult frogs. We examined the age-class structure of the terrestrial stage of the life cycle with the objective of understanding when in the life cycle mortality rates are highest, which in turn impacts on population abundance. There is strong evidence that high mortality rates during the terrestrial stages are responsible for the low population abundance and restricted distribution of the GGBF on KI/AI. Very few females reach reproductive age which occurs in their second season (18 to 24 months after metamorphosing). The cause of this high mortality in the terrestrial stages of the life cycle is the amphibian disease chytridiomycosis. Impact of the disease is not limited to females, but since males reach reproductive maturity in their first year (10 to 12 months) there are more males capable of reproducing and we believe they are not the limiting factor, since we observe them at many wetlands and male mating chorus are also observed at numerous wetlands. As mentioned above, the significance of the disease in limiting the female age-class structure can be seen in comparisons with the age-class structure of a population that is free of the disease. On Broughton Island the GGBF population, which is free of chytridiomycosis, the proportion of females over two years of age is up to ten times higher than on KI/AI (Campbell 2015). Female survivorship translates to a higher output for the population which in turn results in higher abundance and distribution.

Viewed from the prism of population demography the KI/AI GGBF population is in a tenuous situation. Only a small percentage of females (>1%) reach reproductive maturity. To counteract this low level there is a need to boost the overall population size and habitat occupied to provide resilience to the population in the face of the disease. Mirroring the low percentage of reproductive females is the small number of wetlands where breeding occurs (7 out of 72 wetlands surveyed). It is very difficult to uncouple whether this low number is a function of specific habitat selection by adult females and males or of the low numbers of reproductive females per se. Until effective means to mitigate the impact of the disease are discovered the most effective landscape strategy is to enhance the resilience of the population by managing all factors that limit survivorship at every stage of the life cycle of the GGBF. There are factors that can be managed. Construction of permanent freshwater wetlands, connectivity among wetlands and the strategic placement of permanent and ephemeral wetlands, and a mixture of fresh and saline influences in ephemeral wetlands, provide the most effective means to enhance the necessary habitat features for the GGBF. Limiting mortality in the larval stage by managing the invasive fish *Gambusia* is another.

4.2 Additional survey data (NCIG CHEMP)

NCIG Wetlands

Frogs detected	297
Frogs captured	185
Unique frogs captured	184

The NCIG Compensatory Habitat Program (CHP) resulted in the construction of eighteen wetlands in the northwest area of KI/AI which were completed in mid to late 2014. These were constructed in seven stages and each stage consists of a cluster of wetlands with a mixture of permanent and ephemeral wetlands. In most cases the permanent and ephemeral wetlands are interconnected by lower areas that are designed to enable interconnection at the time when the wetlands are charged. Prior to the construction of these wetlands a trail plot was established with 16 wetlands in an area approximately one hectare in size. The trial plot consisted of equal numbers of permanent and ephemeral wetlands, and was surrounded by a frog proof fence. Bell frogs were introduced to this trial plot over a two year period and the consequent population was closely monitored. Two important pieces of information were garnered from the trial plot; firstly, bell frog tadpoles and juveniles were found to survive in the constructed wetlands indicating that there was no fundamental difficulty with the proposal to construct freshwater wetlands in the north western area of the island; and secondly, growth and development of the frog proceeded to the occurrence of successful breeding in the third summer of intensive investigations at the trial plot.

The NCIG CHP wetlands were included in island wide monitoring that involved the standard VES method. In addition to the island wide monitoring these wetlands were also subjected to intensive investigations, the results of which are not included in this report, since inclusion would bias the population estimate method adopted over preceding island wide monitoring reports. We emphasize that the standard method applied continues to provide important comparative information on the occurrence of bell frogs in wetlands on the island and the estimated overall population size.

Three major observations are made about the bell frog population in the northwest of the island. Up to five years ago GGBF had all but disappeared from northwest of the island, as determined by routine surveys and previous island wide monitoring (Clulow et. al., 2012, 2013). Reintroduction of bell frogs to the NCIG trial plot and then subsequently to constructed wetlands has provided a large number of propagules to this area. In 2014-2015 summer season animals from the trial plot were responsible for breeding in the nearby NCIG compensatory habitat. In 2015-2016 season breeding was not detected in the trial plot wetlands or in any of the NCIG CH wetlands, however, breeding was observed in two “natural” ephemeral wetlands (K7A and K58B). In K58B the distance from the nearest constructed wetlands is less than ten meters, and in K7A the distance is about 60 meters. Adult bell frogs were found occupying the constructed wetlands. Breeding was triggered by an exceptionally large rainfall event in January of 2016, and under these climatic conditions the bell frog disperses to ephemeral sites to breed. Without the permanent wetlands constructed as part of the NCIG CH program and the reintroduction of bell frogs to this site there would have been no adult bells frog in the ecosystem to enable the observed breeding. One of the habitat features historically absent from the north west of Kooragang/Ash Island is dispersed, permanent freshwater wetlands that provide habitat for bell frogs over much of their life cycle.

To effectively incorporate the NCIG CH wetlands in the island wide monitoring program the approach will be to include the results of VES at seven wetlands, one selected from each of the stages. Observations will also be made of the occurrence of *Gambusia*, calling activity and evidence of breeding. A separate population estimate is conducted for the NCIG CH and Trial plot as part of an intensive research program on the effectiveness of habitat construction and reintroduction programs to conserve the green and golden bell frog. Information and outcomes from this study are available from NCIG.

Estimation of the GGBF population size on the island is also effected by the compensatory habitat works undertaken by BHP-Billiton in the central zone of the island on land under the jurisdiction of NSW National Parks (see Figure 2.4). This habitat was constructed during 2015 and the ground works were completed in the spring of 2015. At completion several of the wetlands contained water derived from groundwater and others remained dry until summer rains in early 2016. These wetlands were subject to intensive monitoring by BHP-Billiton and the population estimate for the site was 32 individuals (CI ±

29 to 33)(James 2016), based on the same CMR methods applied in the island wide monitoring (this report). This number is added to the population estimate derived in the island wide surveys.

A chorus of adult males was observed in one cluster of constructed wetlands with a maximum count of 19 individuals. In addition, a small number (4) of males were observed calling in another wetland cluster, and subsequently tadpoles were trapped in one wetland in this cluster (Mahony and James 2016).

Only one adult female was observed at the site during the intensive CMR surveys. Visual encounter surveys conducted as part of the island wide surveys (this report) in the Northern Wetland (NWL), which is adjacent to one of the BHP-B CH wetland clusters, resulted in the detection of five juvenile females under the age of 12 months (54.5–60 mm SVL).

Although the BHP-Billiton compensatory habitat wetlands are not included in the island wide surveys they represent an important component of the larger conservation strategy to increase the population resilience (distribution and abundance) within the conservation lands (Kooragang Island NP), and also to provide a corridor of freshwater wetland habitats in the central zone of the island. Observations of occupancy of these wetlands and the occurrence of breeding provide early signs that this strategy is effective.

4.3 Specific management issues at Industrial Zone

i. The 'northern' rail corridor

- At present, this is the stronghold of the GGBF Kooragang population.

  Activities in this area can potentially have a large impact on the Kooragang GGBF population. Mitigation strategies should commence early to minimise any negative effects of development activities upon the population. Potentially, a network of alternative habitats, with high connectivity to the existing wetlands, will promote dispersal of GGBF from the existing wetlands of the northern corridor. This will require careful planning, construction of artificial habitat, and will need several seasons. Evidence from the construction of the NCIG compensatory habitat (northwest zone) and BHP-Billiton compensatory habitat (central zone) show that the addition of permanent freshwater wetlands supports the persistence of GGBF in these areas where they were previously uncommon or had declined.

  The distance between permanent and ephemeral wetlands is also an important component of effective habitat for the GGBF. This connection is often termed the habitat mosaic, and consists of permanent wetlands where adult and juvenile GGBF forage and shelter, and nearby ephemeral wetlands where they show a preference for breeding.

ii. Status of the 'southern' corridor

- The current low numbers of frogs along the southern edge of Industrial Zone likely results (at least in part) from low connectivity with the more densely inhabited wetlands along the northern edge. Increasing numbers of frogs in this corridor will require improved connectivity, ephemeral wetlands that are suitable for breeding, and sheltered 'overwintering' wetlands.
- The low number of GGBF using the BHP-B wetlands (K49A and K49B) is difficult to understand, but is consistent with surveys in the past 2 years. The large size, suitable aquatic and terrestrial habitat of these wetlands would suggest they should support GGBFs. It is most likely that lack of connectivity and not habitat quality is the factor most responsible for low numbers in this habitat.

iii. Potential for translocation / constructed habitats to enhance the Southern Corridor Capping of area to south-east of K105A

- HDC is scheduled to cap the large area between K105A, K106B, K29, and K36. Incorporation of constructed wetlands, similar to those constructed within the NCIG rail loop in 2015, are likely to provide important habitat for GGBF.
- The proximity of this new capping to the 'northern rail corridor' and K106 (see below) may provide opportunities to enhance the GGBF population in the middle part of the Industrial Zone, and minimise the impact of the proposed development along the northern corridor.

iv. K106:

- The observation of a large breeding event at K106A and K106B this year emphasises the importance of ephemeral wetlands that provide shallow, flooded and *Gambusia* freehabitat. Coincidently it also shows that dense reeds are not an essential component of breeding habitat.
- The raised walls around each of these wetlands were probably what kept *Gambusia* out during the April 2015 flood, and are thus an important feature of these wetlands.
- Given the large recruitment event in the 2015-16 season, we predict that the population around these wetlands will be high in 2016-17; as with K104 this year (see (v) below) following a large reproductive event in 2014-15, most animals will be < 12 months old. This recruitment pulse in the middle part of the Industrial Zone site may present opportunities relating to (ii) and (iii) above.

v. K104:

- At present, this is the wetland on Kooragang Island with the highest number of GGBF.
- Most frogs are young, following a large reproductive event in the summer of 2014-2015.
- Minimal reproduction was observed in the 2015-2016 season, despite extensive rainfall and the observation of a large number of adult males at the wetland.
- The larger permanent wetland falls under PWCS jurisdiction, but the ephemeral wetland that occurs on its northern boundary after heavy rainfall is within the rail corridor (under the management of the Australian Rail Track Corporation - ARTC). ARTC use the nearby car-park and control the rail corridor. The ephemeral wetlands (designated K104A), which may be an important breeding habitat, lies partly within the rail corridor. Given the high turnover of the GGBF population, failure of breeding again in 2016-2017 may lead to a population crash at this wetland; this would have serious consequences for the standing population on Kooragang Island.
- Given the importance of this wetland at present, the environmental management of the wetland should be coordinated by the different organisations with environmental responsibility for this area. At present, this is a matter for improved communication for example, several wattle trees adjacent to the rail corridor were felled in February 2016 without any consultation with PWCS.
- More than 200 frogs were PIT tagged at this wetland this year; these may provide valuable data on survivorship and movement next year (see below).

4.5 Knowledge Gaps

Although understanding of GGBF biology and the Kooragang Island population has improved with the last decade of research, there remain some important questions.

1. What is the optimal habitat mosaic for GGBF? In particular, how can the northwest part of the island be managed for higher numbers of frogs? Will increasing the number of permanent wetland, and the provision of Gambusia-free permanent and ephemeral wetland lead to increased numbers?

2. Although it seems likely from the data presented here that *Gambusia* has some effect on GGBF recruitment, this point has been controversial in the past since it is evident that this predator is not the prime cause of the widespread decline in GGBF populations (Hamer et al. 2013, 2014). The answer to this question is of importance to the Kooragang GGBF population - since *Gambusia* can potentially be managed and eliminated from some wetlands, it is important to the efficacy of this strategy.

3. Meta-Population dynamics: despite considerable effort spent on PIT tagging frogs, we have very little direct information on the movement of GGBF across the Kooragang landscape. Understanding the movement of frogs between wetlands, and how far they can move, is of vital importance in determining landscape connectivity, the extent of meta-population structure across the Island, and in assessing the potential impact of any development. PIT tags are appropriate technology for frogs but rely on recapturing individuals, and whilst recapture works well across a limited time of intensive sampling at a specific wetland, recapture rates at larger spatial-temporal scales are low. That said, the large number of animals tagged at K104 this season may provide enough animals to detect survivorship and movement in the vicinity of K104 next season. Radio tracking removes the need to regularly recapture animals, but bell frogs have been found to be sensitive to the attachment of radio transmitters (Stockwell et al. 2006a, Stockwell and Mahony 2007, Stockwell 2011). An alternative approach that could provide the necessary information is an analysis of population genetics across the Island; this is logistically feasible with current technology.

5 Acknowledgements

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Appendices

A. Survey results by wetland

B. Robust Modelling methods

C. Graphics presented in Interim Report (June 2016)

APPENDIX A – Survey results by wetland

Region	Jurisdiction	Wetland	Detected	Search time	Search effort	Breeding
North West	NPWS	K1	0	25	64	
		K15	0	34	68	
		K16	0	25	75	
		K17	1	17	51	
		K18	0	47	94	
		K19	1	24	72	
		K2	0	64	350	
		K2/K2S	0	31	86	
		K27	0	22	66	
		K3	0	30	90	
		K4	0	44	88	
		K5	0	39	99	
		K58A	0	32	96	
		K58B	1	40	120	T
		K6	0	19	57	
		K7	0	26	78	
		K8	1	28	77	
Central	NPWS	K10	1	61	149	
		K107	1	42	101	
		K11	1	35	70	
		K12	0	15	30	
		K13	0	45	179	
		K20A	1	44	132	
		K20B	1	31	119	
		K20C	1	35	70	
		K21	1	34	122	
		K22	92	413	1428	
		K23	127	334	1049	
		K24	1	30	90	
		K25	4	20	48	
		K26	1	61	207	
		K45	1	35	89	
		K45A	0	14	35	
		K48	0	11	33	
		K50	3	51	162	
		K63	1	43	215	
		K9	5	50	180	
		K9A/B	2	29	105	
		K9C	0	31	119	T
		NWL	19	73	279	

Region	Jurisdiction	wetland	Detected	Search time	Search effort	Breeding
T4	(BHP)	K46	0	58	232	
		K49A	1	46	163	
		K49B	1	55	220	
	HDC	K108	23	239	888	
		K111	2	26	52	
		K112	0	21	53	
		K113	5	35	70	T
		K114	9	54	117	
		K117	0	20	60	
		K118	0	16	54	
	NCIG	K115	6	66	188	
		K116	2	18	48	
		K120	0	7	18	
	PWCS	C1	14	25	85	T, M
		C2	0	40	110	
		K102	1	53	159	
		K103	4	70	140	
		K104	913	1300	2696	M
		K105A	5	49	147	
		K106A	0	44	132	T, M
		K106B	1	15	33	T, M
		K106C	3	43	129	
		K119	0	15	35	
		K29	29	419	1334	
		K30	0	14	35	
		K30A	0	43	103	
		K31	1	18	43	
		K32	0	15	37	
		K33	3	28	62	
		K34	0	20	48	
		K35	0	34	82	
		K36	0	58	172	
		K41	0	32	64	
		K42	0	56	138	
		S7	0	17	46	
	RMS	K100A	1	49	147	
		K100E	2	54	162	
		K100W	0	49	116	

Search Time is shown in minutes, **Search Effort** is shown in person.minutes. **Breeding** is recorded as the presence of tadpoles (T) and/or metamorphs (M).

Note that, in the Central Region, four wetlands are actually under the jurisdiction of the Port of Newcastle (PoN) : K22, K23, K24, and K107. This information was discovered during the finalisation of this report and so we have not adjusted the presentation of the data to reflect this, but the role of PoN will be incorporated into future reports. Two of these wetlands (K22, K23) are significant Green and Golden Bell Frog habitats.

APPENDIX B – Robust Modelling Methods

Capture-Mark-Recapture Surveys

Visual encounter surveys alone are inertly affected by imperfect detection of animals. Imperfect detection has two components, exposure to sampling and detection probability (Dodd 2010). Exposure to sampling describes the ability of an animal of being sampled. For example, an inactive individual is probably sheltering and hence less likely to be detected. Similarly, a frog under water or in the middle of the wetland is also less exposed to being sampled. The other component, detection probability, refers to the likelihood of an individual that is exposed to being sampled to actually be detected during the survey. One way of dealing with this is by using capture-mark-recapture surveys. These involve the capture, marking and recapture of animals, and the proportion of recaptured animals that were marked is then used to estimate the population size (Amstrup, 2005).

Capture-Mark-Recapture surveys were conducted at four water bodies on Kooragang Island (K22, K23, K29 and K104; see Figure 2.1) known to have high densities of green and golden bell frogs. Because of their proximity, K22 and K23 were treated as a single population for the purpose of these surveys. An initial survey was conducted at K108 (Rail-loop) but recapture rates were too low to warrant further CMR surveys at this wetland and that data was not included in the robust modelling analysis. Surveys were conducted in December 2015, and January and February, 2016. Survey methods were as described in Section 2.2 of the main report.

Capture-Mark-Recapture surveys were conducted at two temporal scales in order to estimate population size multiple times within the one breeding season using Pollock's robust design (Amstrup et al. 2005). Primary survey periods were conducted in December, January and February which are separated by long intervals during which migration, mortalities and recruitment within the population may occur. Within each of these primary survey sessions, 3 to 5 secondary surveys occurred with less than 48 hours between them; these shorter periods were assumed to be closed to migration, mortality and recruitment. The number of secondary survey conducted at each wetland within each primary survey period was dependant on the number of recaptures. Surveys were continued until a minimum of 20% recaptures were obtained, but a much higher recapture rate (up to 70%) was ideally sought. By ensuring a minimum 20% recapture rate and incorporating both open and closed periods in the one model, the overall estimates are more robust (Pollock 1982, Amstrup et al. 2005, Nichols 2005).

Modelling population size and apparent survival (intra and inter-season) using mark-recapture data

Apparent survival and population size estimates were modelled using Pollock's robust design. Pollock's robust design is able to be used to estimate population size at each primary period (N), apparent survival probability between primary periods (φ), temporary emigration between primary periods (γ), capture probability (*p*) and recapture probability (*c*). It is important here to understand that apparent survival (φ) is inherently different to true survival. Apparent survival consists of two elements – deaths and emigration – that are not separable without directly measuring emigration or death independently in some way.

Robust design has a number of assumptions including: that capture and survival probability are independent of one another; secondary survey periods are closed to migration, mortalities and recruitment; marks are unique and are not lost; and survival probabilities are equal between individuals (Pollock 1982, Amstrup et al. 2005, Nichols 2005). For the purposes of modelling sparse data, the assumption was made that capturing and marking individuals did not alter their capture probabilities, and so *p* was made to equal *c* in many models (although these were also tested separately to see if improved, sensible estimates could be formed). The probability of temporary emigration occurring was also forced to equal zero which allowed abundance, survival and recruitment to be estimated for all sampling periods, maximising the number of estimable parameters. Standard goodness of fit tests used to test the assumption that every marked animal in the population has the same probability of recapture and survival is not available for robust design models (Burnham and Anderson 2002).

Apparent survival across the season was modelled for K22 and K23 and K104 using the above Robust Design approach. An *a priori* set of candidate models were fit to each data set to identify the most parsimonious model. Base models were created in program MARK, version 6.1 (White and Burnham 1999) with combinations of time varying (t) and constant (.) survival and capture/recapture probabilities and population sizes. Base models were created and the best model selected using Akaike information criterion corrected for small sample sizes (AIC_c) (Burnham and Anderson 2002). Models were ranked from lowest to highest AIC_c and ΔAIC_c values were calculated by subtracting the lowest AIC_c score from that of each of the other models. Models with ΔAIC_c of less than two were considered to be the best of the candidate set in representing reality (Burnham and Anderson 2002). Akaike weights (*w*) were also calculated to quantify the relative strength of evidence in support of a particular model, given the data available (Burnham and Anderson 2002).

Appendix C: Graphics presented in Interim Report (June 2016)

Summer 2015-16 Kooragang Island survey for Green and Gold Bell Frog (GGBF) *Litoria aurea*

Colin McHenry, Bede Moses, & Michael Mahony

	Total	VES	CMR	
Total wetlands surveyed	78	78	4	
Total wetland surveys	223	179	44	
Nights of field work	38			
Total search time	5,305	3,300	2,005	(mins)
Total search effort	15,060	10,057	5,003	(person mins)

Wetlands with GGBF detected	42
Wetlands with GGBF breeding	7

Wetlands with *Gambusia*	65

Frogs detected	1,283
Frogs captured	677
Unique frogs captured	539

Frogs detected in:	VES	CMR	Total
NPWS wetlands	133	134	267
PWCS wetlands	256	718	974
NCIG wetlands	8		8
HDC wetlands	29		29
BHP (HDC ema) wetlands	2		2
RMS	3		3

Percentage of	between 6 and 12 months	1 - 2 years	> 2 years
Male	36.0%	13.7%	0.2%
Females	13.0%	19.6%	1.5%

Take home points:

1. This was a good year for GGBF, with large numbers detected and a large breeding event in K106 - a result of very high summer rainfall this year.
2. Constructed wetlands on T4 are performing well, with respect to frog abundance and breeding.
3. There is a link between breeding (presence of tadpoles or metamorphs) and ponds being free of *Gambusia.*
4. Size structure of the population suggests a very high turnover of individuals, with most animals encountered being less than 1 year old.
    - Mortality rates after 1 yr are high (a result of chytrid)
    - Recruitment depends on >2 yr old females, but these make up less than 2% of the population.

- The population depends upon the reproductive effort of a small number of animals that survive their 2nd winter. Very few of these survive their 3rd. Consequently, the Kooragang population may be vulnerable to a small number (i.e. 2) of consecutive 'bad' years.
- The T4 site is highly important for the Kooragang GGBF population. In particular, the 'Northern Rail Corridor' is home to most of the animals detected.

Survey Team
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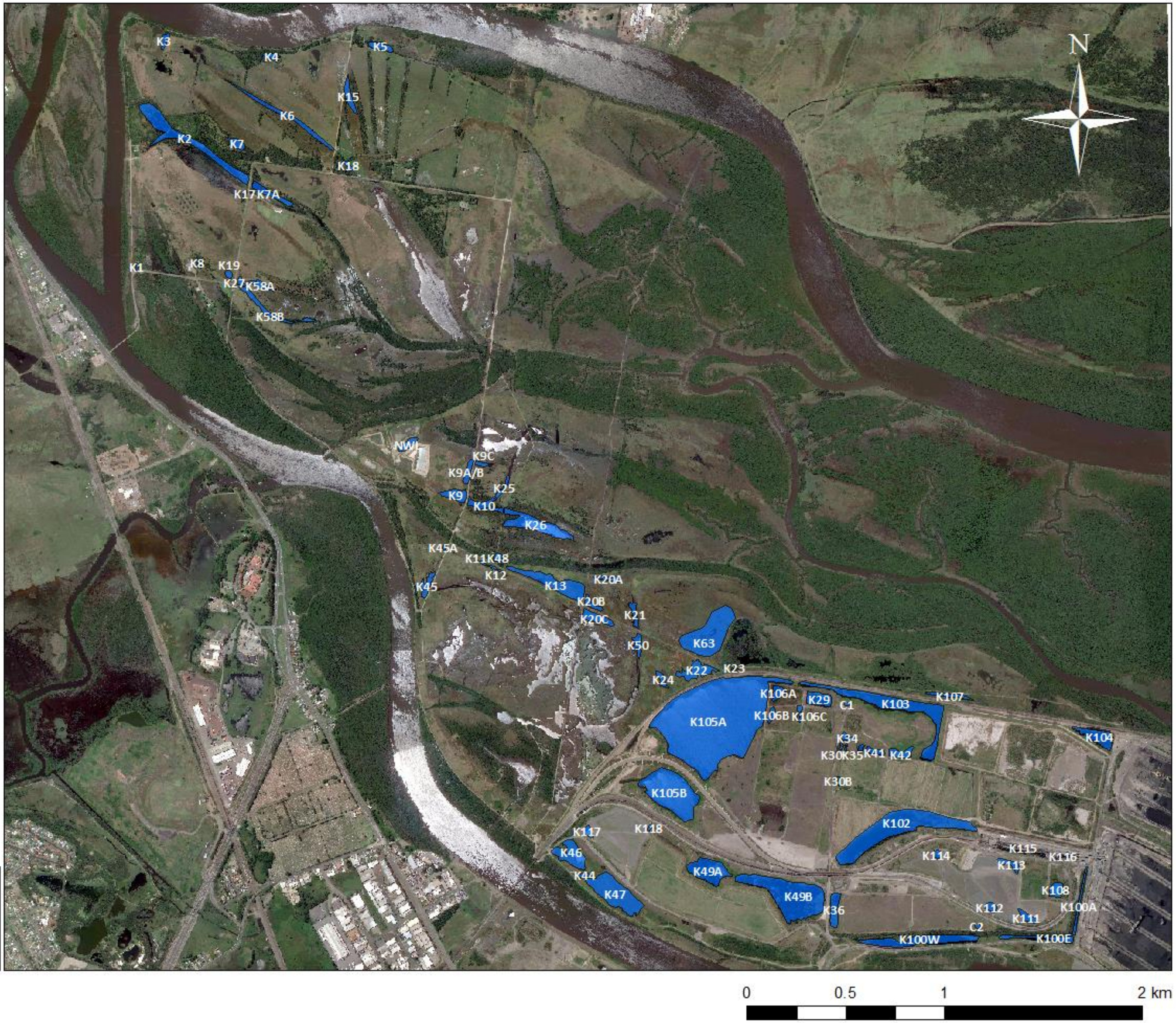
Survey Ponds on Kooragang Island

- Ponds grouped into 3 regions:
  1. NW island (NPWS)
  2. Central island (NPWS)
  3. South island (Industrial Zone)
- UoN pond reference system updated as of April 2016

Pond Overview - Kooragang Island survey area



Legend

Surveyed Ponds-summer 2015/16

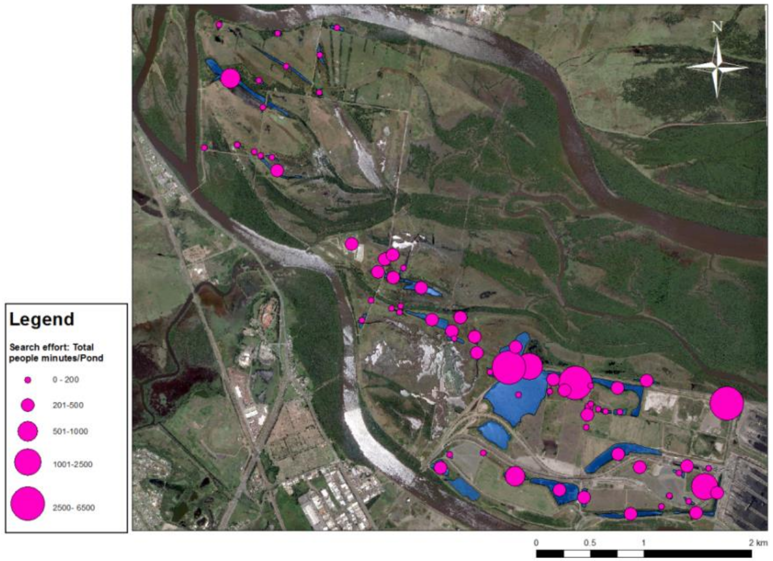
Surveys

1. Visual Encounter Surveys (**VES**)
    - between 2 and 6 people (usually 3) evenly spaced, walking at a constant pace (slow enough to have a good chance of seeing any frogs)
    - maximum 30 mins

1. Capture-Mark-Recapture (**CMR**)
    - repeated intensive surveys for 3-5 consecutive nights
    - Sites:
        1. K22-23 - Central island (NPWS)
        2. K29 ('the Cell') – Industrial Zone (PWCS, NCIG & HDC)
        3. K104 - T4 (PWCS)

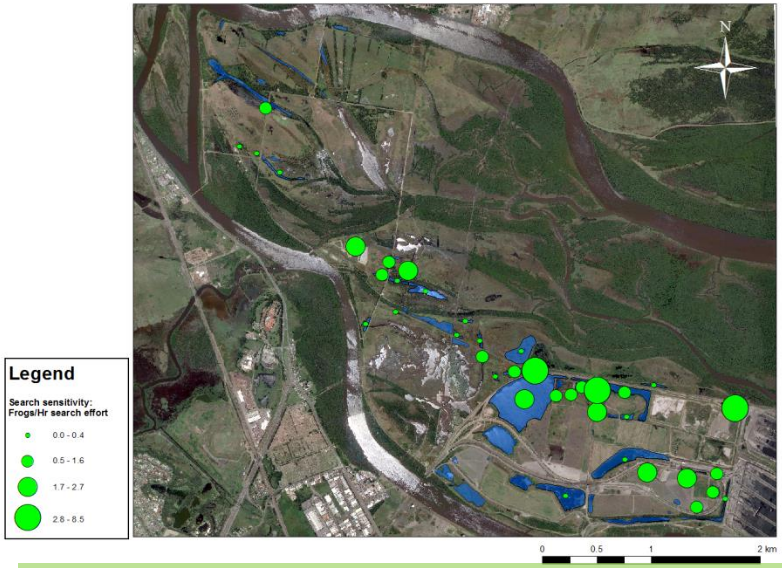
Note: K108 ('the Rail Loop') has been used as a CMR site in previous years. However, our capture rate was low this year (search effort >1000 p.mins, capture rate < 1 frog per 16 minutes). We therefore used K104 as a CMR site (for the first time).

Search effort - summer survey period 2015/16



Search effort was consistent across most ponds
- Five ponds show very large search effort - the 4 CMR ponds, and K108 (aborted CMR in round 1)

Search sensitivity - summer survey period 2015/16



Search sensitivity shows the frogs encountered per person.minute of search effort , and is used here as a proxy for **GGBF adundance.**
- In addition to the 5 'CMR' sites:
    - The **new HDC** ponds within the NCIG rail loop (eastern side of T4) show good numbers of frogs, especially given that these ponds were constructed less than 1 year ago
    - The **Cluster 1** pond (near the Cell) also have good numbers
- In the Central part of the island
    - K9-K9A/B-K25 have good densities of GGBF.
        - Note that breeding was detected at K9C - see page 8
    - The constructed **NWL** pond has high densities

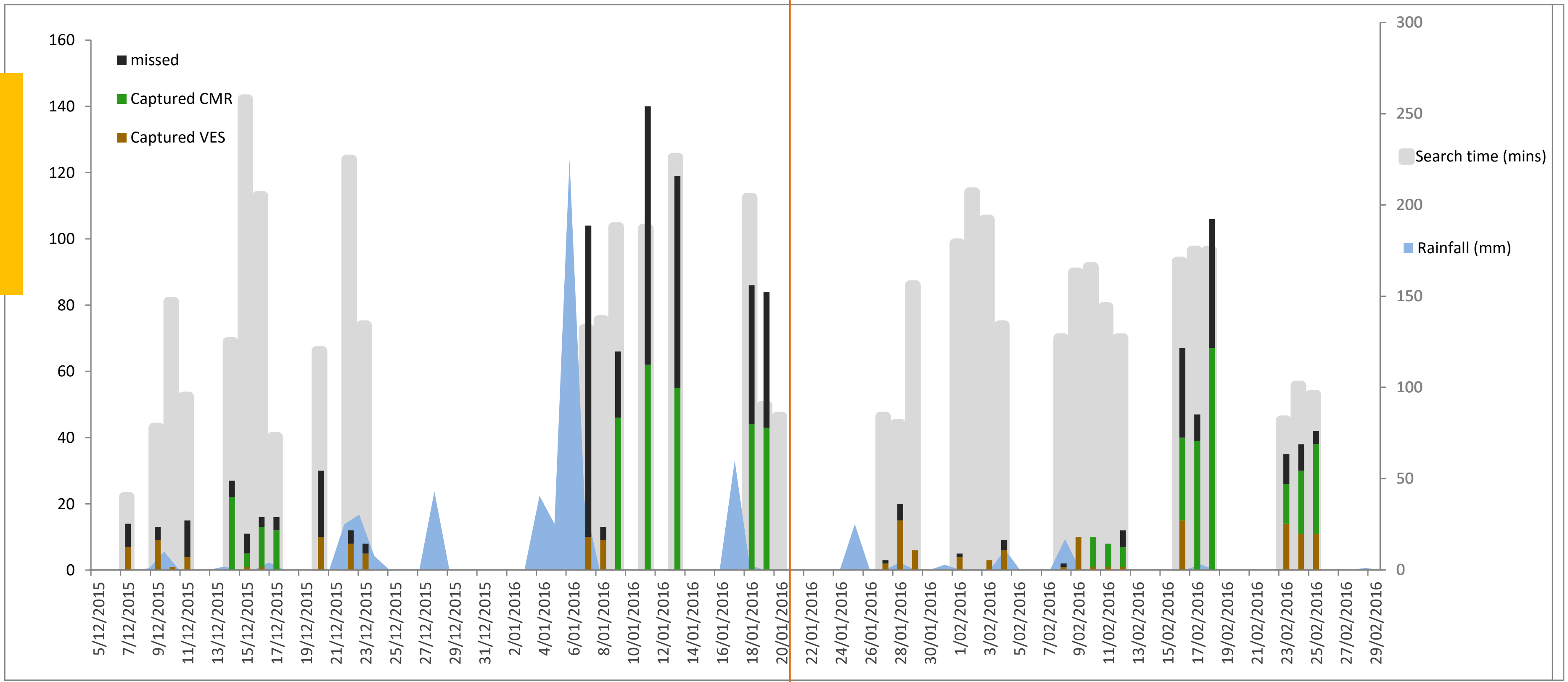
- The '**Northern Rail Corridor"** is clearly important, with high abundance of frogs The new habitats within the **'Rail Loop**' show promise. The Southern Corridor of T4 has low numbers of GGBF

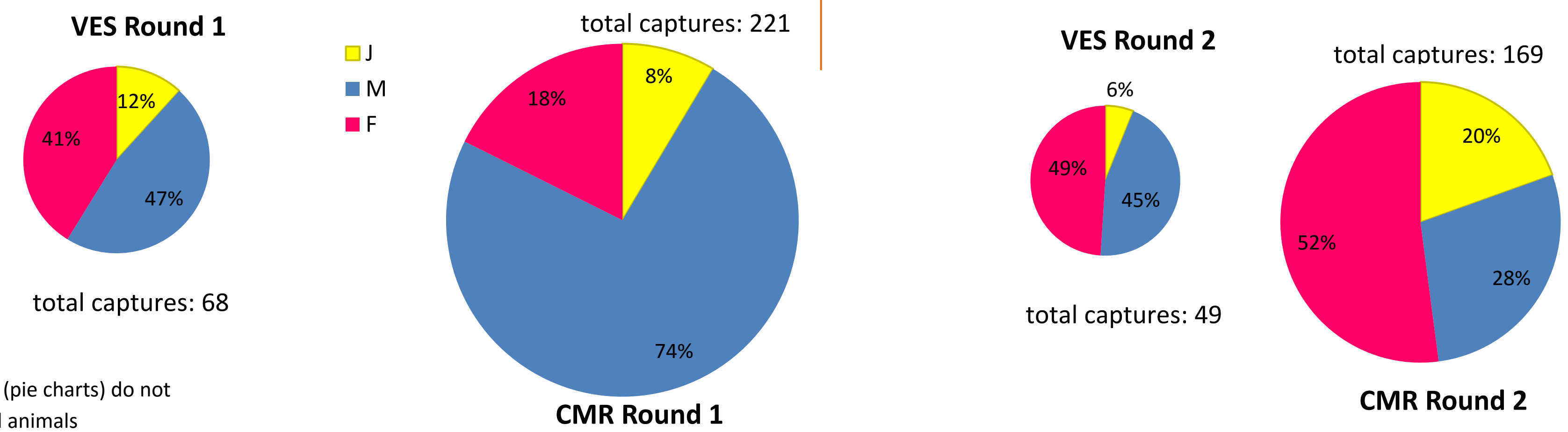
Surveys were conducted between 5th Dec 2015 and 25 Feb 2016.

We detected a large number of Bell frogs- more than 1,200. This was likely due to:

1. An **extreme rainfall** event in early January, which stimulated breeding behaviour
2. Intensive CRM surveying at **K104**, which evidentially has high numbers of GGBF

Capture data includes recaptures (total captured + missed = total detected

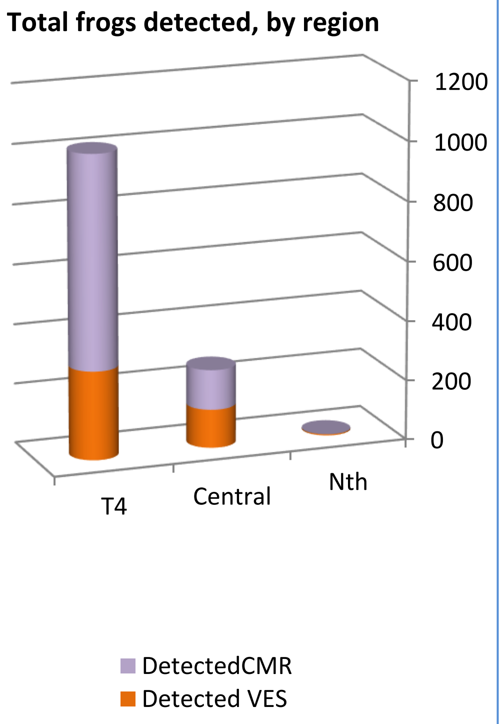


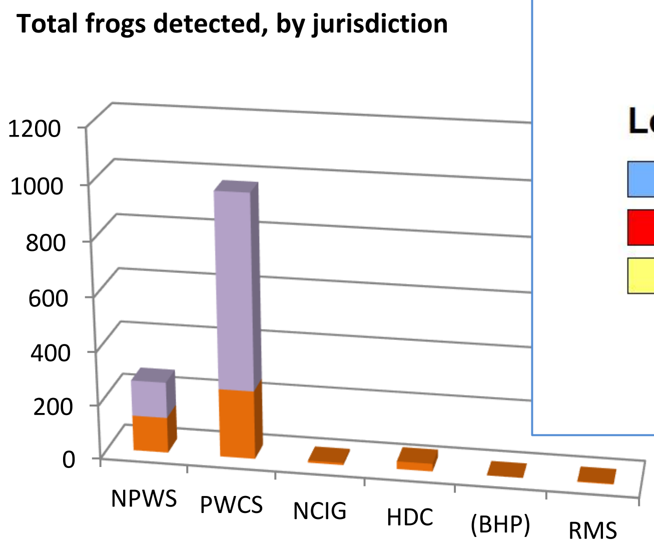


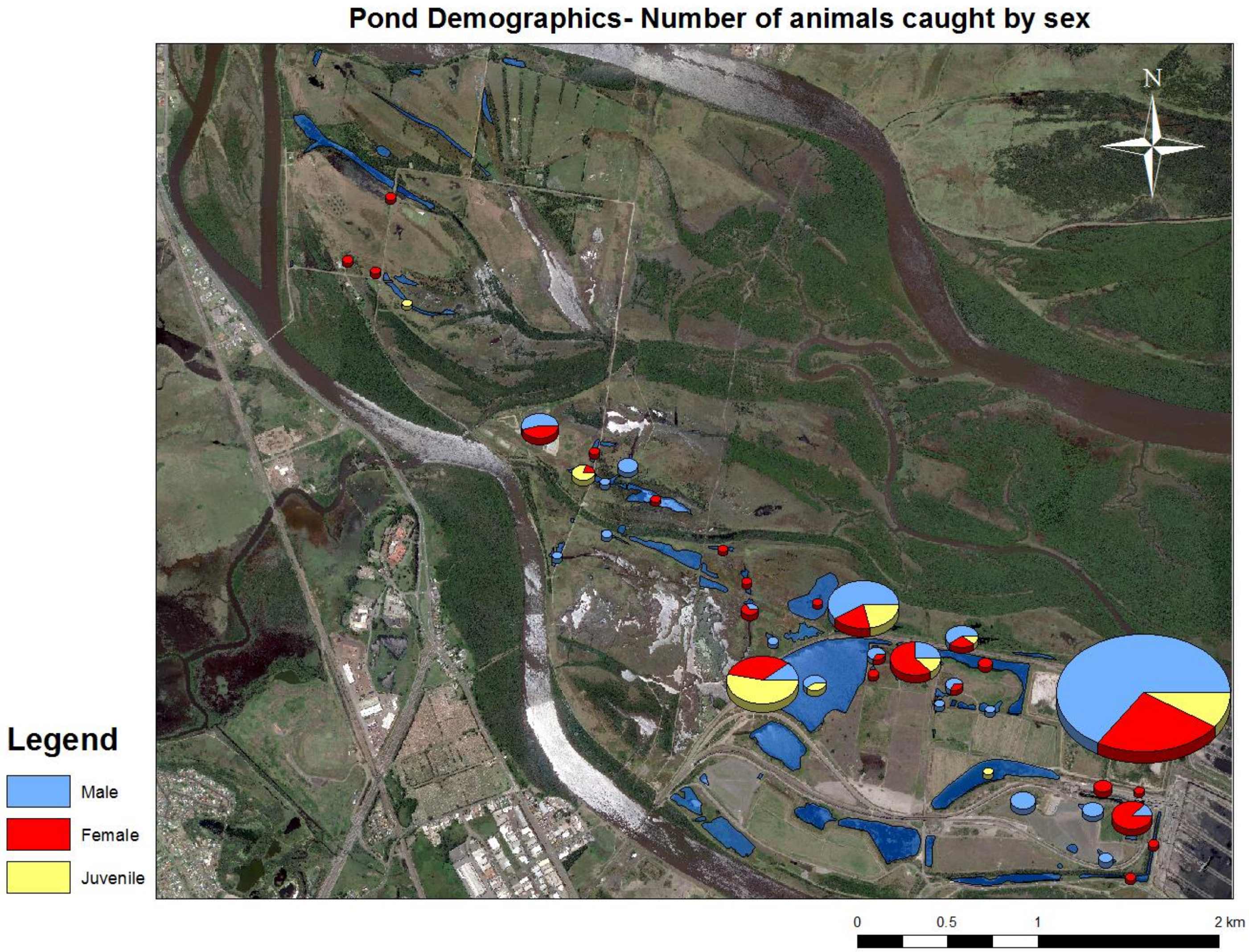
Demographic data (pie charts) do not include recaptured animals

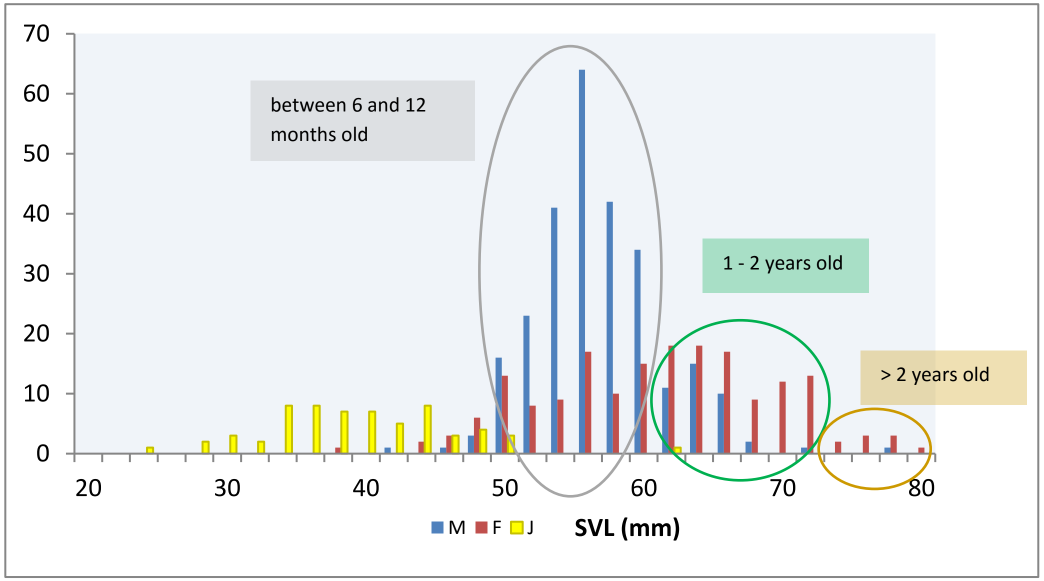
GGBF numbers in the **Northwest** part of the Island are **low**. There are better numbers in the Central (NPWS) part, but **most** animals detected were in the Industrial Zone

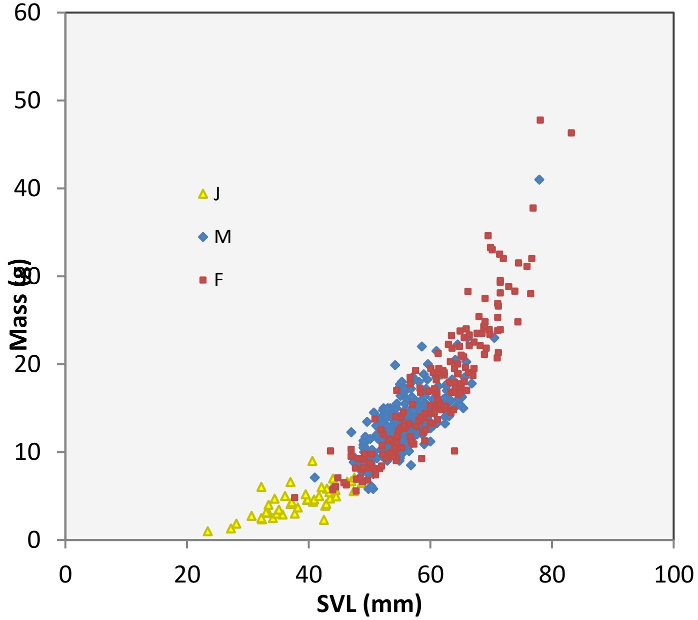
- (difference in numbers cannot be explained by Search Effort - see page 8)
- The highest number of frogs are on PWCS ponds, followed by NPWS.







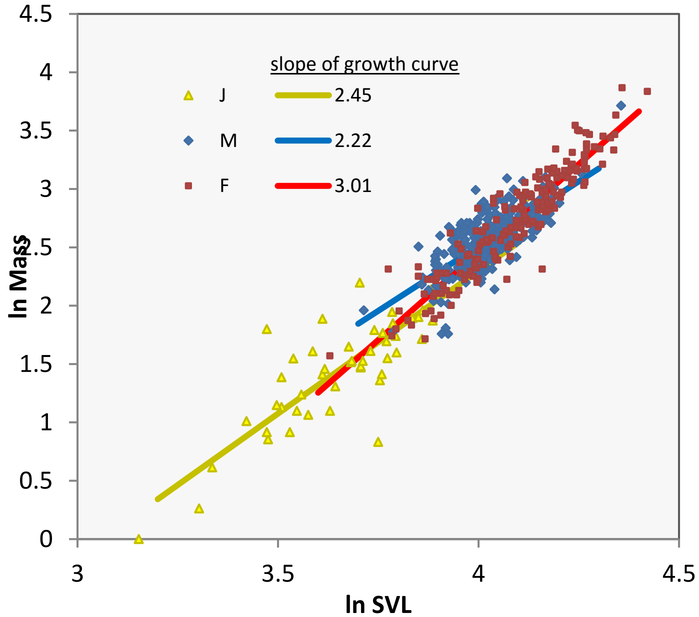




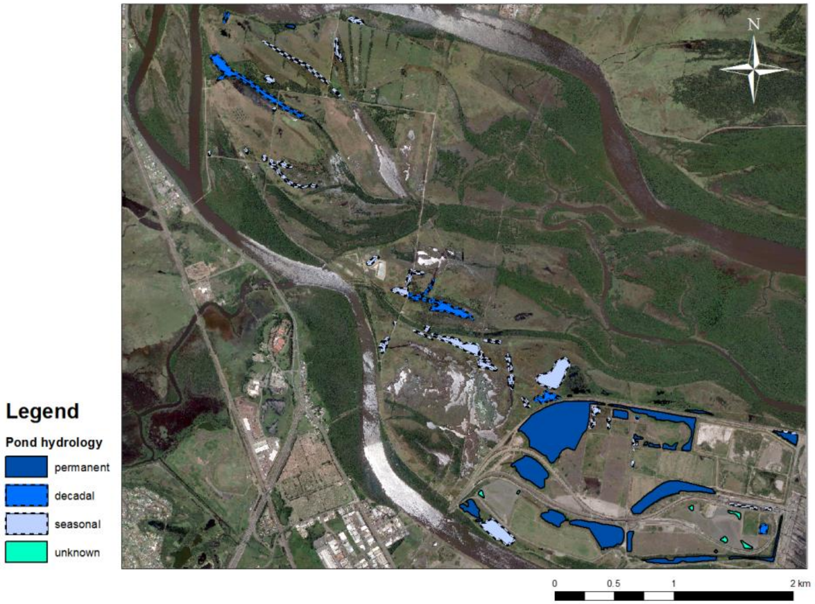
The frequency of size classes show that **most animals are young** (less than 1 yr old).

- The high number of males in this cohort may well be **reproductively active** (which is why they were so visible after the rain event)
- There are virtually **no males** older than 2 yrs
- Only **females >2 yrs** lay eggs. The number of these females is **very low** (8 out of 531 animals captured)

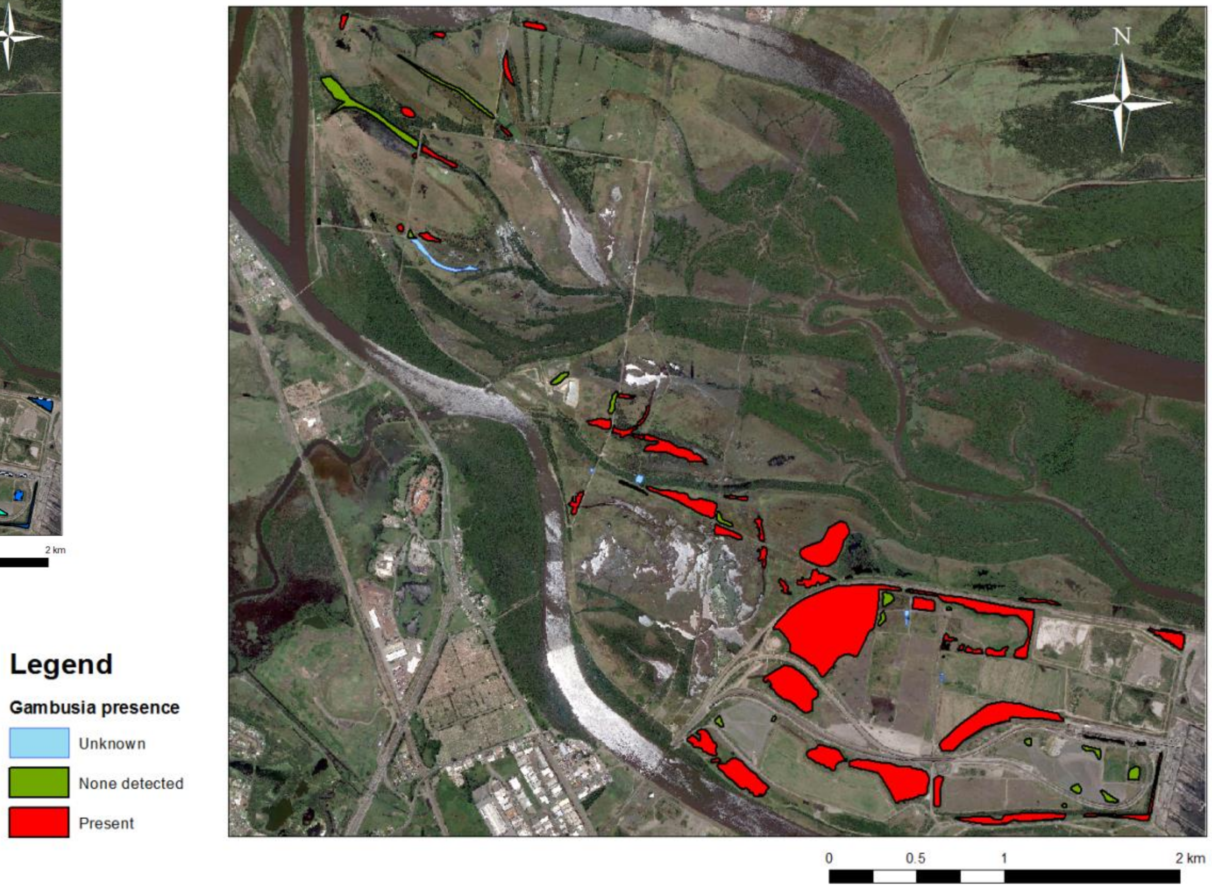
Size vs mass data for >500 individual frogs shows that males and females have slightly different growth curves



Pond Hydrology - ephemerality



Distribution of gambusia - Kooragang Island



The April 2015 floods spread *Gambusia* over large parts of the island - only 19 of the surveyed ponds appear to be free of *Gambusia*

There is a clear link between the absence of *Gambusia* and evidence of reproductive success for the frogs - a much higher proportion of *Gambusia*-free ponds had tadpoles and/or metamorphs

Gambusia present

Gambusia free

Total ponds with

Breeding	*Gambusia*	No *Gambusia*
none	56	15
tads/mets	3	**4**
	59	19

Totals for search effort, **detection rate** (upper bars), and **pond area** (lower bars) for the 78 ponds surveyed. Ponds are grouped by **Jurisdiction** and ordered by net detection rate.

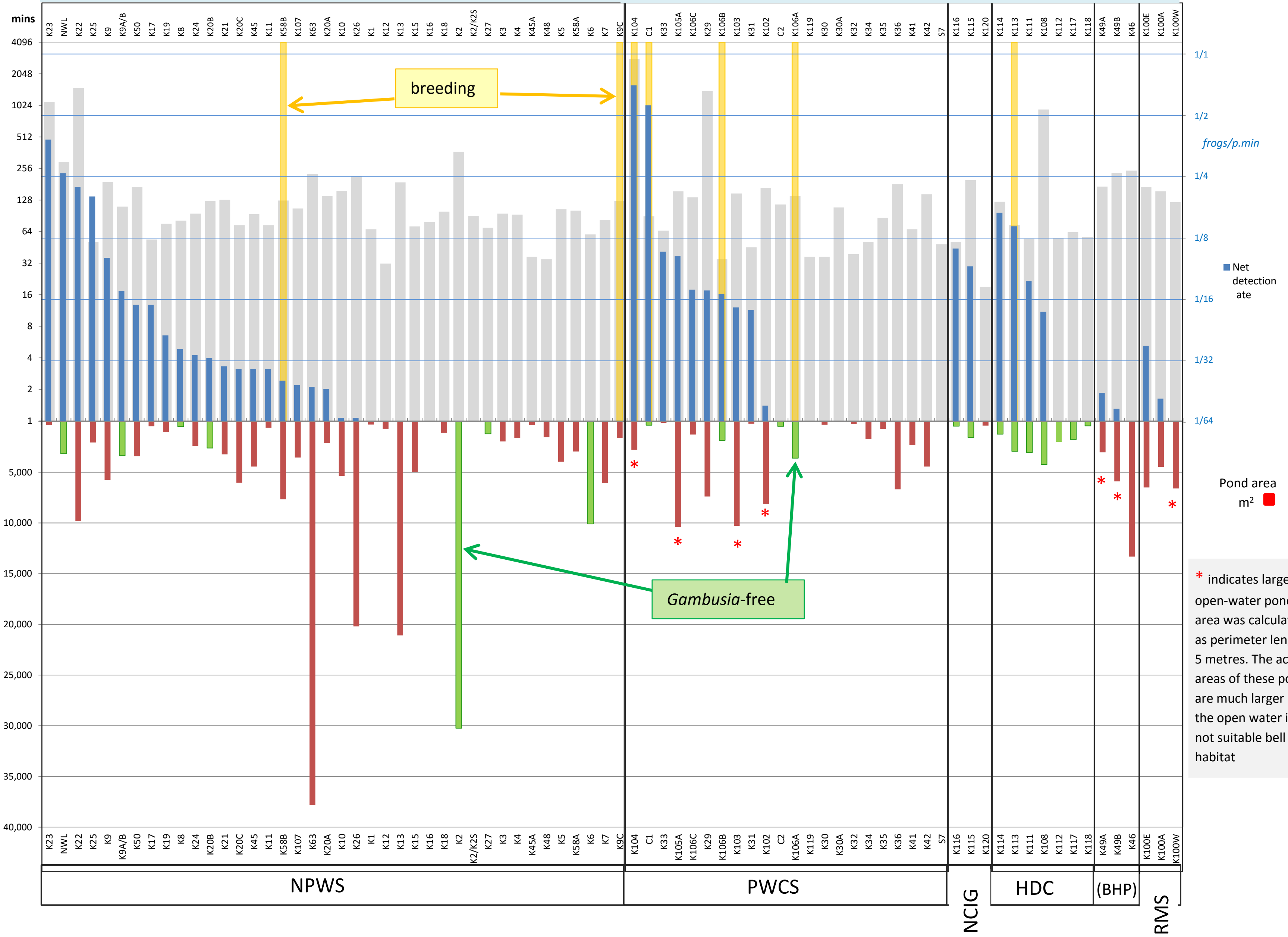
- Search effort is the total *person.minutes* per pond
- **Net detection rate** is the number of frogs detected per minute
- **Pond area** measured from GIS

Breeding (as evidenced by presence of tadpoles or metamorphs):

- Recorded in 7 ponds
- 4 of those ponds were free of *Gambusia*
- The other 3 were in shallow ephemeral ponds (K58A, K9C, K104A)
- There was a **large** breeding event at **K106A** and **K106B**, with thousands of tadpoles and metamorphs observed in mid-February
- With respect to **constructed ponds**, tadpoles were seen in one of the new HDC ponds (K113) and the northern cluster ponds (C1)

Gambusia are present in most ponds (59/78):

- There is a strong correlation between *Gambusia*-free ponds and **breeding**
- Although they have a small number of ponds, **NCIG** (2 out of 3) and **HDC** (7/7) are largely *Gambusia* free
- All **constructed habitats** (cluster ponds, new HDC ponds, NWL) are free of *Gambusia*
- K104A was *Gambusia*-free until the **large rainfall** on the 6th January (which connected it with K104) – in 'normal' years this would probably remain free of *Gambusia*



* indicates large open-water ponds; area was calculated as perimeter length x 5 metres. The actual areas of these ponds are much larger but the open water is not suitable bell frog habitat

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